「국부통계간접추계 기법 개발 및 시산」
참고 자료집 및 OECD추계 메뉴얼

2000년 12월

통계청 통계분석과

일 러 두 기

이 책자는 「국부통계간접추계 기법 개발 및 시산」(2000. 10월 서울대학교 경제연구소 발간)을 위한 프로그램과 기초자료를 수록한 것이다.
국부통계간접추계 기법 개발 및 시산을 위한 프로그램은 SAS IML (Interactive Matrix Language)패키지로서 작성되었다.
프로그램에는 간단한 주석과 중간 중간의 결과물을 참고로서 수록하였다.

SAS IML은 SAS 시스템에서 행렬 연산만을 담당하는 독립적인 언어이자 모듈로서, 자주 사용되는 행렬 연산들을 연산자, 함수, 부프로그램 형태로 단순화하여 사용자들의 편리와 연산효율의 증진을 지향하는 프로그램이라 할 수 있다.
SAS IML에 관한 자세한 매뉴얼은 SAS/IML입문 (세경사, 최 병선 지음), SAS 해설 제5권 SAS/IML-행렬 연산(자유아카데미, 성 내경 지음)을 참고로 하면 되겠다.

또한 2000년 9월 OECD에서 작성한 「MANUAL ON CAPITAL STOCK STATISTICS (Version 2 of the Capital Stock Manual)」을 부록으로 수록하였다.

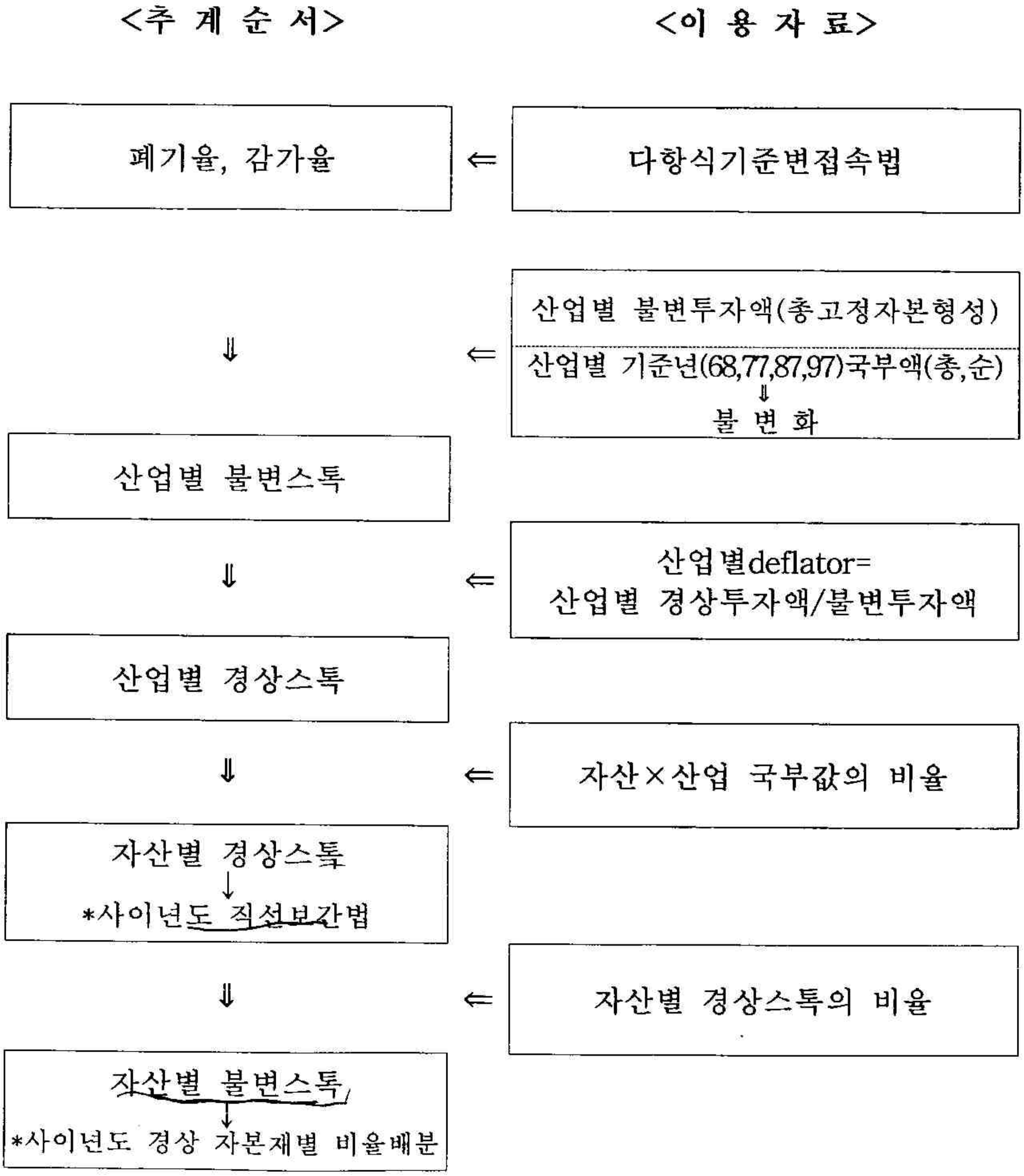
목 차

Ⅰ. 추계 프로그램

Ⅰ. 추계 프로그램

1. NwsbyInew.sas : 산업별 stock 먼저 추계시 프로그램

<u>프 로 그 램 흐 름 도</u>



```
/************************************************************************************
******************            GENERAL DESCRIPTION            ********************
***********************************************************************************/
/**
DATA :  ii95cl - INVESTMENT DATA( 1995 CONSTANT, INDUSTRIES, 1968-99 )
        ii70nl - INVESTMENT DATA( CURRENT,       INDUSTRIES, 1968-99 )
        ic95cl - INVESTMENT DATA( 1995 CONSTANT, TYPES, 1968-99 )
        ic70nl - INVESTMENT DATA( CURRENT,       TYPES, 1968-99 )


        w68gl - 68NATIONAL WEALTH SURVEY( GROSS,  TYPES*INDUSTRIES )
        w68nl - 68NATIONAL WEALTH SURVEY( NET,    TYPES*INDUSTRIES )
        w77gl - 77NATIONAL WEALTH SURVEY( GROSS,  TYPES*INDUSTRIES )
        w77nl - 77NATIONAL WEALTH SURVEY( NET,    TYPES*INDUSTRIES )
        w87gl - 87NATIONAL WEALTH SURVEY( GROSS,  TYPES*INDUSTRIES )
        w87nl - 87NATIONAL WEALTH SURVEY( NET,    TYPES*INDUSTRIES )
        w97gl - 97NATIONAL WEALTH SURVEY( GROSS,  TYPES*INDUSTRIES )
        w97nl - 97NATIONAL WEALTH SURVEY( NET,    TYPES*INDUSTRIES )
**/

proc iml;  sas에서 IML시작


/************************************************************************************
******************            ANNUAL DATA            ********************
***********************************************************************************/

/* INVESTMENT 1995 CONSTANT : INDUSTRIES 1968-1999 */
/* 1st col=> YEAR,2nd col=> TOTAL, 3rd col=>sub total, 4th-13th =>10 INDUSTRIES*/
/* 농림어업, 광업, 제조업, 전기가스수도업, 건설업, 도소매및음식숙박업, 통신업, 금융부동산업, 서비스업 정부,공공행정,사회서비스,기타*/

ii95cl={
1968   7192.3   5458.8   1160.0   36.5   914.9   295.3   71.5   335.2   138.7   2324.3   182.3   1733.5   1116.2   446.5   170.7,
1969   8886.5   6744.7   1433.2   45.2   1130.4   364.8   88.3   414.2   171.3   2871.9   225.3   2141.8   1379.1   551.7   210.9,
1970   8973.2   6810.5   1447.2   45.6   1141.4   368.4   89.2   418.2   173   2899.9   227.5   2162.7   1392.6   557.1   213  ,
1971   9246.4   7038.3   1347.8   80.2   1473.8   571.5   108.4   418.1   334.3   2494.4   209.7   2208.1   1400.4   635.3   172.5,
1972   9355.5   7416.7   1437.4   77.1   1138.5   669.7   138.7   553.3   601.5   2542.4   258.1   1938.8   1160   578.5   200.3,
1973   11949.4   10086.8   1725.9   100.9   2115.2   698   112   576   1123.7   3344.8   290.5   1862.6   1138.2   527.9   196.5,
1974   13718.3   12013.9   2494.1   134.6   2376.3   613.9   140.6   532.2   1471.7   3970.6   279.9   1704.4   1124.6   412.1   167.7,
1975   14775   12459.1   1635.9   120.9   3134.7   747.5   265.4   654.1   1207.3   4325.8   367.5   2315.9   1615.6   477.8   222.6,
1976   17877.2   15179.9   1757.8   208   4241.3   765.1   494.9   845.5   2182.9   4309.6   374.9   2697.3   1822.3   533.8   341.2,
1977   22995.1   19442.8   2333.1   274.1   6003.9   1440.7   758.3   898.3   1839.3   5323.4   571.6   3552.3   2442.9   730.7   378.7,
1978   30896.2   26393.2   2792.4   340.5   8100.1   1905.6   847.2   1343.4   2665.7   7759.6   638.7   4503   3168.3   969   365.6,
1979   33892.2   28602.1   2900.3   360.4   8789.4   2660   955.3   1247.1   3149.1   7879.9   660.7   5290.1   3578.2   1195   516.8,
1980   30261.8   25167.8   2436.2   312.1   6279.4   2559.6   918.6   1180.4   3699.7   7190.4   591.4   5094   3628.5   1051.9   413.6,
1981   29141.6   23957.7   2199.3   361.8   5802.6   2851   936.7   1399.1   4120.7   5709.1   577.4   5183.9   3442.6   1241   500.2,
1982   32377.9   26336.3   2172.7   384.5   6020.5   2836.4   1042.9   1983.1   3892.5   7237.2   766.4   6041.6   3919.2   1447   675.5,
1983   37991   31087.2   2636.2   394.8   6211.2   3463.1   969.9   1523.3   5738.7   9407   743   6903.8   5005.9   1466.4   431.5,
1984   41798.8   34000.2   2856   452.2   8432   3131.4   1210.4   1951.6   5467.2   9499.7   999.6   7798.6   5227.4   1814.7   756.5,
1985   43607   35102.6   2941.6   480.9   10049.9   3085.5   1175.9   1923.6   5704.2   8863.4   877.6   8504.4   5686.9   2189   628.5,
1986   48279.1   39895.3   3486.8   454.8   12475.3   2553.3   1057.2   2645.1   5697   10484.5   1041.3   8383.8   5426   2155.5   802.3,
1987   56482.5   47423.4   4396.1   422.1   17404.4   2665.2   1498.6   3020.9   5667.1   11201.4   1147.6   9059.1   5892   2207.7   959.4,
1988   64170.4   53904.3   4263.8   420.5   19826   2237   1698   4005.1   6209.8   13691.7   1552.4   10266.1   7140.1   2204.1   921.9,
1989   74302.4   63425.6   6463.1   475.7   22471.7   3076.1   1953.5   4014.8   6799.2   16566.8   1604.7   10876.8   7883.5   2236.3   757  ,
1990   93528.9   81169.2   6323.1   422.1   26128.4   3222.4   2759.8   3912.4   8539   28052.1   1810.1   12359.7   9037.4   2552.3   770  ,
1991   105970.6   90871.6   6951.7   399.8   27606.8   5007   3916.6   4380   8932.7   31814.1   1862.9   15099   11268.4   2882.4   948.2,
1992   105225.4   88460.7   6829.2   371.5   24406.3   6448.8   4007.3   3582.7   9598   30828.6   2388.4   16764.7   12342.2   3223.9   1198.7,
1993   111831.6   95168.6   6757   371.2   23325.8   6471.5   3388   4406.3   9650.1   38257.8   2541   16663   12079   3415.9   1168.1,
1994   123750.5   105722.8   7030.6   317.2   30543.3   7326.6   2992   4916.1   11904.4   37605.6   3087.1   18027.7   11087   4328.5   2612.2,
1995   138438.6   119999.8   8568   216   37031.9   8040   3024   5376   14400   39923.9   3420   18438.8   11551.9   4145   2741.8,
1996   148579.8   126531   8768.6   215.1   42134.8   9363.3   3340.4   5947   15576   37832.8   3353.1   22048.8   12834.6   5353.4   3860.7,
1997   145294.6   122341.2   11822.4   162.2   42577   7515.1   3665.2   5620   10989.1   36944.3   3045.8   22953.4   12299   5965.7   4688.7,
1998   114563.5   90839.6   12154.3   145.3   23109.6   7267.2   1853.1   4978   9329.2   29677.3   2316.4   23723.9   10515.4   8035.4   5173.1,
1999   119272.9   94573.8   12653.9   151.3   24059.6   7565.9   1929.3   5182.6   9712.7   30897.3   2411.6   24699.1   10947.7   6283.5   5385.8
};
```

/* INVESTMENT DATA (Current, INDUSTRIFS 1968-1999) */

ii70n1={

1968	517.7	412.6	80.7	1.9	77.5	25.8	5.0	24.1	10.6	171.8	15.3	105.1	67.7	27.1	10.3,
1969	591.0	471.0	92.2	2.2	88.4	29.4	5.7	27.5	12.1	196.1	17.4	120.0	77.3	30.9	11.8,
1970	695.6	554.4	108.5	2.6	104.1	34.6	6.7	32.4	14.3	230.8	20.5	141.2	91	36.4	13.9,
1971	768.6	614.9	110.8	4.9	143.4	56.5	8.6	34.4	29.4	207	19.9	153.8	97.5	44.2	12 ,
1972	871.4	720.4	128.4	5.5	124.4	74.7	12.6	51.9	60.4	234.7	27.7	151	90.3	45	15.6,
1973	1298.3	1128.3	173.1	8.3	280.6	88.7	11.7	61.9	130.2	338.2	35.6	170	103.9	48.2	17.9,
1974	2068.6	1853.4	366.2	15.8	419.2	109.1	20.8	80.7	241.3	552.1	48.2	215.2	142	52.1	21.1,
1975	2744.8	2387.1	277	18.1	687.3	164	49.1	123.7	247.4	742.5	78.1	357.7	249.5	73.8	34.4,
1976	3593.7	3142.2	336.2	33.6	981.6	176.5	97.5	169.3	475.8	787.9	83.8	451.5	305	89.4	57.1,
1977	5107	4452.5	493.9	49.5	1521.9	362	164.5	197.6	441.5	1081.9	139.6	654.6	450.1	134.6	69.8,
1978	7923.5	6973	692.5	71.9	2341.8	542.3	210.5	337.9	734.6	1864.2	177.2	950.5	668.8	204.6	77.2,
1979	10573.4	9216.3	903.7	92.9	3027	896.9	284.6	374.6	1040.3	2379	217.4	1357.2	917.8	306.5	132.8,
1980	12229.9	10522.3	970.4	106.2	2811.2	1115.9	357.9	462.5	1598.5	2847.4	252.2	1707.6	1216.4	352.6	138.7,
1981	13368.8	11374.9	1009.1	143.9	2893.2	1374.7	412.4	622.8	2091.9	2553.9	273.1	1993.9	1337.3	464.4	192.2,
1982	15586.3	13166.1	1093.2	163.7	3198.7	1449.8	492.6	938	2060.6	3382.4	386.9	2420.2	1571.5	576.5	272.2,
1983	18944.4	16122.8	1356.4	178.1	3439.7	1827.3	477	743.7	3187.7	4521.4	391.6	2821.6	2037.5	605.8	178.4,
1984	21381.2	18097.9	1541	213.2	4764.5	1673.9	615.4	912.2	3131.9	4714.2	531.8	3283.3	2213.6	751.9	317.8,
1985	23434.9	19756.4	1585.4	245	6010.3	1737.8	621.9	1020.1	3480.8	4563.5	491.6	3678.5	2460	946.7	271.8,
1986	26975.8	23360.4	1920.2	242.9	7900.5	1518.4	577	1492.7	3562.5	5534.1	612	3615.4	2340	929.7	345.7,
1987	32600	28528.8	2504.8	236.8	11186.1	1606.2	833	1723.1	3623.2	6133.7	681.8	4071.2	2648	992.2	431 ,
1988	39450.8	34477.5	2685.8	248.2	13187.6	1417	986.1	2378.9	4230.4	8395.3	948.1	4973.3	3459.1	1067.8	446.4,
1989	47673.4	41947.9	4278.7	344	15424.2	2063.8	1258.4	2680.5	4773.7	10042.3	1082.3	5725.5	4150	1177.4	358.1,
1990	66689.3	58775.4	4578.6	305.6	18919.8	2333.4	1998.4	2833	6183.2	20312.8	1310.7	7913.9	5786.6	1634.2	493 ,
1991	84506.7	73491	5622.1	323.4	21606.4	3983.2	3116	3527.6	6871.4	26861	1580.1	11015.7	8221	2102.9	691.8,
1992	90809.3	77406.3	6076.4	317.4	20334.6	5441.7	3390.4	3135	7903.2	28601.6	2206.1	13403	9867.3	2577.4	958.3,
1993	100354.4	85936.4	6359.3	318	20281	5525.7	2956.2	3987.4	8095.2	36015.9	2397.6	14418	10451.6	2955.7	1010.7,
1994	116436.4	100070.4	7345.2	310.2	27739.5	6234.4	2731.9	4853.4	10407.3	37356.3	3092.2	16366	10065.1	3929.5	2371.4,
1995	138438.6	119999.8	8568	216	37031.9	8040	3024	5376	14400	39923.9	3420	18438.8	11551.9	4145	2741.8,
1996	153975.6	131490.9	10624.5	210.4	41472.2	9257	3431.9	6403.6	13911.7	42287.5	3892.1	22484.7	13088.3	5459.3	3937.1,
1997	159110.4	133253.5	9670.9	175.8	44673.6	8161.6	4065.8	6267.7	11585.5	45299.4	3353	25856.9	15040.3	6297.9	4518.7,
1998	132307.5	104337	7084.5	166.9	26898.1	8305.2	2085.9	5279.5	11153.6	40722.7	2660.6	27970.5	12397.7	9473.7	6099.1,
1999	135233.8	106644.7	7241.2	170.6	27493	8488.9	2111.6	5396.3	11400.3	41623.4	2719.4	28589.1	12671.9	9683.2	6234

};

/* INVESTMENT DATA(1995 CONSTANT, TYPES, 1968-99)

/* 연도 total 주거용건물, 비주거용건물,기타구축물, 토지개량, 운수장비, 기계류, 낙농축 */

ic95c1={

1968	7192.3	1909.1	1661.3	1097.6	1005.0	650.4	867.1	1.8,
1969	8886.5	2358.8	2052.7	1356.2	1241.7	803.7	1071.3	2.2,
1970	8973.2	2381.8	2072.7	1369.4	1253.8	811.5	1081.8	2.2,
1971	9246.4	2327.7	1860.1	1707.2	999.3	1015.7	1334.2	2.2,
1972	9355.5	1956.1	1890.1	1677.6	1205.1	1201.0	1422.0	3.5,
1973	11949.4	2689.6	2834.8	1612.2	1622.3	1353.2	1826.8	10.7,
1974	13718.3	4252.5	2624.4	1730.5	1397.3	1957.7	1742.8	13.1,
1975	14775.0	4245.9	2731.9	2130.7	1545.1	2044.2	2069.8	7.3,
1976	17877.2	4361.3	3413.0	2691.8	1734.6	2476.5	3196.2	3.9,
1977	22995.1	5466.9	3955.6	3715.3	2082.1	2685.8	5073.9	15.5,
1978	30896.2	7508.9	5400.8	4047.7	2230.1	3480.9	8202.4	25.4,
1979	33892.2	6818.0	5939.6	5490.6	1867.7	3582.5	10169.5	24.4,
1980	30261.8	6268.3	5391.3	5745.3	1837.8	3431.0	7569.0	19.1,
1981	29141.6	5140.9	4759.1	6072.8	2088.9	3690.7	7376.1	13.1,
1982	32377.9	6405.8	5253.1	7237.2	2290.9	3484.1	7652.4	54.4,
1983	37991.0	8380.2	6751.6	8148.2	2620.8	3708.5	8299.9	81.7,
1984	41798.8	7657.4	8226.8	8940.0	2789.9	4368.8	9722.4	93.3,
1985	43607.0	7718.3	7789.7	10465.7	2796.4	4556.3	10211.1	69.4,
1986	48279.1	9032.8	8243.6	9535.9	2936.7	5150.0	13324.8	55.2,
1987	56482.5	9871.8	10521.6	9949.5	4019.7	5683.1	16405.8	30.9,
1988	64170.4	12068.8	12673.5	11067.4	3449.8	6135.9	18754.2	20.9,
1989	74302.4	14414.5	15502.1	12806.3	3112.5	6864.6	21481.1	121.5,
1990	93528.9	23075.7	18376.3	15372.9	3210.6	8615.0	24760.7	117.7,
1991	105970.6	25564.7	18504.0	19858.9	3591.3	9644.7	28666.6	140.3,
1992	105225.4	23690.2	17081.3	22566.3	3555.8	10300.5	27875.0	156.2,
1993	111831.6	26337.8	19853.4	23335.3	3865.1	10634.1	27632.2	173.7,

```
1994    123750.5   25887.6   20806.7   24893.2    4551.0   13157.7   34217.4     237.0,
1995    138438.6   28026.9   23262.5   25437.5    5470.6   13399.1   42555.8     286.1,
1996    148579.8   28448.8   22441.3   29841.2    6515.9   14531.6   46540.6     260.4,
1997    145294.6   26667.8   22544.5   32686.0    7386.6   12555.7   43139.8     314.3,
1998    114563.5   24548.2   17793.7   32045.2    5908.1    6204.2   27803.8     260.3,
1999    119272.9   19861.1   11007.7   33930.7    7188.3   10405.1   36654.7     225.4
};

/* INVESTMENT DATA( Current, TYPES, 1968-99 )
/* 연도     total  주거용건물, 비주거용건물, 기타구축물, 토지개량,  운수장비,   기계류,      낙농축 */
ic70n1={
1968       517.7     121.4     111.6      77.8      48.1      66.3      91.8       0.6,
1969       591.0     138.6     127.4      88.9      54.9      75.7     104.8       0.7,
1970       695.6     163.1     150.0     104.6      64.6      89.1     123.4       0.8,
1971       768.6     163.5     137.2     128.6      55.5     119.6     162.8       1.5,
1972       871.4     152.1     153.6     136.6      74.0     158.4     195.1       1.6,
1973      1298.3     230.1     257.9     148.4     113.1     223.0     319.2       6.6,
1974      2068.6     502.5     326.6     216.5     133.2     449.1     431.7       9.0,
1975      2744.8     620.7     409.5     328.7     188.6     561.7     628.3       7.2,
1976      3593.7     693.5     553.0     454.4     232.0     682.2     974.1       4.5,
1977      5107.0     952.2     709.8     690.9     320.5     759.7    1650.2      23.7,
1978      7923.5    1545.8    1149.8     885.1     434.5    1076.2    2788.6      43.6,
1979     10573.4    1778.7    1589.9    1504.8     470.9    1271.1    3921.0      37.1,
1980     12229.9    2189.7    1885.5    2115.5     619.8    1586.3    3799.8      33.3,
1981     13368.8    1998.1    1842.6    2539.4     799.0    2062.1    4099.9      27.8,
1982     15586.3    2635.2    2153.0    3168.0     875.1    2039.1    4658.3      57.6,
1983     18944.4    3628.4    2940.1    3627.2     983.4    2432.2    5266.9      66.3,
1984     21381.2    3401.0    3718.2    4065.6    1110.2    2925.2    6082.9      78.2,
1985     23434.9    3520.5    3613.4    4904.2    1163.4    3239.2    6913.7      80.6,
1986     26975.8    4107.3    3828.8    4483.3    1324.4    3487.9    9686.8      57.4,
1987     32600.0    4637.6    5057.8    4826.8    1868.7    4111.5   12074.8      22.9,
1988     39450.8    6201.6    6678.0    5850.6    1781.4    4846.3   14073.0      19.9,
1989     47673.4    8004.5    8854.2    7375.3    1870.7    5777.7   15668.8     122.3,
1990     66689.3   14694.5   12223.6   10430.8    2377.0    7751.6   19093.2     118.6,
1991     84506.7   19521.2   14292.3   15401.5    3120.0    8904.9   23109.0     157.8,
1992     90809.3   19956.3   14394.6   19107.5    3299.8    9831.7   24030.0     189.5,
1993    100354.4   22996.5   17345.4   20424.2    3603.0   10330.1   25458.5     196.7,
1994    116436.4   23975.1   19162.1   22757.9    4376.2   12986.1   32956.9     222.2,
1995    138438.6   28026.9   23262.5   25437.5    5470.6   13399.1   42555.8     286.1,
1996    153975.6   29965.9   23613.5   31662.2    6895.1   14654.7   46952.9     231.3,
1997    159110.4   29851.5   25398.4   37118.0    8282.7   12948.7   45292.4     218.8,
1998    132307.5   28385.1   20522.3   37031.9    6765.9    6716.8   32785.5      99.9,
1999    135233.8   23355.2   12933.5   39424.7    8378.6   10818.7   40186.2     136.9
};
```

```
/* NATIONAL WEALTH SURVEY 1968 GROSS ( 1 mil ) */
/* rows are 5 TYPE of CAPITAL:계, 거주용건물,비주거용건물,구축물,운수설비,기계설비 */
/* cols are 11 INDUSTRIES     :계, 농림어, 광,제조,전가수,건설,도음숙,운창통,금융보험부동산,주택,서비스,정부*/
w68g1={
4703743 160098  33338  715616 119847 37656  172734 93077 24350  1791458 376635 1178934,
2030993  28513   1996   26184     55  6959   19048  1208  1838  1791458 123996   29737,
 867631  12170   6419  234833  40028  4520  106764 12351 17535        0 175352  257660,
 772750   5071   8940   30526  34532   167    1685   253   295        0   4414  686867,
 299171  89108   3140   23217    504  4789   10695 73293  1064        0   6380   86981,
 733198  25236  12843  400856  44728 21221   34542  5972  3618        0  66493  117689
};

/* NATIONAL WEALTH SURVEY 1968 NET ( 1 mil ) */
w68n1={
2352994  98808  14978  388272 119759 23226  102365 46939 19115   593731 245891  699910,
 749329  11342   1082   14128     43  5946   11622   954  1336   593731  89068   20076,
 555371   6023   3342  142738  40022  3685   69769  7568 14057        0 117646  150522,
 466521   4444   5452   21901  34524   123    1085   162   282        0   2851  395697,
 159262  56389   1171   10867    484  3052    6265 36534   742        0   3451   40307,
 422511  20610   3931  198638  44686 10420   13624  1721  2698        0  32875   93308
};

/* NATIONAL WEALTH SURVEY 1977 GROSS ( 1 bil ) */
w77g1={
45236.7 1950.9 294.5 10796.4 1710.4 1010.1 2707.8 3477.1 3161.3 12862.2 1806.9 5459.0,
13392.7    4.3  15.6   110.8    0.7  121.2   54.4    9.9   21.4 12862.2   49.0  143.3,
12472.4  451.7  46.0  3394.1  691.4  313.5 1890.1  263.2 2866.6     0.0 1215.6 1340.4,
 6461.2  301.9  80.6   589.9  386.7   45.5   23.3 1315.8   21.5     0.0   99.1 3596.8,
 2986.6  696.6  39.7   406.8    4.7  122.6  159.7 1368.0   54.7     0.0   43.2   90.7,
 9923.8  496.4 112.6  6294.9  626.9  407.4  580.3  520.3  197.2     0.0  400.0  287.9
};

/* NATIONAL WEALTH SURVEY 1977 NET ( 1 bil ) */
w77n1={
24515.0 885.6 137.4 6422.9 1295.2 641.3 1338.3 1688.7 1711.7 5239.6 1013.5 4140.8,
 5613.6   1.9  14.0   91.8    0.4 101.2   24.3    6.6   10.3 5239.6   29.9   93.6,
 7916.4 241.7  25.3 2460.9  638.2 233.5  940.6  185.0 1556.9    0.0  765.3  868.8,
 4608.8 132.5  45.3  454.5  277.9  39.8   12.9  579.7   10.7    0.0   39.6 3015.8,
 1377.5 277.3  17.7  203.6    0.9  61.5   94.6  643.7   26.3    0.0   19.6   32.3,
 4998.7 232.1  35.1 3212.2  377.8 205.2  265.8  273.7  107.5    0.0  159.1  130.2
};

/* NATIONAL WEALTH SURVEY 1987 GROSS ( 1 bil ) */
w87g1={
400349.7  27210.9  2945.2 120844.0 18284.6 7929.8 21110.1 39327.0 24131.9 83010.8 19839.9 35715.5,
 90165.4     50.3   175.6   2251.4   418.9 1085.9   239.1   244.3  1107.8 83010.8   588.9   992.4,
101954.9  11544.7   273.9  32053.0  1735.1 2020.1 12972.9  3992.6 16505.4       0 12749.5  8107.7,
 64189.0   8035.8   905.4   9270.4  7095.5  116.0   634.1 12146.0   182.5       0  1071.7 24731.6,
 31499.8   3558.9   368.0   4266.8    69.7  753.3  2802.2 17501.5   974.6       0   684.3   520.5,
112540.6   4021.2  1222.3  73002.4  8965.4 3954.5  4461.8  5442.6  5361.6       0  4745.5  1363.3
};
```

```
/* NATIONAL WEALTH SURVEY 1987 NET ( 1 bil ) */
w87nl={
203194.5   9451.6  1265.0  54020.4  10805.2  3777.3  10592.5  18677.6  16565.3  41619.4  10125.7  26294.5,
 47188.8     28.7   131.5   1685.0    386.2  1109.3    129.0    193.3    847.4  41619.4    372.0    687.0,
 59032.6   3258.1   161.5  19224.7   1520.5  1398.2   6762.5   2573.7  11759.6        0   7061.7   5312.1,
 40957.1   3740.6   508.5   4432.8   4382.6    75.5    337.0   7180.2    106.5        0    570.8  19622.6,
 11770.4    762.8   118.7   1514.1     20.0   287.4   1367.7   6962.5    297.5        0    274.0    165.7,
 44245.6   1661.4   344.8  27163.8   4495.9   906.9   1996.3   1767.9   3554.3        0   1847.2    507.1
};

/* NATIONAL WEALTH SURVEY 1997 GROSS ( 1 bil ) */
w97gl={
2455413.8  95375.1  3822    729694.5 100435.6  83962.8 210397.6 169714.8  98747.3 485026.4 164097.2 314140.5,
 527134.6   2790.7   136.6    7548.3    688.3  16935.1   1747.2    422       664.9 485026.4   5819.8   5355.3,
 425219.7  47627.1   363.4  116910.3   3039.8   7491.2  70979.7  10350.6  35974.8        0  85033.3  47449.5,
 576589.1  14286.3  1040.1  151299.3  51877.4  35299.3  10069.3  58573.3   9144          0  20268.1 224732  ,
 156929    11195.6   975.8   15035.1    716.8   9150.1  37383    67384.9   4464.8        0   4363.1   6259.8,
 769541.4  19475.4  1306.1  438901.5  44113.3  15087.1  90218.4  32984     48498.8        0  48612.9  30343.9
};
/* NATIONAL WEALTH SURVEY 1997 NET ( 1 bil ) */
w97nl={
1301916.8  47390.8  1221.7  310270.3  55797.1  63087.8 112691.4  64917.9  55896.4 273742.5  98527.8 218373.1,
 305436.7   1441.5    77.3    5222.6    451.5  14659.9   1100.2    235.9    498.3 273742.5   4499.3   3507.7,
 283868.2  29169.9   195.5   76496.4   2126.9   5485.5  50051.3   7150.5  25232.5        0  57982.9  29976.8,
 380855.5   6137.2   383.1   89193.3  34441.3  35142.7   7115.3  15131.4   8326          0  15522   169463.2,
  64849.4   2744.4   239.9    4842.9    196.4   3379.7  17368.2  29133.5   1720.7        0   2856.3   2367.4,
 266907     7897.8   325.9  134515.1  18581     4420    37056.4  13266.6  20118.9        0  17667.3  13058
};


/** Data Adjustment 68unit : mil=>bil **/
w68gl=w68gl/1000;  w68nl=w68nl/1000;

/'금융보험부동산'=금융보험부동산+주택: 주택부문을 금융보험부동산업에 포함시킴'/
w68gl[,9]=w68gl[,9]+w68gl[,10]; w68gl=w68gl[,1:9]||w68gl[,11:12];
w68nl[,9]=w68nl[,9]+w68nl[,10]; w68nl=w68nl[,1:9]||w68nl[,11:12];
w77gl[,9]=w77gl[,9]+w77gl[,10]; w77gl=w77gl[,1:9]||w77gl[,11:12];
w77nl[,9]=w77nl[,9]+w77nl[,10]; w77nl=w77nl[,1:9]||w77nl[,11:12];
w87gl[,9]=w87gl[,9]+w87gl[,10]; w87gl=w87gl[,1:9]||w87gl[,11:12];
w87nl[,9]=w87nl[,9]+w87nl[,10]; w87nl=w87nl[,1:9]||w87nl[,11:12];
w97gl[,9]=w97gl[,9]+w97gl[,10]; w97gl=w97gl[,1:9]||w97gl[,11:12];
w97nl[,9]=w97nl[,9]+w97nl[,10]; w97nl=w97nl[,1:9]||w97nl[,11:12];


/* LINEAR PROJECTION between BENCHMARK YEARS (INVESTMENT) */1)d
start proj(a,b,c,d);   ----proj(사용자가 임의 지정)라는 module시작Ⓐ와 연결
    n=d-c;
    r1=a[1]/a[,+]; →초기 기준년도 서비스업의 비율, a(,+)→열합
    r2=b[1]/b[,+]; →후기 기준년도 서비스업의 비율, a(,+)→열합
    df=(r2-r1)/n; /* COMPUTING THE AVERAGE DIFFERENCE */ →직선보간식
    w=do(r1,r2,df)`; →등차수열(초항, 말항, 공차)
return(w);
finish;
```

1) 투자자료의 정부부분을 국부의 정부(정부편), 민간(종합편 정부-정부편 정부)의 비율에 따라 배분하여 계산후 다시 합침 *민간은 서비스업을 의미

```
w6877gl=proj(w68gl[1,10:11],w77gl[1,10:11],1968,1977);  ┐ w6877gl=proj(a,b,c,d);
w6877nl=proj(w68nl[1,10:11],w77nl[1,10:11],1968,1977);  │
w7787gl=proj(w77gl[1,10:11],w87gl[1,10:11],1977,1987);  │
w7787nl=proj(w77nl[1,10:11],w87nl[1,10:11],1977,1987);  │ Ⓐ
w8797gl=proj(w87gl[1,10:11],w97gl[1,10:11],1987,1997);  │
w8797nl=proj(w87nl[1,10:11],w97nl[1,10:11],1987,1997);  ┘

wg=w6877gl//w7787gl[2:10]//w8797gl[2:10]//w8797gl[10]//w8797gl[10]; /*참고 #1*/
wn=w6877nl//w7787nl[2:10]//w8797nl[2:10]//w8797nl[10]//w8797nl[10]; /*경상에 대해*/


ii95cl[,4]=ii95cl[,4]-ic95cl[,9]; /*산업별 불변투자자료 농림어업에서 자산별 투자자료 낙농축부분을 제거*/
ii70nl[,4]=ii70nl[,4]-ic70nl[,9]; /*경상에 대해*/

ii95cl[,13]=ii95cl[,12]+ii95cl[,13]+ii95cl[,14]+ii95cl[,15]; /*불변투자 정부부분을 사회서비스와 합침*/
ii70nl[,13]=ii70nl[,12]+ii70nl[,13]+ii70nl[,14]+ii70nl[,15]; /*경상에 대해*/

ii95cl[,12]=ii95cl[,13]#wg;     /*민간=(정부+민간)행렬의 원소와 wg행렬의 원소끼리의 곱=>원소곱*/
ii70nl[,12]=ii70nl[,13]#wn;     /*경상에 대해*/

ii95cl[,13]=ii95cl[,13]#(1-wg);/*정부=(정부+민간)행렬의 원소와 (1-wg)행렬의 원소끼리의 곱*/
ii70nl[,13]=ii70nl[,13]#(1-wn);/*경상에 대해*/

ii95cl=ii95cl[,1:2]||ii95cl[,4:13]; /*ii95cl(,3)은 산업소계이므로 제거후 행렬 좌우 병합(||)*/
ii70nl=ii70nl[,1:2]||ii70nl[,4:13]; /*경상에 대해*/

ii95cl[,2]=ii95cl[,3:ncol(ii95cl)][,+];/*ii95cl(,2)은 총계이므로 3열부터 끝까지 새로 합침*/
ii70nl[,2]=ii70nl[,3:ncol(ii70nl)][,+];/*경상에 대해*/


/** Computing DEFLATORS by (NOMINAL/CONSTANT) **/
def95=ii70nl[,1]||ii70nl[,2:ncol(ii70nl)]/ii95cl[,2:ncol(ii95cl)];

/*
print " Deflator 1995", def95; /*참고 #2*/
*/

/** Change NATIONAL WEALTH CAPITAL STOCK DATA in CURRENT PRICES into those in 1995 CONSTANT PRICES **/

w68gc=w68gl#(1/def95[1,2:12]);[2]
w68nc=w68nl#(1/def95[1,2:12]);
w68gc[,1]=(w68gc[,2:ncol(w68gc)][,+]); /*총합 재조정*/
w68nc[,1]=(w68nc[,2:ncol(w68nc)][,+]); /*경상에 대해*/

w77gc=w77gl#(1/def95[10,2:12]);
w77nc=w77nl#(1/def95[10,2:12]);
w77gc[,1]=(w77gc[,2:ncol(w77gc)][,+]);
w77nc[,1]=(w77nc[,2:ncol(w77nc)][,+]);
```

---

2) 경상을 디플로 나누어서 불변화 ⇔ 경상을 디플의 역수를 곱하여 불변화
(원소곱은 행 또는 열만 일치하면 되지만 원소나누기는 행과 열이 모두 같아야 하므로 원소곱으로 하는 것이 수월함)

```
w87gc=w87gl#(1/def95[20,2:12]);
w87nc=w87nl#(1/def95[20,2:12]);
w87gc[,1]=(w87gc[,2:ncol(w87gc)][,+]);
w87nc[,1]=(w87nc[,2:ncol(w87nc)][,+]);

w97gc=w97gl#(1/def95[30,2:12]);
w97nc=w97nl#(1/def95[30,2:12]);
w97gc[,1]=(w97gc[,2:ncol(w97gc)][,+]);
w97nc[,1]=(w97nc[,2:ncol(w97nc)][,+]);

print "'68 GROSS & NET", w68gc, w68nc;
print "'77 GROSS & NET", w77gc, w77nc;
print "'87 GROSS & NET", w87gc, w87nc;
print "'97 GROSS & NET", w97gc, w97nc;

/** Computing 'd'(폐기율) & 'r'(감가율) **/
/*투자자료를 69-77(2nd~10th row),78-87(11th~20th row),88-97(21th~30th row),98-99(31th~32th row) 로 분할*/
i1c=ii95c1[02:10,]; /* INVESTMENT 1969-1977 */
i2c=ii95c1[11:20,]; /* INVESTMENT 1978-1987 */
i3c=ii95c1[21:30,]; /* INVESTMENT 1988-1997 */
i4c=ii95c1[31:32,]; /* INVESTMENT 1998-1999 */
```

참고#3

```
/*****************************************************************************
************     PROCEDURE TO GET A DEPRECIATON RATE       *****************
************      < input >                                 *****************
************   1. a: 1st benchmark year capital stock(1*k)  *****************
************   2. b: 2nd benchmark year capital stock(1*k)  *****************
************   3. c: series of investent(a+1||b) (n*k)     *****************
************      < formula >                               *****************
************   y(z)=a*z^n+c(1)*z^(n-1)+...+c(n)-b           *****************
************   z=1-d  : 'd(n*k)' is what you will get.       *****************
************        - this contains only real numbers.      *****************
************          imaginary solutions appear as '0's'   *****************
*****************************************************************************/
start depr(a,b,c);              ----depr(사용자가 임의 지정)이라는 module시작. ⓑ와 연결
   n=nrow(c);                   /*투자계열수*/
   k=ncol(c);                   /*산업의 수 */
   c[n,]=c[n,]-b;               /*투자-스톡*/
   ds=a//c;                     /*n차 방정식의 계수 부분*/
   d=j(n,2*k,0);                /*j는  n(=투자계열수)×2k(=2산업의수) 원소가 모두0(반드시 숫자로 지정)인
                                 행렬을 생성하는 SAS IML에서의 함수*/

   i=1;
   do until (i>k);  /*i가 k보다 클때까지, 11까지 즉 11번 반복하라*/
   dsi=ds[,i];
   di=polyroot(dsi);
   di[,1]=1-di[,1]; /*if 2nd=0 then 실근*/
   d[,2*i-1:2*i]=di;
   i=i+1;
   end;

return(d);
finish;                          ----depr module끝
```

```
r1=depr(w68gc[1,],w77gc[1,],i1c[,2:12]);─┐ⓑ r1= depr(a,b,c)3)
d1=depr(w68nc[1,],w77nc[1,],i1c[,2:12]);  │
r2=depr(w77gc[1,],w87gc[1,],i2c[,2:12]);  │
d2=depr(w77nc[1,],w87nc[1,],i2c[,2:12]);  │
r3=depr(w87gc[1,],w97gc[1,],i3c[,2:12]);  │
d3=depr(w87nc[1,],w97nc[1,],i3c[,2:12]);─┘

print "1ST GROSS" r1;  /*참고 #4*/
  print "1ST NET" d1;
print "2ND GROSS" r2;
  print "2ND NET" d2;
print "3RD GROSS" r3;
  print "3RD NET" d3;


/** Computing CAPITAL STOCK for 1969-1976, 1978-1986, 1988-1996 **/
/** n차 방정식의 n개 근 가운데 어느 근을 이용할 것인가의 문제
    이 과정을 통해 실근이면서 절대값이 1보다 작은 경우만 해로 선택**/

start real(a);                        ----real module 시작 ©와 연결      이하 참고#5
    z=a=0;                        /* a행렬 원소가 0이면 1,그렇지 않으면 0로 하라*/ 4)
    c=z[,2:ncol(z)]||z[,1];  /* z행렬에서 1열을 맨뒤로*/
    d=a#c;
    z=abs(d)<1;                   /* d행렬 원소중 절대값이 1보다 작으면 1, 그렇지 않으면 0*/
    f=d#z;                        /* d행렬 원소중 절대값이 1보다 작은것의 계수 남음,그외 0*/

    s=f[+,];                      /* f행렬 열끼리의 합*/
    r=s[,1]||s[,3]||s[,5]||s[,7]||s[,9]||s[,11]||s[,13]||s[,15]||s[,17]||s[,19]||s[,21];
    /** 홀수번째 열은 실수부분, 짝수번째 열은 허수부분이므로 홀수열만 취한다. **/

return(r);
finish;                               ----real module 끝

rr1=real(r1);─┐©
dd1=real(d1);  │
rr2=real(r2);  │
dd2=real(d2);  │
rr3=real(r3);  │
dd3=real(d3);─┘
```

3) a=>초기기준년 산업별 총스톡(here w68gc[1,],68년), b=>후기기준년 산업별 총스톡(here w77gc[1,],77년), c=>양기준년 사이의 산업별 투자치(i1c[,2:12])

4) 논리연산자가 두 개로 되어있는 경우 두 번째 연산자(a=0)가 참이면 1로 주고 거짓이면 0으로 하여 처음에 지정되어 있는 행렬(z)를 만들어라.

```
/*******************************************************************************
************      COMPUTIONG CAPITAL STOCKS OF INDUSTRIES       ***************
************         BETWEEN BENCHMARK YEARS                     ***************
************      < input >                                      ***************
************      1. a: 1st benchmark year capital stock (1*k)   ***************
************      2. b: series of investment data (n*k+1)-year   ***************
************             'a||a+n-1' years data                   ***************
************      3. c: series of depreciation data (1*k)        ***************
************      < output >                                     ***************
************      d : (n-1*k+1) of capital stock of each year    ***************
*******************************************************************************/
start stock(a,b,c); /*stock라는 module 이용하여 69-76, 78-86, 88-96의 스톡추계*/
    f=b[,2:ncol(b)];
    n=nrow(f);k=ncol(f);
    d=a[1,]//j(n-1,k,0);e=j(1,k,1)-c;    예)w69=w68(1-r) + I69

    i=1;
    do until (i>n-1);
    d[i+1,]=d[i,]#e+f[i,];
    i=i+1;
    end;

d=b[1:n-1,1]||d[2:n,];
return(d);
finish;


/*******************************************************************************
************      PROCEDURE TO GET A CAPITAL STOCK SERIES(1)     ***************
************      < input >                                      ***************
************      1. a: base year capital stock (1*k)            ***************
************      2. b: series of investment after 'a' (n*k+1)   ***************
************      3. c: series of depresiation rate or retire-   ***************
************            ment rate (1*k)                          ***************
************      < output >                                     ***************
************       d: (n*k+1) matrix of capital stock (a+1~ )    ***************
*******************************************************************************/
start cap1(a,b,c);   ---------cap1이라는 module이용하여 98-99 스톡 추계
    n=nrow(b);k=ncol(b)-1;
    d=a[1,]//j(n,k,0);
    c1=c>0;
    r=c1#c; /* c1>0 contains 0&1, where 1 means it is true */
    b1=b[,2:ncol(b)];

    i=1;
    do until (i>n);
    d[i+1,]=b1[i,]+(j(1,ncol(r))-r)#d[i,];
    i=i+1;
    end;

d=b[,1]||d[2:n+1,];
return(d);
finish;
```

```
stc6976g=stock(w68gc,i1c,rr1); /* Computing GROSS CAPITAL STOCK 1969-1976 */
stc6976n=stock(w68nc,i1c,dd1); /*           NET                           */

stc7886g=stock(w77gc,i2c,rr2); /*           GROSS               1978-1986 */
stc7886n=stock(w77nc,i2c,dd2); /*           NET                           */

stc8896g=stock(w87gc,i3c,rr3); /*           GROSS               1988-1996 */
stc8896n=stock(w87nc,i3c,dd3); /*           NET                           */

stc9899g= capl(w97gc,i4c,rr3); /*           GROSS               1998-1999 */
stc9899n= capl(w97nc,i4c,dd3); /*           NET                           */

stn6976g=stc6976g[,1]||stc6976g[,2:12]#def95[2:9,2:ncol(def95)];
stn6976n=stc6976n[,1]||stc6976n[,2:12]#def95[2:9,2:ncol(def95)];
stn7886g=stc7886g[,1]||stc7886g[,2:12]#def95[11:19,2:ncol(def95)];
stn7886n=stc7886n[,1]||stc7886n[,2:12]#def95[11:19,2:ncol(def95)];
stn8896g=stc8896g[,1]||stc8896g[,2:12]#def95[21:29,2:ncol(def95)];
stn8896n=stc8896n[,1]||stc8896n[,2:12]#def95[21:29,2:ncol(def95)];
stn9899g=stc9899g[,1]||stc9899g[,2:12]#def95[31:32,2:ncol(def95)];
stn9899n=stc9899n[,1]||stc9899n[,2:12]#def95[31:32,2:ncol(def95)];

stn9899g=stc9899g[,1]||capl(w97gl,i4c,rr3)[,2:12];5)
stn9899n=stc9899n[,1]||capl(w97nl,i4c,dd3)[,2:12]; /*순자산의 경우*/


/*print "CAPITAL STOCK BETWEEN BENCHMARK YEARS";
print "1ST PERIOD GROSS", stc6976g;
print "1ST PERIOD NET", stc6976n;
print "2ND PERIOD GROSS", stc7886g;
print "2ND PERIOD NET", stc7886n;
print "3RD PERIOD GROSS", stc8896g;
print "3RD PERIOD NET", stc8896n;
print "4TH PERIOD GROSS", stc9899g;
print "4TH PERIOD NET", stc9899n; */


/*------------------------ 1995 CONSTANT PRICES --------------------------*/
/*--- 1. GROSS ---*/
c_grossi=(1968||w68gc[1,])//stc6976g//(1977||w77gc[1,])//stc7886g;
c_grossi=c_grossi//(1987||w87gc[1,])//stc8896g//(1997||w97gc[1,])//stc9899g;6)
c_grossi[,2]=(c_grossi[,3:ncol(c_grossi)][,+]);   /*연도별 산업총계를 다시 계산*/

print "GROSS 1968-1999 IN 1995 CONSTANT PRICES", c_grossi;          결과표#15

/*--- 2. NET ---*/
c_neti=(1968||w68nc[1,])//stc6976n//(1977||w77nc[1,])//stc7886n;
c_neti=c_neti//(1987||w87nc[1,])//stc8896n//(1997||w97nc[1,])//stc9899n;
c_neti[,2]=(c_neti[,3:ncol(c_neti)][,+]);

print "NET 1968-1999 IN 1995 CONSTANT PRICES", c_neti;              결과표#17
```

5) 98, 99년 경상가격으로 환산은 불변값에 디플레이터를 곱하는 것이 아니라 $W_{98} = (1-r)W_{97} + I_{98}$(=불변투자액)으로 계산함에 유의

6) 각년도 68, 69-76, 77, 78-86, 87, 88-96, 97, 98-99년을 위아래로 합침

```
/*---------------------------- CURRENT PRICES ----------------------------*/
/*--- 1. GROSS ---*/
n_grossi=(1968||w68gl[1,])//stn6976g//(1977||w77gl[1,])//stn7886g;
n_grossi=n_grossi//(1987||w87gl[1,])//stn8896g//(1997||w97gl[1,])//stn9899g;
n_grossi[,2]=(n_grossi[,3:ncol(n_grossi)][,+]);

print "GROSS 1968-1999 IN CURRENT PRICES", n_grossi;                결과표#16

/*--- 2. NET ---*/
n_neti=(1968||w68nl[1,])//stn6976n//(1977||w77nl[1,])//stn7886n;
n_neti=n_neti//(1987||w87nl[1,])//stn8896n//(1997||w97nl[1,])//stn9899n;
n_neti[,2]=(n_neti[,3:ncol(n_neti)][,+]);

print "NET 1968-1999 IN CURRENT PRICES", n_neti;                    결과표#18

/*****************************************
********    TYPE OF CAPITAL    *********
*****************************************/
/* 기준년의 자산별 스톡 구하기=>기준년 산업의 값을 국부의(자산×산업표)의 구성비를 이용하여 배분*/
/* Making CAPITAL STOCKS by TYPES OF CAPITAL STOCK */
/* LINEAR PROJECTION between BENCHMARK YEARS */
/**************************************************************************
************      PROCEDURE FOR LINEAR INTERPOLATION          ***************
************   - interpolate ratios between benchmark years   ***************
************     < input >                                    ***************
************     1. a: 1st base year capital stock (k*i)      ***************
************          k - types of capital                    ***************
************          i - industries                          ***************
************     2. b: 2nd base year capital stock (k*i)      ***************
************     3. c: year of "a"                            ***************
************     4. d: year of "b"                            ***************
************     5. e: generated capital stocks between       ***************
************        benchmark years (d-c*i+1)-indust. totals ***************
************     < output >                                   ***************
************ ei:ith indus. capital stock by types of capital ***************
************       between benchmark years(row:year,col.:type)***************
**************************************************************************/
start projl(a,b,c,d,e);
   n=d-c;k=nrow(a);il=ncol(a);
   rl=a#(1/a[1,]);                 /*산업내에서 각 자산의 구성비, 참고 #6*/
   r2=b#(1/b[1,]);                 /* COMPUTING THE RATIO */
   dl=(r2-rl)/n;                   /* COMPUTING THE AVERAGE DIFFERENCE */
   e2=j(1,k+1,0);
   w=do(c+1,d-1,1);                /* CREATING THE 1ST COLUMN - YEAR */
   w=w`;

   j=1;                            /* `j` STANDS FOR INDUSTRY */
   do until (j>il);
      i=1;                         /* `i` STANDS FOR YEAR */
      el=j(n,k,0);el=rl[,j]`//el;
      do until (i>n);
      el[i+1,]=el[i,]+dl[,j]`;
      i=i+1;
      end;
```

```
    e2=e2//(w||e1[2:nrow(e1)-1,]);
    j=j+1;
    end;

 ee=e2[2:nrow(e2),2:ncol(e2)];
 es=e[,2:ncol(e)]; es=es`;
 sh=shape(es,1);    sh=sh`;

    i=1;
    do until (i>k);
    ee[,i]=ee[,i]#sh;
    i=i+1;
    end;

e2=e2[2:nrow(e2),1]||ee;
return(e2);
finish;
/*--- 1. 1969-1976 ---*/
st11=proj1(w68g1,w77g1,1968,1977,stn6976g);
st12=proj1(w68n1,w77n1,1968,1977,stn6976n);

/*
print "GROSS 1969-1976", st11; /* (8×5)×11행렬. 참고#7*/
print "NET 1969-1976", st12;
*/


/*--- 2. 1978-1986 ---*/
st21=proj1(w77g1,w87g1,1977,1987,stn7886g);
st22=proj1(w77n1,w87n1,1977,1987,stn7886n);

/*print "GROSS 1978-1986", st21;
print "NET 1978-1986", st22;*/


/*--- 3. 1988-1996 ---*/
st41=proj1(w87g1,w97g1,1987,1997,stn8896g);
st42=proj1(w87n1,w97n1,1987,1997,stn8896n);

/*print "GROSS 1988-1996", st41;
print "NET 1988-1996", st42;*/

/*--- 4. 1998-1999 ---*/
/* GROSS */
st_ra11=w97g1#(1/w97g1[1,]); /* ratio of capital types in 1997 */
temp11=j(1,nrow(w97g1)+1,0);

i=1;
do until (i>ncol(stn9899g)-1);
  stntem11=stn9899g[,i+1]*st_ra11[,i]`;
  stntem11=stn9899g[,1]||stntem11;
  temp11=temp11//stntem11;
  i=i+1;
end;
```

```
st51=templl[2:nrow(templl),];

/* NET */
st_ra22=w97nl#(1/w97nl[1,]); /* ratio of capital types in 1997 */
temp22=j(1,nrow(w97nl)+1,0);

i=1;
do until (i>ncol(stn9899n)-1);
  stntem22=stn9899n[,i+1]*st_ra22[,i]`;
  stntem22=stn9899n[,1]||stntem22;
  temp22=temp22//stntem22;
  i=i+1;
end;
st52=temp22[2:nrow(temp22),];

/*"GROSS 1998-1999" st51;
"NET 1998-1999" st52;*/


/***************************************************************************
************          PROCEDURE TO GET A TOTAL TABLES        ****************
************       < input >                                  ****************
************       1. a: capital stock series by both types and ****************
************             industries ((n*i)*(k+1))             ****************
************             n: year, i: industries, k: types     ****************
************       2. b: starting year                        ****************
************       3. c: finishing year                       ****************
************       < output >                                 ****************
************       d: (n*k) matrix of total capital stock     ****************
************          n: year, k: types of capital            ****************
***************************************************************************/
start total(a,b,c);
    n=c-b+1;
    k=ncol(a)-1;
    d=j(n,k,0);

    i=2;
    do until (i>nrow(a)/n);
    d=a[(i-1)*n+1:i*n,2:ncol(a)]+d;
    i=i+1;
end;

x=(a[1:n,1]||d);
return(x);
finish;


/* INDUSTRY TOTAL according to the TYPES OF CAPITAL STOCK */
t_6976gn=total(st11,1969,1976);
t_6976nn=total(st12,1969,1976);
t_7886gn=total(st21,1978,1986);
t_7886nn=total(st22,1978,1986);
t_8896gn=total(st41,1988,1996);
```

```
t_8896nn=total(st42,1988,1996);
t_9899gn=total(st51,1998,1999);
t_9899nn=total(st52,1998,1999);

/*
print "GROSS 69-76" t_6976gn;
print "NET 69-76" t_6976nn;
print "GROSS 78-86" t_7886gn;
print "NET 78-86" t_7886nn;
print "GROSS 88-96" t_8896gn;
print "NET 88-96" t_8896nn;
print "GROSS 98-99" t_9899gn;
print "NET 98-99" t_9899nn;
*/


/** Making a SERIES of CAPITAL STOCK by TYPES */
/* Connect the above DISCONTINUOUS SERIES by inserting NATIONAL WEALTH SURVEY DATA of 1968, 1977,
1987, 1997 */


/*------------------ CURRENT PRICES ------------------*/

/*--- 1. GROSS ---*/
n_grossc=(1968||w68gl[,1]`)//t_6976gn//(1977||w77gl[,1]`)//t_7886gn;
n_grossc=n_grossc//(1987||w87gl[,1]`)//t_8896gn//(1997||w97gl[,1]`)//t_9899gn;
n_grossc[,2]=(n_grossc[,3:ncol(n_grossc)][,+]);

/*--- 2. NET ---*/
n_netc=(1968||w68nl[,1]`)//t_6976nn//(1977||w77nl[,1]`)//t_7886nn;
n_netc=n_netc//(1987||w87nl[,1]`)//t_8896nn//(1997||w97nl[,1]`)//t_9899nn;
n_netc[,2]=(n_netc[,3:ncol(n_netc)][,+]);


/*------------- 1995 CONSTANT PRICES ---------------*/
/* Getting a RATIO to distribute the TOTAL into TYPES OF CAPITAL */

ra_gross=n_grossc[,2:ncol(n_grossc)]#(1/n_grossc[,2]);
ra_net=n_netc[,2:ncol(n_netc)]#(1/n_netc[,2]);


/*--- 1. GROSS ---*/
c_grossc=c_grossi[,1]||(c_grossi[,2]#ra_gross);

print "GROSS 1968-1999 IN 1995 CONSTANT PRICES", c_grossc;                    결과표#19

/*--- 2. NET ---*/
c_netc=c_neti[,1]||(c_neti[,2]#ra_net);

print "NET 1968-1999 IN 1995 CONSTANT PRICES", c_netc;                        결과표#21

/*--------------- CURRENT PRICES PRINT ---------------*/
print "GROSS 1968-1999 IN CURRENT PRICES", n_grossc;
print "NET 1968-1999 IN CURRENT PRICES", n_netc;
```

```
/******************************************************************************
*****************          MANUFACTURING SECTOR          *******************
******************************************************************************/

/*      Manufacturing - 23 Sectors - National Wealth Survey      */
/*      68GRSS    68NET    77GRSS    77NET    87GRSS    87NET    97GRSS    97NET */
/*   (23개 중분류*3개 자산형태)×기준년 총및순자산액, 참고#8*/
m_data={
제 ┌건물   60.8   34.6   510.2   273.2   4541.7   2047.7   14521.7   9250.1,
조 │기계   36.4   15.7   420.3   172.3   4560.3   1690.7   21510.0   6547.1,
1  └운반    4.1    2.0    70.5    34.7    427.5    164.2    3234.3    820.2,
제 ┌건물   19.5    7.7    10.8     8.3    348.1    215.5      72.3     40.5,
조 │기계    4.9    3.4     9.2     5.3    179.9    161.8      23.3      3.3,
2  └운반    0.1    0.1     0.3     0.2      5.9      4.7       0.4      0.1,
     ≀     38.0   28.3   597.6   426.6   5175.8   2617.1   15898.0   7480.2,
          100.5   46.4  1271.7   602.3  11556.5   3322.0   29146.3   7587.4,
     ≀      1.4    0.7    38.4    18.1    423.4    138.6     668.1    136.9,
            5.5    4.0   113.7    78.0    982.0    588.4    2098.8   1273.3,
            3.9    2.3   146.0    60.1    785.8    307.2    2250.0    733.8,
            0.3    0.1     8.4     4.9    102.8     54.1     347.5    155.7,
            2.4    1.7    37.2    27.7   1093.7    696.7    1530.6    902.1,
            4.8    2.3    94.0    44.8   1627.3    599.4    1259.3    429.0,
            0.2    0.1     3.3     1.7     68.9     30.8     146.2     62.9,
           10.2    6.3    99.9    54.8    302.1    147.7    1774.4   1085.6,
           26.4    6.2   138.7    42.9    438.9    129.1    1892.2    663.3,
            3.9    0.7    24.4    11.6    164.6     27.4     284.0     94.9,
            5.2    3.8    66.2    45.6    785.6    437.9    6487.0   4061.6,
           20.1    7.6   159.2    89.5   1812.7    639.0   17666.2   5854.5,
            0.3    0.2     7.9     4.0     81.5     37.9     316.0    112.5,
           11.0    4.3    94.4    48.9    467.4    276.5    2723.7   1880.1,
           11.9    6.1   173.8    58.5   1071.3    357.4    5740.5   2413.9,
            0.6    0.3     6.3     3.2     73.9     36.6     283.8    119.8,
           15.2   12.7    96.6    63.1   1865.0   1041.4    7195.2   5512.9,
           13.9    6.8   278.4   134.2   1264.9    239.9   20620.0  11130.3,
            2.2    1.6    21.7     9.6     98.1     21.5      97.3     34.0,
           28.6   24.8   382.9   311.2   3692.2   2420.5   27157.4  21006.9,
           77.6   46.9   562.2   267.1   7791.0   2532.7   52231.3  16271.0,
            2.0    1.2    31.3    15.2    214.5     93.8     625.1    248.9,
            3.0    2.3    73.2    46.5    752.9    432.0    6548.3   4539.1,
            7.5    4.0   191.7    85.7   1516.4    592.0   13645.2   4829.1,
            0.2    0.1     7.9     4.3     87.5     46.3     439.5    177.0,
           25.6   20.1   264.2   183.8   4649.8   2508.8   16604.5   1321.3,
           42.9   22.9   421.3   213.3   7049.1   2001.7   34913.0  10323.0,
            4.5    2.1    68.9    33.6   1275.8    311.7    1773.0    530.6,
           13.6   11.9   865.3   773.2   5257.1   2984.1   30242.3  23818.0,
           20.7   12.8   901.8   601.4   9717.2   4215.0   49374.0  13136.5,
            1.0    0.6    28.3    12.6    253.4     78.0     558.6    165.2,
            4.4    3.3   107.1    69.1   1303.4    745.2   10154.5   6569.4,
            6.5    3.6   188.1    94.4   1840.0    723.7   14417.2   5061.6,
            0.3    0.2    14.0     8.3    140.5     63.1    1175.1    452.3,
            6.3    3.7   163.6   121.7   3053.6   1889.1   15001.1   8463.3,
            8.3    4.3   338.3   190.9   6141.9   2064.3   26169.6   9335.6,
            0.2    0.1    25.6    16.4    223.6    118.4    1492.3    525.8,
            1.3    1.1    70.9    55.5   1718.5   1202.1     760.2    565.0,
```

```
        2.4     1.6    146.5    79.0   3355.3  1729.2   1286.9   460.8,
        0.2     0.1      4.0     2.4     84.9    45.0     63.5    31.9,
        0.9     0.7     46.1    36.1   1117.0   781.4   4160.1  2862.2,
        1.5     1.0     95.2    51.3   2181.0  1124.0   8625.3  3066.2,
        0.1     0.1      2.6     1.5     55.2    29.3    360.6   156.7,
        1.1     1.0     60.2    47.2   1460.7  1021.8  15188.3 12209.2,
        2.0     1.3    124.5    67.1   2852.0  1469.8  42959.9 17216.3,
        0.1     0.1      3.4     2.0     72.2    38.3    439.8   202.7,
        0.6     0.5     14.5     8.2    241.9   155.1   1292.0   883.3,
        0.8     0.5     14.8     7.2    315.5   140.6   1759.0   655.8,
        0.0     0.0      1.2     0.6     22.6    12.2    124.5    50.3,
       11.2     7.2    178.6   151.0   2710.0  1808.7  17269.5 12510.0,
       10.7     6.3    318.8   178.0   4169.5  1892.2  32737.2 10847.6,
        1.0     0.3     19.8     9.2    198.0    76.3   1026.1   233.8,
        5.5     3.6     88.0    74.4   1334.8   890.9  75132.7 30490.2,
        5.2     3.1    157.0    87.7   2053.6   932.0  55821.5  5423.6,
        0.5     0.2      9.8     4.5     97.5    37.6   1011.5   181.4,
        5.0     3.7     67.7    44.8    718.7   432.0   3766.6  2514.4,
        2.8     1.8     63.0    37.2    720.0   298.9   4532.2  1265.5,
        0.2     0.1      7.7     4.9     93.2    47.7    509.1   210.0,
        0.0     0.0      0.0     0.0      0.0     0.0    178.6   139.9,
        0.0     0.0      0.0     0.0      0.0     0.0    221.4   110.8,
        0.0     0.0      0.0     0.0      0.0     0.0     58.7    23.8
};

/* SHARE OF TYPES in all SHARE across all SECTORS */
m_w68g=shape(m_data[,1]`,23,3)`;   /*행렬의 모양을 변화시킴. (m_data 1st열)`을 (23by3)`행렬로 변환*/
r1_w68g=(m_w68g[,+]/m_w68g[+])`;   /*각 자산의 전체자산에 대한 비율*/
r2_w68g=m_w68g#(1/m_w68g[,+]);     /*제조업중분류별 자산의 해당 전체 자산에 대한 비율*/
m_w68n=shape(m_data[,2]`,23,3)`;   /*2nd열에 대하여*/
r1_w68n=(m_w68n[,+]/m_w68n[+])`;
r2_w68n=m_w68n#(1/m_w68n[,+]);

m_w77g=shape(m_data[,3]`,23,3)`;   /*3rd열*/
r1_w77g=(m_w77g[,+]/m_w77g[+])`;
r2_w77g=m_w77g#(1/m_w77g[,+]);
m_w77n=shape(m_data[,4]`,23,3)`;   /*4th열*/
r1_w77n=(m_w77n[,+]/m_w77n[+])`;
r2_w77n=m_w77n#(1/m_w77n[,+]);

m_w87g=shape(m_data[,5]`,23,3)`;   /*5th열*/
r1_w87g=(m_w87g[,+]/m_w87g[+])`;
r2_w87g=m_w87g#(1/m_w87g[,+]);
m_w87n=shape(m_data[,6]`,23,3)`;   /*6th열*/
r1_w87n=(m_w87n[,+]/m_w87n[+])`;
r2_w87n=m_w87n#(1/m_w87n[,+]);

m_w97g=shape(m_data[,7]`,23,3)`;   /*7th열*/
r1_w97g=(m_w97g[,+]/m_w97g[+])`;
r2_w97g=m_w97g#(1/m_w97g[,+]);
m_w97n=shape(m_data[,8]`,23,3)`;   /*8th열*/
r1_w97n=(m_w97n[,+]/m_w97n[+])`;
r2_w97n=m_w97n#(1/m_w97n[,+]);
```

/** Computing RATIOS & CAPITAL STOCKS both by BY TYPES & BY SECTORS **/

```
/****************************************************************************
************ PROCEDURE FOR LINEAR INTERPOLATION(직선보간)     ****************
************   -in types, ratio interpolation                ****************
************     < input >                                   ****************
************     1. a: 1st base year capital stock ratio(1*k) ****************
************           k - types of capital(3)               ****************
************     2. b: 2nd base year capital stock (1*k)     ****************
************     3. c: year of "a"                           ****************
************     4. d: year of "b"                           ****************
************     5. e,f: generated capital stocks between    ****************
************          benchmark years (d-c*1+1)-indust. totals ****************
************     < output >                                  ****************
************     e2: ratio of capital by types between c & d ****************
************        nrow:years, ncol:types  (d-c*4)          ****************
************     e3: capital by types                        ****************
****************************************************************************/
start proj31(a,b,c,d,e,f);                         -------------------------ⓓ와 연결
    n=d-c;k=ncol(a);
    d1=(b-a)/n;                /* COMPUTING THE AVERAGE DIFFERENCE */
    i=1;                          /* `i` STANDS FOR YEAR */
    e1=a//j(n,k,0);
    do until (i>n);
        e1[i+1,]=e1[i,]+d1;
        i=i+1;
    end;
    e2=e1#e[,5];
              /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e3=e1#f[,5];   /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e1=e[,1]||e1;e2=e[,1]||e2;e3=f[,1]||e3;
return(e1);
finish;

start proj32(a,b,c,d,e,f);                        -----------------------ⓔ(불변)와 연결
    n=d-c;k=ncol(a);
    d1=(b-a)/n;                /* COMPUTING THE AVERAGE DIFFERENCE */
    i=1;                          /* `i` STANDS FOR YEAR */
    e1=a//j(n,k,0);
    do until (i>n);
        e1[i+1,]=e1[i,]+d1;
        i=i+1;
    end;
    e2=e1#e[,5];   /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e3=e1#f[,5];   /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e1=e[,1]||e1;e2=e[,1]||e2;e3=f[,1]||e3;
return(e2);
finish;

start proj33(a,b,c,d,e,f);                        ------------------------ⓕ(경상)와 연결
    n=d-c;k=ncol(a);
    d1=(b-a)/n;                /* COMPUTING THE AVERAGE DIFFERENCE */
    i=1;                          /* `i` STANDS FOR YEAR */
    e1=a//j(n,k,0);
    do until (i>n);
        e1[i+1,]=e1[i,]+d1;
        i=i+1;
    end;
```

```
    e2=e1#e[,5];    /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e3=e1#f[,5];    /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
    e1=e[,1]||e1;e2=e[,1]||e2;e3=f[,1]||e3;
return(e3);
finish;

/* ------ 1.1968-1997 ------- */
/* Computing the 3 RATIOS between BENCHMARK YEARS by LINEAR INTERPOLATION */
r1_6877g=proj31(r1_w68g,r1_w77g,1968,1977,c_grossi[1:10,],n_grossi[1:10,]);  ┐ Ⓓ각 자산의 전체에 대한 연도별 비율
r1_6877n=proj31(r1_w68n,r1_w77n,1968,1977,c_neti[1:10,],n_neti[1:10,]);
r1_7787g=proj31(r1_w77g,r1_w87g,1977,1987,c_grossi[10:20,],n_grossi[10:20,]);
r1_7787n=proj31(r1_w77n,r1_w87n,1977,1987,c_neti[10:20,],n_neti[10:20,]);
r1_8797g=proj31(r1_w87g,r1_w97g,1987,1997,c_grossi[20:30,],n_grossi[20:30,]);
r1_8797n=proj31(r1_w87n,r1_w97n,1987,1997,c_neti[20:30,],n_neti[20:30,]);     ┘

m_6877gc=proj32(r1_w68g,r1_w77g,1968,1977,c_grossi[1:10,],n_grossi[1:10,]);  ┐ Ⓔ
m_6877nc=proj32(r1_w68n,r1_w77n,1968,1977,c_neti[1:10,],n_neti[1:10,]);
m_7787gc=proj32(r1_w77g,r1_w87g,1977,1987,c_grossi[10:20,],n_grossi[10:20,]);
m_7787nc=proj32(r1_w77n,r1_w87n,1977,1987,c_neti[10:20,],n_neti[10:20,]);
m_8797gc=proj32(r1_w87g,r1_w97g,1987,1997,c_grossi[20:30,],n_grossi[20:30,]);
m_8797nc=proj32(r1_w87n,r1_w97n,1987,1997,c_neti[20:30,],n_neti[20:30,]);     ┘

m_6877gn=proj33(r1_w68g,r1_w77g,1968,1977,c_grossi[1:10,],n_grossi[1:10,]);  ┐ Ⓕ
m_6877nn=proj33(r1_w68n,r1_w77n,1968,1977,c_neti[1:10,],n_neti[1:10,]);
m_7787gn=proj33(r1_w77g,r1_w87g,1977,1987,c_grossi[10:20,],n_grossi[10:20,]);
m_7787nn=proj33(r1_w77n,r1_w87n,1977,1987,c_neti[10:20,],n_neti[10:20,]);
m_8797gn=proj33(r1_w87g,r1_w97g,1987,1997,c_grossi[20:30,],n_grossi[20:30,]);
m_8797nn=proj33(r1_w87n,r1_w97n,1987,1997,c_neti[20:30,],n_neti[20:30,]);     ┘


/* RATIOS 합침*/
r1_6897g=r1_6877g[1:nrow(r1_6877g)-1,]//r1_7787g[1:nrow(r1_7787g)-1,]//r1_8797g;
r1_6897n=r1_6877n[1:nrow(r1_6877n)-1,]//r1_7787n[1:nrow(r1_7787n)-1,]//r1_8797n;

/* CAPITAL STOCKS 합침*/
m_6897gc=m_6877gc[1:nrow(m_6877gc)-1,]//m_7787gc[1:nrow(m_7787gc)-1,]//m_8797gc;
m_6897nc=m_6877nc[1:nrow(m_6877nc)-1,]//m_7787nc[1:nrow(m_7787nc)-1,]//m_8797nc;
m_6897gn=m_6877gn[1:nrow(m_6877gn)-1,]//m_7787gn[1:nrow(m_7787gn)-1,]//m_8797gn;
m_6897nn=m_6877nn[1:nrow(m_6877nn)-1,]//m_7787nn[1:nrow(m_7787nn)-1,]//m_8797nn;


/*************************************************************************
************         PROCEDURE FOR LINEAR INTERPOLATION        ***************
************   -in manufacturing sectors, ratio interpolation ***************
************    < input >                                      ***************
************    1. a: 1st base year capital stock ratio(k*i)   ***************
************          k - types of capital(3)                  ***************
************          i - sectors(28)                          ***************
************    2. b: 2nd base year capital stock (k*i)        ***************
************    3. c: year of "a"                              ***************
************    4. d: year of "b"                              ***************
************    5. e: generated capital stocks between         ***************
************         benchmark years (d-c*1+1)-indust. totals  ***************
```

```
************     < output >                                    ****************
************    e2:ith sector's ratio of capital by types      ****************
************       between benchmark years                     ****************
************       nrow:years, ncol:types & sectors            ****************
************    e3:ith sector's capital by types               ****************
******************************************************************************/

start proj2(a,b,c,d,e);
    n=d-c;k=nrow(a);i1=ncol(a);
    d1=(b-a)/n;                  /* COMPUTING THE AVERAGE DIFFERENCE */
    e2=j(n+1,1,0);e3=j(n+1,1,0);
    j=1;                         /* 'J' STANDS FOR INDUSTRY */
    do until (j>i1);
        i=1;                     /* 'I' STANDS FOR YEAR */
        e1=a[,j]`//j(n,k,0);
        do until (i>n);
            e1[i+1,]=e1[i,]+d1[,j]`;
            i=i+1;
        end;
        e2=e2||e1;               /* RATIOS */
        e3=e3||(e1#e[,5]);   /* CAPITAL STOCKS - 5TH COL. IS MANUFACTURING */
        j=j+1;
    end;
    e2[,1]=do(c,c+n,1)`;

return(e2);
finish;


r2_6877g=proj2(r2_w68g,r2_w77g,1968,1977,c_grossi[1:10,]);    /*제조업중분류별 각 자산에 대한 연도별 비율*/
r2_6877n=proj2(r2_w68n,r2_w77n,1968,1977,c_neti[1:10,]);
r2_7787g=proj2(r2_w77g,r2_w87g,1977,1987,c_grossi[10:20,]);
r2_7787n=proj2(r2_w77n,r2_w87n,1977,1987,c_neti[10:20,]);
r2_8797g=proj2(r2_w87g,r2_w97g,1987,1997,c_grossi[20:30,]);
r2_8797n=proj2(r2_w87n,r2_w97n,1987,1997,c_neti[20:30,]);


/* RATIOS */
r2_6897g=r2_6877g[1:nrow(r2_6877g)-1,]//r2_7787g[1:nrow(r2_7787g)-1,]//r2_8797g;
r2_6897n=r2_6877n[1:nrow(r2_6877n)-1,]//r2_7787n[1:nrow(r2_7787n)-1,]//r2_8797n;

/* CAPITAL STOCKS - COMPUTING : SHARE OF TYPES*RATIO B/W SECTORS*CAPITAL */
tt=j(1,23,1);
m_6897gc=m_6897gc[,1]||((tt@m_6897gc[,2:4])#r2_6897g[,2:70]); /* @means kronecker의 곱(直積). 참고#9*/
m_6897nc=m_6897nc[,1]||((tt@m_6897nc[,2:4])#r2_6897n[,2:70]);
m_6897gn=m_6897gn[,1]||((tt@m_6897gn[,2:4])#r2_6897g[,2:70]);
m_6897nn=m_6897nn[,1]||((tt@m_6897nn[,2:4])#r2_6897n[,2:70]);

/*------ 2.1998-1999 -------*/
/* FOR THIS PERIOD, WE USE THE RATIO OF 1997 NATIONAL WEALTH SURVEY */
ra_9899g=(tt@r1_6897g[30,2:4])#r2_6897g[30,2:ncol(r2_6897g)];
ra_9899n=(tt@r1_6897n[30,2:4])#r2_6897n[30,2:ncol(r2_6897n)];
gn=nrow(c_grossi);nn=nrow(n_neti);
m_9899gc=c_grossi[31:gn,1]||(c_grossi[31:nrow(c_grossi),5]*ra_9899g);
```

```
m_9899nc=c_neti[31:nn,1]||(c_neti[31:nrow(c_neti),5]*ra_9899n);
m_9899gn=n_grossi[31:gn,1]||(n_grossi[31:nrow(n_grossi),5]*ra_9899g);
m_9899nn=n_neti[31:nn,1]||(n_neti[31:nrow(n_neti),5]*ra_9899n);

/* CONNECTING THE SERIES : These series start at 1968 */
m_6899gc=m_6897gc//m_9899gc;
m_6899nc=m_6897nc//m_9899nc;
m_6899gn=m_6897gn//m_9899gn;
m_6899nn=m_6897nn//m_9899nn;

/* Making SUBTOTAL COLUMNS */
rr=nrow(m_6899gc); /*행수*/
cc=ncol(m_6899gc); /*열수*/
aa=(cc-1[7])*rr/3;
m_gcs=shape(m_6899gc[,2:70[8]],aa,3);
m_gcs=m_gcs||m_gcs[,+];                          /*산업의 자산별 합*/
m_6899gc=m_6899gc[,1]||shape(m_gcs,rr,92);
m_ncs=shape(m_6899nc[,2:70],aa,3);
m_ncs=m_ncs||m_ncs[,+];
m_6899nc=m_6899nc[,1]||shape(m_ncs,rr,92[9]);
m_gns=shape(m_6899gn[,2:70],aa,3);
m_gns=m_gns||m_gns[,+];
m_6899gn=m_6899gn[,1]||shape(m_gns,rr,92);
m_nns=shape(m_6899nn[,2:70],aa,3);
m_nns=m_nns||m_nns[,+];
m_6899nn=m_6899nn[,1]||shape(m_nns,rr,92);


print " MANUFACTURING SECTORS - 1995 CONSTANT PRICES : GROSS ";                결과표#23
print "(1)-(3)   ": s=m_6899gc[,1]||m_6899gc[,02:13]; print s;
print "(4)-(6)   ": s=m_6899gc[,1]||m_6899gc[,14:25]; print s;
print "(7)-(9)   ": s=m_6899gc[,1]||m_6899gc[,26:37]; print s;
print "(10)-(12)": s=m_6899gc[,1]||m_6899gc[,38:49]; print s;
print "(13)-(15)": s=m_6899gc[,1]||m_6899gc[,50:61]; print s;
print "(16)-(18)": s=m_6899gc[,1]||m_6899gc[,62:73]; print s;
print "(19)-(21)": s=m_6899gc[,1]||m_6899gc[,74:85]; print s;
print "(22)-(23)": s=m_6899gc[,1]||m_6899gc[,86:93]; print s;

print " MANUFACTURING SECTORS - 1995 CONSTANT PRICES : NET " ;                 결과표#25
print "(1)-(3)   ": s=m_6899nc[,1]||m_6899nc[,02:13]; print s;
print "(4)-(6)   ": s=m_6899nc[,1]||m_6899nc[,14:25]; print s;
print "(7)-(9)   ": s=m_6899nc[,1]||m_6899nc[,26:37]; print s;
print "(10)-(12)": s=m_6899nc[,1]||m_6899nc[,38:49]; print s;
print "(13)-(15)": s=m_6899nc[,1]||m_6899nc[,50:61]; print s;
print "(16)-(18)": s=m_6899nc[,1]||m_6899nc[,62:73]; print s;
print "(19)-(21)": s=m_6899nc[,1]||m_6899nc[,74:85]; print s;
print "(22)-(23)": s=m_6899nc[,1]||m_6899nc[,86:93]; print s;

print " MANUFACTURING SECTORS -  CURRENT PRICES : GROSS " ;                     결과표#26
print "(1)-(3)   ": s=m_6899gn[,1]||m_6899gn[,02:13]; print s;
```

7) 1은 연도

8) 70=23제조중분류*3개자산분류+1

9) 92=23*4+1

```
print "(4)-(6)   ": s=m_6899gn[,1]||m_6899gn[,14:25]; print s;
print "(7)-(9)   ": s=m_6899gn[,1]||m_6899gn[,26:37]; print s;
print "(10)-(12)": s=m_6899gn[,1]||m_6899gn[,38:49]; print s;
print "(13)-(15)": s=m_6899gn[,1]||m_6899gn[,50:61]; print s;
print "(16)-(18)": s=m_6899gn[,1]||m_6899gn[,62:73]; print s;
print "(19)-(21)": s=m_6899gn[,1]||m_6899gn[,74:85]; print s;
print "(22)-(23)": s=m_6899gn[,1]||m_6899gn[,86:93]; print s;

print " MANUFACTURING SECTORS -  CURRENT PRICES : NET " :                    결과표#27
print "(1)-(3)   ": s=m_6899nn[,1]||m_6899nn[,02:13]; print s;
print "(4)-(6)   ": s=m_6899nn[,1]||m_6899nn[,14:25]; print s;
print "(7)-(9)   ": s=m_6899nn[,1]||m_6899nn[,26:37]; print s;
print "(10)-(12)": s=m_6899nn[,1]||m_6899nn[,38:49]; print s;
print "(13)-(15)": s=m_6899nn[,1]||m_6899nn[,50:61]; print s;
print "(16)-(18)": s=m_6899nn[,1]||m_6899nn[,62:73]; print s;
print "(19)-(21)": s=m_6899nn[,1]||m_6899nn[,74:85]; print s;
print "(22)-(23)": s=m_6899nn[,1]||m_6899nn[,86:93]; print s;

quit;        /*sas iml종료*/
```

2. NwsbyAnew.sas : 자본재별 stock 먼저 추계시 프로그램

```
/*****************************************************************************
******************          GENERAL DESCRIPTION          *******************
*****************************************************************************/

/**
DATA :  ic95c1 - INVESTMENT DATA( 1995 CONSTANT, TYPES, 1968-99 )
        ic70n1 - INVESTMENT DATA( CURRENT,        TYPES, 1968-99 )

        w68g1 - NATIONAL WEALTH SURVEY( GROSS,  TYPES*INDUSTRIES )
        w68n1 - NATIONAL WEALTH SURVEY( NET,    TYPES*INDUSTRIES )
        w77g1
        w77n1
        w87g1
        w87n1
        w97g1
        w97n1
**/

proc iml;


/*****************************************************************************
******************          ANNUAL DATA          *******************
*****************************************************************************/


ic95c1={
1968     7192.3    1909.1    1661.3    1097.6    1005.0     650.4     867.1      1.8,
1969     8886.5    2358.8    2052.7    1356.2    1241.7     803.7    1071.3      2.2,
1970     8973.2    2381.8    2072.7    1369.4    1253.8     811.5    1081.8      2.2,
1971     9246.4    2327.7    1860.1    1707.2     999.3    1015.7    1334.2      2.2,
1972     9355.5    1956.1    1890.1    1677.6    1205.1    1201.0    1422.0      3.5,
1973    11949.4    2689.6    2834.8    1612.2    1622.3    1353.2    1826.8     10.7,
1974    13718.3    4252.5    2624.4    1730.5    1397.3    1957.7    1742.8     13.1,
1975    14775.0    4245.9    2731.9    2130.7    1545.1    2044.2    2069.8      7.3,
1976    17877.2    4361.3    3413.0    2691.8    1734.6    2476.5    3196.2      3.9,
1977    22995.1    5466.9    3955.6    3715.3    2082.1    2685.8    5073.9     15.5,
1978    30896.2    7508.9    5400.8    4047.7    2230.1    3480.9    8202.4     25.4,
1979    33892.2    6818.0    5939.6    5490.6    1867.7    3582.5   10169.5     24.4,
1980    30261.8    6268.3    5391.3    5745.3    1837.8    3431.0    7569.0     19.1,
1981    29141.6    5140.9    4759.1    6072.8    2088.9    3690.7    7376.1     13.1,
1982    32377.9    6405.8    5253.1    7237.2    2290.9    3484.1    7652.4     54.4,
1983    37991.0    8380.2    6751.6    8148.2    2620.8    3708.5    8299.9     81.7,
1984    41798.8    7657.4    8226.8    8940.0    2789.9    4368.8    9722.4     93.3,
1985    43607.0    7718.3    7789.7   10465.7    2796.4    4556.3   10211.1     69.4,
1986    48279.1    9032.8    8243.6    9535.9    2936.7    5150.0   13324.8     55.2,
1987    56482.5    9871.8   10521.6    9949.5    4019.7    5683.1   16405.8     30.9,
1988    64170.4   12068.8   12673.5   11067.4    3449.8    6135.9   18754.2     20.9,
1989    74302.4   14414.5   15502.1   12806.3    3112.5    6864.6   21481.1    121.5,
1990    93528.9   23075.7   18376.3   15372.9    3210.6    8615.0   24760.7    117.7,
```

```
1991    105970.6   25564.7   18504.0   19858.9   3591.3   9644.7   28666.6   140.3,
1992    105225.4   23690.2   17081.3   22566.3   3555.8   10300.5  27875.0   156.2,
1993    111831.6   26337.8   19853.4   23335.3   3865.1   10634.1  27632.2   173.7,
1994    123750.5   25887.6   20806.7   24893.2   4551.0   13157.7  34217.4   237.0,
1995    138438.6   28026.9   23262.5   25437.5   5470.6   13399.1  42555.8   286.1,
1996    148579.8   28448.8   22441.3   29841.2   6515.9   14531.6  46540.6   260.4,
1997    145294.6   26667.8   22544.5   32686.0   7386.6   12555.7  43139.8   314.3,
1998    114563.5   24548.2   17793.7   32045.2   5908.1   6204.2   27803.8   260.3,
1999    119272.9   19861.1   11007.7   33930.7   7188.3   10405.1  36654.7   225.4
};


ic70nl={
1968       517.7     121.4     111.6      77.8     48.1     66.3      91.8     0.6,
1969       591.0     138.6     127.4      88.9     54.9     75.7     104.8     0.7,
1970       695.6     163.1     150.0     104.6     64.6     89.1     123.4     0.8,
1971       768.6     163.5     137.2     128.6     55.5    119.6     162.8     1.5,
1972       871.4     152.1     153.6     136.6     74.0    158.4     195.1     1.6,
1973      1298.3     230.1     257.9     148.4    113.1    223.0     319.2     6.6,
1974      2068.6     502.5     326.6     216.5    133.2    449.1     431.7     9.0,
1975      2744.8     620.7     409.5     328.7    188.6    561.7     628.3     7.2,
1976      3593.7     693.5     553.0     454.4    232.0    682.2     974.1     4.5,
1977      5107.0     952.2     709.8     690.9    320.5    759.7    1650.2    23.7,
1978      7923.5    1545.8    1149.8     885.1    434.5   1076.2    2788.6    43.6,
1979     10573.4    1778.7    1589.9    1504.8    470.9   1271.1    3921.0    37.1,
1980     12229.9    2189.7    1885.5    2115.5    619.8   1586.3    3799.8    33.3,
1981     13368.8    1998.1    1842.6    2539.4    799.0   2062.1    4099.9    27.8,
1982     15586.3    2635.2    2153.0    3168.0    875.1   2039.1    4658.3    57.6,
1983     18944.4    3628.4    2940.1    3627.2    983.4   2432.2    5266.9    66.3,
1984     21381.2    3401.0    3718.2    4065.6   1110.2   2925.2    6082.9    78.2,
1985     23434.9    3520.5    3613.4    4904.2   1163.4   3239.2    6913.7    80.6,
1986     26975.8    4107.3    3828.8    4483.3   1324.4   3487.9    9686.8    57.4,
1987     32600.0    4637.6    5057.8    4826.8   1868.7   4111.5   12074.8    22.9,
1988     39450.8    6201.6    6678.0    5850.6   1781.4   4846.3   14073.0    19.9,
1989     47673.4    8004.5    8854.2    7375.3   1870.7   5777.7   15668.8   122.3,
1990     66689.3   14694.5   12223.6   10430.8   2377.0   7751.6   19093.2   118.6,
1991     84506.7   19521.2   14292.3   15401.5   3120.0   8904.9   23109.0   157.8,
1992     90809.3   19956.3   14394.6   19107.5   3299.8   9831.7   24030.0   189.5,
1993    100354.4   22996.5   17345.4   20424.2   3603.0  10330.1   25458.5   196.7,
1994    116436.4   23975.1   19162.1   22757.9   4376.2  12986.1   32956.9   222.2,
1995    138438.6   28026.9   23262.5   25437.5   5470.6  13399.1   42555.8   286.1,
1996    153975.6   29965.9   23613.5   31662.2   6895.1  14654.7   46952.9   231.3,
1997    159110.4   29851.5   25398.4   37118.0   8282.7  12948.7   45292.4   218.8,
1998    132307.5   28385.1   20522.3   37031.9   6765.9   6716.8   32785.5    99.9,
1999    135233.8   23355.2   12933.5   39424.7   8378.6  10818.7   40186.2   136.9
};
```

```
/* NATIONAL WEALTH SURVEY 1968 GROSS ( 1 mil ) */
/* col.s are INDUSTRIES, rows are TYPE of CAPITAL */
/* rows: 유형고정자산 거주용건물 비주거용건물 구축물 운수설비 기계설비 */

w68gl={
 4703743 160098 33338  715616 119847 37656  172734 93077  24350  1791458 376635 1178934,
 2030993  28513  1996   26184     55  6959   19048  1208   1838  1791458 123996   29737,
  867631  12170  6419  234833  40028  4520  106764 12351  17535        0 175352  257660,
  772750   5071  8940   30526  34532   167    1685   253    295        0   4414  686867,
  299171  89108  3140   23217    504  4789   10695 73293   1064        0   6380   86981,
  733198  25236 12843  400856  44728 21221   34542  5972   3618        0  66493  117689
};

/* NATIONAL WEALTH SURVEY 1968 NET ( 1 mil ) */
w68nl={
 2352994  98808 14978  388272 119759 23226  102365 46939  19115   593731 245891  699910,
  749329  11342  1082   14128     43  5946   11622   954   1336   593731  89068   20076,
  555371   6023  3342  142738  40022  3685   69769  7568  14057        0 117646  150522,
  466521   4444  5452   21901  34524   123    1085   162    282        0   2851  395697,
  159262  56389  1171   10867    484  3052    6265 36534    742        0   3451   40307,
  422511  20610  3931  198638  44686 10420   13624  1721   2698        0  32875   93308
};

/* NATIONAL WEALTH SURVEY 1977 GROSS ( 1 bil ) */
w77gl={
 45236.7 1950.9 294.5  10796.4 1710.4 1010.1 2707.8  3477.1 3161.3 12862.2 1806.9 5459.0,
 13392.7    4.3  15.6    110.8    0.7  121.2   54.4     9.9   21.4 12862.2   49.0  143.3,
 12472.4  451.7  46.0   3394.1  691.4  313.5 1890.1   263.2 2866.6     0.0 1215.6 1340.4,
  6461.2  301.9  80.6    589.9  386.7   45.5   23.3  1315.8   21.5     0.0   99.1 3596.8,
  2986.6  696.6  39.7    406.8    4.7  122.6  159.7  1368.0   54.7     0.0   43.2   90.7,
  9923.8  496.4 112.6   6294.9  626.9  407.4  580.3   520.3  197.2     0.0  400.0  287.9
};

/* NATIONAL WEALTH SURVEY 1977 NET ( 1 bil ) */
w77nl={
 24515.0 885.6  137.4  6422.9 1295.2 641.3  1338.3 1688.7 1711.7 5239.6 1013.5 4140.8,
  5613.6   1.9   14.0    91.8    0.4 101.2    24.3    6.6   10.3 5239.6   29.9   93.6,
  7916.4 241.7   25.3  2460.9  638.2 233.5   940.6  185.0 1556.9    0.0  765.3  868.8,
  4608.8 132.5   45.3   454.5  277.9  39.8    12.9  579.7   10.7    0.0   39.6 3015.8,
  1377.5 277.3   17.7   203.6    0.9  61.5    94.6  643.7   26.3    0.0   19.6   32.3,
  4998.7 232.1   35.1  3212.2  377.8 205.2   265.8  273.7  107.5    0.0  159.1  130.2
};

/* NATIONAL WEALTH SURVEY 1987 GROSS ( 1 bil ) */
w87gl={
 400349.7  27210.9  2945.2 120844.0  18284.6  7929.8 21110.1 39327.0 24131.9 83010.8 19839.9 35715.5,
  90165.4     50.3   175.6   2251.4    418.9  1085.9   239.1   244.3  1107.8 83010.8   588.9   992.4,
 101954.9  11544.7   273.9  32053.0   1735.1  2020.1 12972.9  3992.6 16505.4       0 12749.5  8107.7,
  64189.0   8035.8   905.4   9270.4   7095.5   116.0   634.1 12146.0   182.5       0  1071.7 24731.6,
  31499.8   3558.9   368.0   4266.8     69.7   753.3  2802.2 17501.5   974.6       0   684.3   520.5,
 112540.6   4021.2  1222.3  73002.4   8965.4  3954.5  4461.8  5442.6  5361.6       0  4745.5  1363.3
};

/* NATIONAL WEALTH SURVEY 1987 NET ( 1 bil ) */
w87nl={
 203194.5   9451.6  1265.0  54020.4  10805.2  3777.3 10592.5 18677.6 16565.3 41619.4 10125.7 26294.5,
  47188.8     28.7   131.5   1685.0    386.2  1109.3   129.0   193.3   847.4 41619.4   372.0   687.0,
  59032.6   3258.1   161.5  19224.7   1520.5  1398.2  6762.5  2573.7 11759.6       0  7061.7  5312.1,
  40957.1   3740.6   508.5   4432.8   4382.6    75.5   337.0  7180.2   106.5       0   570.8 19622.6,
  11770.4    762.8   118.7   1514.1     20.0   287.4  1367.7  6962.5   297.5       0   274.0   165.7,
  44245.6   1661.4   344.8  27163.8   4495.9   906.9  1996.3  1767.9  3554.3       0  1847.2   507.1
};
```

```
/* NATIONAL WEALTH SURVEY 1997 GROSS ( 1 bil ) */
w97gl={
 2455413.8   95375.1    3822    729694.5 100435.6   83962.8 210397.6 169714.8   98747.3 485026.4 164097.2 314140.5,
  527134.6    2790.7     136.6    7548.3     688.3  16935.1    1747.2     422       664.9 485026.4   5819.8    5355.3,
  425219.7   47627.1     363.4  116910.3    3039.8   7491.2   70979.7  10350.6   35974.8        0  85033.3   47449.5,
  576589.1   14286.3    1040.1  151299.3   51877.4  35299.3   10069.3  58573.3    9144           0  20268.1  224732  ,
  156929     11195.6     975.8   15035.1     716.8   9150.1   37383    67384.9    4464.8        0   4363.1    6259.8,
  769541.4   19475.4    1306.1  438901.5   44113.3  15087.1   90218.4  32984     48498.8        0  48612.9   30343.9
};

/* NATIONAL WEALTH SURVEY 1997 NET ( 1 bil ) */
w97nl={
 1301916.8   47390.8    1221.7  310270.3   55797.1  63087.8  112691.4  64917.9   55896.4 273742.5  98527.8  218373.1,
  305436.7    1441.5      77.3    5222.6     451.5  14659.9    1100.2    235.9     498.3 273742.5   4499.3    3507.7,
  283868.2   29169.9     195.5   76496.4    2126.9   5485.5   50051.3   7150.5   25232.5        0  57982.9   29976.8,
  380855.5    6137.2     383.1   89193.3   34441.3  35142.7    7115.3  15131.4    8326           0  15522    169463.2,
   64849.4    2744.4     239.9    4842.9     196.4   3379.7   17368.2  29133.5    1720.7        0   2856.3    2367.4,
  266907      7897.8     325.9  134515.1   18581    4420     37056.4  13266.6   20118.9        0  17667.3   13058
};


/** Data Adjustment **/
w68gl=w68gl/1000;
w68nl=w68nl/1000;

w68gl[,9]=w68gl[,9]+w68gl[,10]; w68gl=w68gl[,1:9]||w68gl[,11:12];
w68nl[,9]=w68nl[,9]+w68nl[,10]; w68nl=w68nl[,1:9]||w68nl[,11:12];
w77gl[,9]=w77gl[,9]+w77gl[,10]; w77gl=w77gl[,1:9]||w77gl[,11:12];
w77nl[,9]=w77nl[,9]+w77nl[,10]; w77nl=w77nl[,1:9]||w77nl[,11:12];
w87gl[,9]=w87gl[,9]+w87gl[,10]; w87gl=w87gl[,1:9]||w87gl[,11:12];
w87nl[,9]=w87nl[,9]+w87nl[,10]; w87nl=w87nl[,1:9]||w87nl[,11:12];
w97gl[,9]=w97gl[,9]+w97gl[,10]; w97gl=w97gl[,1:9]||w97gl[,11:12];
w97nl[,9]=w97nl[,9]+w97nl[,10]; w97nl=w97nl[,1:9]||w97nl[,11:12];

ic95cl[,5]=ic95cl[,5]+ic95cl[,6];
ic70nl[,5]=ic70nl[,5]+ic70nl[,6];

ic95cl=ic95cl[,1:5]||ic95cl[,7:8];
ic70nl=ic70nl[,1:5]||ic70nl[,7:8];

ic95cl[,2]=ic95cl[,3:ncol(ic95cl)][,+];
ic70nl[,2]=ic70nl[,3:ncol(ic70nl)][,+];

w68gl=w68gl'; w68nl=w68nl';
w77gl=w77gl'; w77nl=w77nl';
w87gl=w87gl'; w87nl=w87nl';
w97gl=w97gl'; w97nl=w97nl';


/** Computing DEFLATORS by (NOMINAL/CONSTANT) **/
def95=ic70nl[,1]||ic70nl[,2:ncol(ic70nl)]/ic95cl[,2:ncol(ic95cl)];

/*
print " Deflator 1995", def95;
*/
```

```
/** Change NATIONAL WEALTH CAPITAL STOCK DATA in CURRENT PRICES into those in 1995 CONSTANT PRICES **/
w68gc=w68gl#(1/def95[1,2:7]);
w68nc=w68nl#(1/def95[1,2:7]);
w68gc[,1]=(w68gc[,2:ncol(w68gc)][,+]);
w68nc[,1]=(w68nc[,2:ncol(w68nc)][,+]);

w77gc=w77gl#(1/def95[10,2:7]);
w77nc=w77nl#(1/def95[10,2:7]);
w77gc[,1]=(w77gc[,2:ncol(w77gc)][,+]);
w77nc[,1]=(w77nc[,2:ncol(w77nc)][,+]);

w87gc=w87gl#(1/def95[20,2:7]);
w87nc=w87nl#(1/def95[20,2:7]);
w87gc[,1]=(w87gc[,2:ncol(w87gc)][,+]);
w87nc[,1]=(w87nc[,2:ncol(w87nc)][,+]);

w97gc=w97gl#(1/def95[30,2:7]);
w97nc=w97nl#(1/def95[30,2:7]);
w97gc[,1]=(w97gc[,2:ncol(w97gc)][,+]);
w97nc[,1]=(w97nc[,2:ncol(w97nc)][,+]);

/*
print "`68 GROSS & NET", w68gc, w68nc;
print "`77 GROSS & NET", w77gc, w77nc;
print "`87 GROSS & NET", w87gc, w87nc;
print "`97 GROSS & NET", w97gc, w97nc;
*/


/** Computing `d`(폐기율) & `r`(감가율) **/
i1c=ic95c1[02:10,]; /* INVESTMENT 1969-1977 */
i2c=ic95c1[11:20,]; /* INVESTMENT 1978-1987 */
i3c=ic95c1[21:30,]; /* INVESTMENT 1988-1997 */
i4c=ic95c1[31:32,]; /* INVESTMENT 1998-1999 */


/*****************************************************************************
************      PROCEDURE TO GET A DEPRECIATON RATE        *****************
************     < input >                                    *****************
************   1. a: 1st benchmark year capital stock(1*k)    *****************
************   2. b: 2nd benchmark year capital stock(1*k)    *****************
************   3. c: series of investent(a+1||b) (n*k)       *****************
************     < formula >                                  *****************
************   y(z)=a*z^n+c(1)*z^(n-1)+...+c(n)-b             *****************
************   z=1-d  : `d(n*k)` is what you will get.         *****************
************       - this contains only real numbers.         *****************
************         imaginary solutions appear as `0`s`      *****************
*****************************************************************************/
start depr(a,b,c);
   n=nrow(c);
   k=ncol(c);
   c[n,]=c[n,]-b;
   ds=a//c;
   d=j(n,2*k,0);
```

```
    i=1;
    do until (i>k);
    dsi=ds[,i];
    di=polyroot(dsi);
    di[,1]=1-di[,1];
    d[,2*i-1:2*i]=di;
    i=i+1;
    end;

return(d);
finish;


r1=depr(w68gc[1,],w77gc[1,],i1c[,2:7]);
d1=depr(w68nc[1,],w77nc[1,],i1c[,2:7]);
r2=depr(w77gc[1,],w87gc[1,],i2c[,2:7]);
d2=depr(w77nc[1,],w87nc[1,],i2c[,2:7]);
r3=depr(w87gc[1,],w97gc[1,],i3c[,2:7]);
d3=depr(w87nc[1,],w97nc[1,],i3c[,2:7]);

/*
print "1ST GROSS" r1;
  print "1ST NET" d1;
print "2ND GROSS" r2;
  print "2ND NET" d2;
print "3RD GROSS" r3;
  print "3RD NET" d3;
*/


/** Computing CAPITAL STOCK for 1969-1976, 1978-1986, 1988-1996 **/
/** n차 방정식의 n개 근 가운데 어느 근을 이용할 것인가의 문제 **/

start real(a);
z=a=0;
c=z[,2:ncol(z)]||z[,1];
d=a#c;
z=abs(d)<1;
f=d#z;

s=f[+,];
r=s[,1]||s[,3]||s[,5]||s[,7]||s[,9]||s[,11];
        /** 홀수법째 열은 실수부분, 짝수번째 열은 허수부분이므로 홀수열만 취한다. **/

return(r);
finish;

rr1=real(r1);
dd1=real(d1);
rr2=real(r2);
dd2=real(d2);
rr3=real(r3);
dd3=real(d3);
```

```
/*****************************************************************************
*************        COMPUTIONG CAPITAL STOCKS OF INDUSTRIES       ***************
*************           BETWEEN BENCHMARK YEARS                    ***************
*************      < input >                                       ***************
*************      1. a: 1st benchmark year capital stock (1*k)    ***************
*************      2. b: series of investment data (n*k+1)-year    ***************
*************              `a||a+n-1` years data                   ***************
*************      3. c: series of depreciation data (1*k)         ***************
*************      < output >                                      ***************
*************      d : (n-1*k+1) of capital stock of each year     ***************
*****************************************************************************/
start stock(a,b,c);
   f=b[,2:ncol(b)];
   n=nrow(f);k=ncol(f);
   d=a[1,]//j(n-1,k,0);e=j(1,k,1)-c;

   i=1;
   do until (i>n-1);
   d[i+1,]=d[i,]#e+f[i,];
   i=i+1;
   end;

d=b[1:n-1,1]||d[2:n,];
return(d);
finish;


/*****************************************************************************
*************      PROCEDURE TO GET A CAPITAL STOCK SERIES(1)      ***************
*************      < input >                                       ***************
*************      1. a: base year capital stock (1*k)             ***************
*************      2. b: series of investment after 'a' (n*k+1)    ***************
*************      3. c: series of depresiation rate or retire-    ***************
*************            ment rate (1*k)                           ***************
*************      < output >                                      ***************
*************       d: (n*k+1) matrix of capital stock (a+1~ )     ***************
*****************************************************************************/
start capl(a,b,c);
   n=nrow(b);k=ncol(b)-1;
   d=a[1,]//j(n,k,0);
   cl=c>0;
   r=cl#c; /* cl>0 contains 0&1, where 1 means it is true */
   bl=b[,2:ncol(b)];

   i=1;
   do until (i>n);
   d[i+1,]=bl[i,]+(j(1,ncol(r))-r)#d[i,];
   i=i+1;
   end;

d=b[,1]||d[2:n+1,];
return(d);
finish;
```

```
stc6976g=stock(w68gc,i1c,rr1);  /* Computing GROSS CAPITAL STOCK 1969-1976 */
stc6976n=stock(w68nc,i1c,dd1);  /*           NET                          */

stc7886g=stock(w77gc,i2c,rr2);  /*           GROSS                1978-1986 */
stc7886n=stock(w77nc,i2c,dd2);  /*           NET                          */

stc8896g=stock(w87gc,i3c,rr3);  /*           GROSS                1988-1996 */
stc8896n=stock(w87nc,i3c,dd3);  /*           NET                          */

stc9899g= capl(w97gc,i4c,rr3);  /*           GROSS                1998-1999 */
stc9899n= capl(w97nc,i4c,dd3);  /*           NET                          */

stn6976g=stc6976g[,1]||stc6976g[,2:7]#def95[2:9,2:ncol(def95)];
stn6976n=stc6976n[,1]||stc6976n[,2:7]#def95[2:9,2:ncol(def95)];
stn7886g=stc7886g[,1]||stc7886g[,2:7]#def95[11:19,2:ncol(def95)];
stn7886n=stc7886n[,1]||stc7886n[,2:7]#def95[11:19,2:ncol(def95)];
stn8896g=stc8896g[,1]||stc8896g[,2:7]#def95[21:29,2:ncol(def95)];
stn8896n=stc8896n[,1]||stc8896n[,2:7]#def95[21:29,2:ncol(def95)];
stn9899g=stc9899g[,1]||stc9899g[,2:7]#def95[31:32,2:ncol(def95)];
stn9899n=stc9899n[,1]||stc9899n[,2:7]#def95[31:32,2:ncol(def95)];

stn9899g=stc9899g[,1]||capl(w97gl,i4c,rr3)[,2:7];
stn9899n=stc9899n[,1]||capl(w97nl,i4c,dd3)[,2:7];

/*
print "CAPITAL STOCK BETWEEN BENCHMARK YEARS";
print "1ST PERIOD GROSS", stc6976g;
print "1ST PERIOD NET", stc6976n;
print "2ND PERIOD GROSS", stc7886g;
print "2ND PERIOD NET", stc7886n;
print "3RD PERIOD GROSS", stc8896g;
print "3RD PERIOD NET", stc8896n;
print "4TH PERIOD GROSS", stc9899g;
print "4TH PERIOD NET", stc9899n;
*/


/*----------------------- 1995 CONSTANT PRICES --------------------------*/

/*--- 1. GROSS ---*/
c_grossi=(1968||w68gc[1,])//stc6976g//(1977||w77gc[1,])//stc7886g;
c_grossi=c_grossi//(1987||w87gc[1,])//stc8896g//(1997||w97gc[1,])//stc9899g;
c_grossi[,2]=(c_grossi[,3:ncol(c_grossi)][,+]);

print "GROSS 1968-1999 IN 1995 CONSTANT PRICES", c_grossi;

/*--- 2. NET ---*/
c_neti=(1968||w68nc[1,])//stc6976n//(1977||w77nc[1,])//stc7886n;
c_neti=c_neti//(1987||w87nc[1,])//stc8896n//(1997||w97nc[1,])//stc9899n;
c_neti[,2]=(c_neti[,3:ncol(c_neti)][,+]);

print "NET 1968-1999 IN 1995 CONSTANT PRICES", c_neti;
```

```
/*--------------------------- CURRENT PRICES ----------------------------*/

/*--- 1. GROSS ---*/
n_grossi=(1968||w68gl[1,])//stn6976g//(1977||w77gl[1,])//stn7886g;
n_grossi=n_grossi//(1987||w87gl[1,])//stn8896g//(1997||w97gl[1,])//stn9899g;
n_grossi[,2]=(n_grossi[,3:ncol(n_grossi)][,+]);

print "GROSS 1968-1999 IN CURRENT PRICES", n_grossi;

/*--- 2. NET ---*/
n_neti=(1968||w68nl[1,])//stn6976n//(1977||w77nl[1,])//stn7886n;
n_neti=n_neti//(1987||w87nl[1,])//stn8896n//(1997||w97nl[1,])//stn9899n;
n_neti[,2]=(n_neti[,3:ncol(n_neti)][,+]);

print "NET 1968-1999 IN CURRENT PRICES", n_neti;


/****************************************
********        INDUSTRIES      *********
****************************************/

/* Making CAPITAL STOCKS by TYPES OF CAPITAL STOCK */
/* LINEAR PROJECTION between BENCHMARK YEARS */

/****************************************************************************
************          PROCEDURE FOR LINEAR INTERPOLATION          ***************
************  - interpolate ratios between benchmark years         ***************
************    < input >                                         ***************
************    1. a: 1st base year capital stock (k*i)           ***************
************          k - types of capital                        ***************
************          i - industries                              ***************
************    2. b: 2nd base year capital stock (k*i)           ***************
************    3. c: year of "a"                                 ***************
************    4. d: year of "b"                                 ***************
************    5. e: generated capital stocks between            ***************
************         benchmark years (d-c*i+1)-indust. totals     ***************
************    < output >                                        ***************
************ ei:ith indus. capital stock by types of capital       ***************
************       between benchmark years(row:year,col.:type)***************
****************************************************************************/
start projl(a,b,c,d,e);
   n=d-c;k=nrow(a);il=ncol(a);
   rl=a#(1/a[1,]);
   r2=b#(1/b[1,]);                        /* COMPUTING THE RATIO */
   dl=(r2-rl)/n;                          /* COMPUTING THE AVERAGE DIFFERENCE */
   e2=j(1,k+1,0);
   w=do(c+1,d-1,1);                       /* CREATING THE 1ST COLUMN - YEAR */
   w=w`;

   j=1;                                   /* `J` STANDS FOR INDUSTRY */
   do until (j>il);
      i=1;                                /* `I` STANDS FOR YEAR */
      el=j(n,k,0);el=rl[,j]`//el;
      do until (i>n);
```

```
        e1[i+1,]=e1[i,]+d1[,j]`;
        i=i+1;
        end;
    e2=e2//(w||e1[2:nrow(e1)-1,]);
    j=j+1;
    end;

ee=e2[2:nrow(e2),2:ncol(e2)];

es=e[,2:ncol(e)]; es=es`;
sh=shape(es,1);   sh=sh`;

    i=1;
    do until (i>k);
    ee[,i]=ee[,i]#sh;
    i=i+1;
    end;

e2=e2[2:nrow(e2),1]||ee;

return(e2);
finish;

/*--- 1. 1969-1976 ---*/
st11=projl(w68gl,w77gl,1968,1977,stn6976g);
st12=projl(w68nl,w77nl,1968,1977,stn6976n);

/*
print "GROSS 1969-1976", st11;
print "NET 1969-1976", st12;
*/


/*--- 2. 1978-1986 ---*/
st21=projl(w77gl,w87gl,1977,1987,stn7886g);
st22=projl(w77nl,w87nl,1977,1987,stn7886n);

/*
print "GROSS 1978-1986", st21;
print "NET 1978-1986", st22;
*/


/*--- 3. 1988-1996 ---*/
st41=projl(w87gl,w97gl,1987,1997,stn8896g);
st42=projl(w87nl,w97nl,1987,1997,stn8896n);

/*
print "GROSS 1988-1996", st41;
print "NET 1988-1996", st42;
*/
```

```
/*--- 4. 1998-1999 ---*/

/* GROSS */
st_ra11=w97g1#(1/w97g1[1,]); /* ratio of capital types in 1997 */
temp11=j(1,nrow(w97g1)+1,0);

i=1;
do until (i>ncol(stn9899g)-1);
stntem11=stn9899g[,i+1]*st_ra11[,i]`;
stntem11=stn9899g[,1]||stntem11;
temp11=temp11//stntem11;
i=i+1;
end;
st51=temp11[2:nrow(temp11),];

/* NET */
st_ra22=w97n1#(1/w97n1[1,]); /* ratio of capital types in 1997 */
temp22=j(1,nrow(w97n1)+1,0);

i=1;
do until (i>ncol(stn9899n)-1);
stntem22=stn9899n[,i+1]*st_ra22[,i]`;
stntem22=stn9899n[,1]||stntem22;
temp22=temp22//stntem22;
i=i+1;
end;
st52=temp22[2:nrow(temp22),];

/*
print "GROSS 1998-1999" st51;
print "NET 1998-1999" st52;
*/


/*****************************************************************************
************        PROCEDURE TO GET A TOTAL TABLES          ****************
************     < input >                                   ****************
************     1. a: capital stock series by both types and ****************
************           industries ((n*i)*(k+1))              ****************
************           n: year, i: industries, k: types      ****************
************     2. b: starting year                         ****************
************     3. c: finishing year                        ****************
************     < output >                                  ****************
************     d: (n*k) matrix of total capital stock      ****************
************          n: year, k: types of capital           ****************
*****************************************************************************/
start total(a,b,c);
   n=c-b+1;
   k=ncol(a)-1;
   d=j(n,k,0);

   i=2;
   do until (i>nrow(a)/n);
   d=a[(i-1)*n+1:i*n,2:ncol(a)]+d;
```

```
    i=i+1;
    end;

 x=(a[1:n,1]||d);
 return(x);
 finish;


/* INDUSTRY TOTAL according to the TYPES OF CAPITAL STOCK */
t_6976gn=total(st11,1969,1976);
t_6976nn=total(st12,1969,1976);
t_7886gn=total(st21,1978,1986);
t_7886nn=total(st22,1978,1986);
t_8896gn=total(st41,1988,1996);
t_8896nn=total(st42,1988,1996);
t_9899gn=total(st51,1998,1999);
t_9899nn=total(st52,1998,1999);

/*
print "GROSS 69-76" t_6976gn;
print "NET 69-76" t_6976nn;
print "GROSS 78-86" t_7886gn;
print "NET 78-86" t_7886nn;
print "GROSS 88-96" t_8896gn;
print "NET 88-96" t_8896nn;
print "GROSS 98-99" t_9899gn;
print "NET 98-99" t_9899nn;
*/


/** Making a SERIES of CAPITAL STOCK by INDUSTRIES */
/* Connect the above DISCONTINUOUS SERIES by inserting NATIONAL WEALTH SURVEY DATA of 1968, 1977,
1987, 1997 */


/*------------------ CURRENT PRICES ------------------*/

/*--- 1. GROSS ---*/
n_grossc=(1968||w68gl[,1]`)//t_6976gn//(1977||w77gl[,1]`)//t_7886gn;
n_grossc=n_grossc//(1987||w87gl[,1]`)//t_8896gn//(1997||w97gl[,1]`)//t_9899gn;
n_grossc[,2]=(n_grossc[,3:ncol(n_grossc)][,+]);

/*--- 2. NET ---*/
n_netc=(1968||w68nl[,1]`)//t_6976nn//(1977||w77nl[,1]`)//t_7886nn;
n_netc=n_netc//(1987||w87nl[,1]`)//t_8896nn//(1997||w97nl[,1]`)//t_9899nn;
n_netc[,2]=(n_netc[,3:ncol(n_netc)][,+]);


/*------------- 1995 CONSTANT PRICES ---------------*/

/* Getting a RATIO to distribute the TOTAL into TYPES OF CAPITAL */

ra_gross=n_grossc[,2:ncol(n_grossc)]#(1/n_grossc[,2]);
ra_net=n_netc[,2:ncol(n_netc)]#(1/n_netc[,2]);
```

```
/*--- 1. GROSS ---*/
c_grossc=c_grossi[,1]||(c_grossi[,2]#ra_gross);

print "GROSS 1968-1999 IN 1995 CONSTANT PRICES", c_grossc;

/*--- 2. NET ---*/
c_netc=c_neti[,1]||(c_neti[,2]#ra_net);

print "NET 1968-1999 IN 1995 CONSTANT PRICES", c_netc;


/*--------------- CURRENT PRICES PRINT ---------------*/

print "GROSS 1968-1999 IN CURRENT PRICES", n_grossc;

print "NET 1968-1999 IN CURRENT PRICES", n_netc;

quit;
```

Ⅱ. 기초자료 현황

Ⅱ. 기초자료 현황

추계시 이용 기초자료 현황

	68,77,87국부자료	97국부자료	국민계정
자료형태	자본재및 산업별	자본재 및 산업별	자본재별 산업별
자료의이용 <자본재별>			
주거용건물	건설가계정의값을주거용, 비주거용건물의 합에서 주거용건물 비율로 배분된 값만큼을 원래의 주거용 건물값에 합하여 계산	주거용건물	
비주거용건물	주거용건물의 경우와 동일하며 여기에 건물부속 설비의 값도 합하여 계산	비주거용건물	
구축물	구축물	구축물+건설가계정	
운수설비	선박+차량운반구	좌동	
기계설비	기계및장치+공구와기구비품	좌동	
<산업별>			
농림어업			자본재별 자료의 낙농축부문을 산업별 자료 농림어업에서 차감
금융보험부동산업	주택부분을 포함시킴	좌동	
정부	사회및개인서비스업을정부와 민간(서비스업)으로분리	정부편국부보고서 산업편(p46-47)의 L, M, N, O의 합	사회 및 개인서비스업과 정부 서비스 생산자의 값을 합하여 국부의(정부+서비스업(민간))에 대한 정부의 비율에 따라 배분
서비스업(민간)	사회및개인서비스업을정부와 민간(서비스업)으로분리	종합편국부보고서산업 편(p72-75)의 L,M,N,O의 합에서 위에서 구한 정부부분을 차감	사회및개인서비스업과정부서비스생산자의 값을 합하여 국부의(정부+서비스업(민간))에 대한 서비스업의 비율에따라배분

1. 87년 자산형태 및 경제활동별 국부자료(종합편 4-1표)

<국부보고서>

	농림어업	광업	제조업	전기가스 수도업	건설업	도소매 음식숙박업	운수창고 통신업	금융보험 부동산	사회및개인 서비스
주거용건물	50.0	142.5	1931.9	269.8	832.1	227.0	186.7	1049.1	1496.5
비주거용건물	11422.6	218.8	26268.5	1112.5	1448.2	837.2	2799.2	14986.0	18708.5
건물부속설비	57.6	4.2	1440.7	7.9	130.1	504.2	329.1	680.7	1088.0
구축물	8035.8	905.4	9270.4	7095.5	116.0	634.1	12146	182.5	25803.3
기계및장비	3272.7	1166.7	65150.2	8795.7	3357.1	976.2	4831.8	3550.3	2615.5
선박	3106.2	33.3	286.5	0.6	100.1	45.2	8671.0	44.7	296.0
차량운반구	452.7	334.7	3980.3	69.1	653.2	2757.0	8830.5	526.9	908.8
공구와기구비품	748.5	55.6	7852.2	169.7	597.4	3485.6	610.8	1811.3	3493.3
건설가계정	64.8	84.0	4663.3	763.8	695.6	643.5	921.9	897.2	1145.5

<추계이용자료>

	농림어업	광업	제조업	전가수	건설업	도음숙	운창통	금보부	사회및개인서비스
주거용건물	50.3	175.6	2251.4	418.9	1085.9	239.1	244.3	1107.8	1581.3
비주거용건물	11544.7	273.9	32053.0	1735.1	2020.1	12972.8	3992.6	16505.4	20857.2
주거용+비주거용	11472.6	361.3	28200.4	1382.3	2280.3	12064.2	2985.9	16035	20205
주거용건물	50	142.5	1931.9	269.8	832.1	227	186.7	1049.1	1496.5
비주거용건물	11422.6	218.8	26268.5	1112.5	1448.2	11837.2	2799.2	14986	18708.5
건물부속설비	57.6	4.2	1440.7	7.9	130.1	504.2	329.1	680.7	1088.0
건설가계정	64.8	84.0	4663.3	763.8	695.6	643.5	921.9	897.2	1145.5
구축물	8035.8	905.4	9270.4	7095.5	116	634.1	12146	182.5	25803.3
운수=선박+운반구	3558.9	368	4266.8	69.7	753.3	2802.2	17501.5	571.6	1204.8
선박	3106.2	33.3	286.5	0.6	100.1	45.2	8671.0	44.7	296.0
차량운반구	452.7	334.7	3980.3	69.1	653.2	2757.0	8830.5	526.9	908.8
기계=기계장비+공비	4021.2	1222.3	73002.4	8965.4	3954.5	4461.8	5442.6	5361.6	6108.8
기계및장비	3272.7	1166.7	65150.2	8795.7	3357.1	976.2	4831.8	3550.3	2615.5
공구와기구비품	748.5	55.6	7852.2	169.7	597.4	3485.6	610.8	1811.3	3493.3

2. 97년 자산형태 및 경제활동별 국부자료(종합편 4-1표)

	A+B.농림어업	A. 농업	B. 어업	C. 광업	D. 제조업	E.전기가스수도
주거용	2,790.7	2,720.8	69.9	*136.6*	7,548.3	688.3
비주거용	47,627.1	46,873.2	753.9	*363.4*	116,910.3	3,039.8
구축물+건설가계정	14,286.3	14,105.4	180.9	1,040.1	151,299.3	51,877.4
건설가계정	243.9	240.2	3.7	*18.0*	41,103.1	7,711.4
구축물	*14,042.4*	*13,865.2*	*177.2*	*1,022.1*	*110,196.2*	*44,166.0*
운수설비	11,195.6	3,392.4	7,803.2	*975.8*	15,035.1	716.8
선박	7,614.6	0.1	7,614.5	*452.4*	2,380.0	5.2
차량운반구	3,581.0	3,392.3	188.7	*523.4*	12,655.1	711.6
기계설비	19,475.4	16,791.3	2,684.1	*1,306.1*	438,901.5	44,113.3
기계 및 장치	17,672.2	15,559.9	2,112.3	*1,232.2*	382,357.7	35,755.4
공구와기구・비품	1,803.2	1,231.4	571.8	*73.9*	56,543.8	8,357.9

	F. 건설업	G+H.도음숙	G. 도소매	H. 숙박음식	I. 운창통	J+K.금.보.부
주거용	16,935.1	1,747.2	1,152.2	595.0	422.0	664.9
비주거용	7,491.2	70,979.7	31,049.0	39,930.7	10,350.6	35,974.8
구축물+건설가계정	35,299.3	10,069.3	4,378.7	5,690.6	58,573.3	9,144.0
건설가계정	34,901.4	1,398.2	988.4	409.8	12,352.3	7,006.8
구축물	*397.9*	*8,671.1*	*3,390.3*	*5,280.8*	*46,221.0*	*2,137.2*
운수설비	9,150.1	37,383.0	31,911.9	5,471.1	67,384.9	4,464.8
선박	957.4	994.3	988.9	5.4	28,609.5	123.5
차량운반구	8,192.7	36,388.7	30,923.0	5,465.7	38,775.4	4,341.3
기계설비	15,087.1	90,218.4	27,069.0	63,149.4	32,984.0	48,498.8
기계 및 장치	7,620.3	8,913.2	4,515.4	4,397.8	23,720.1	16,199.4
공구와기구・비품	7,466.8	81,305.2	22,553.6	58,751.6	9,263.9	32,299.4

	J. 금융 및보험업	K.부동산	가계	*L+M+N+O.서비스업*	L.공공행정,국방, 사회보장	M.교육서비스업
주거용	184.7	480.2	485,026.4	*11,175.1*	4,897.2	2,197.3
비주거용	19,881.1	16,093.7		*132,482.8*	43,135.5	43,817.0
구축물+건설가계정	4,855.6	4,288.4		245,000.1	223,886.8	10,870.7
건설가계정	4,206.8	2,800.0		*7,585.7*	0.0	4,588.6
구축물	*648.8*	*1,488.4*		*237,414.4*	*223,886.8*	*6,282.1*
운수설비	742.9	3,721.9		*10,622.9*	6,072.4	1,314.0
선박	26.4	97.1		*3,912.6*	3,768.0	73.8
차량운반구	716.5	3,624.8		*6,710.3*	2,304.4	1,240.2
기계설비	32,589.0	15,909.8		*78,956.8*	22,932.3	25,564.2
기계 및 장치	8,703.4	7,496.0		*22,960.2*	4,341.3	6,110.2
공구와기구・비품	23,885.6	8,413.8		55,996.6	18,591.0	19,454.0

	N.보건및사회 복지사업	O.기타 공공행정	서비스업	정부		
주거용	2,884.3	1,196.3	5,819.8	5,355.3		
비주거용	10,255.9	35,274.4	85,033.3	47,449.5		
구축물+건설가계정	1,146.1	9,096.5	10,268.1	234,732.0		
건설가계정	466.5	2,530.6	7,405.7	180.0		
구축물	*679.6*	*6,565.9*	2,862.4	234,552.0		
운수설비	594.0	2,642.5	4,363.1	6,259.8		
선박	0.5	70.3	70.2	3,842.4		
차량운반구	593.5	2,572.2	4,292.9	2,417.4		
기계설비	8,118.8	22,341.5	48,612.9	30,343.9		
기계 및 장치	3,311.5	9,197.2	17,806.2	5,154.0		
공구와기구・비품	4,807.3	13,144.3	30,806.7	25,189.9		

3. 97년 제조업 자산형태 및 산업중분류별 국부자료(종합편 4-1표)

	건물+구축물+건설가계정	건물	구축물	건설중인 자산	기계+공구	기계 및 장치	공구와 기구·비품	차량+선박	차량 운반구	선박
제조업	275758.0	124458.7	110196.2	41103.1	438901.5	382357.7	56543.8	15035.1	12655.1	2380.0
15. 음식료품 제조업	14521.7	11691.3	2450.5	379.9	21610.0	18297.3	3312.7	3234.3	1152.1	2082.2
16. 담배제조업	72.3	68.4	3.9	-	23.3	21.7	1.6	0.4	0.4	-
17. 섬유제품제조업	15898.0	14014.9	1741.1	142.0	29146.3	27055.8	2090.5	668.1	668.1	-
18. 의복 및 모피제품	2098.8	1946.3	79.1	73.4	2250.0	1217.1	1032.9	347.5	347.5	-
19.가죽,가방,마구류,신발	1530.6	1355.4	161.1	14.1	1259.3	862.8	396.5	146.2	146.2	-
20.목재 및나무제품	1774.4	1621.3	136.2	16.9	1892.2	1695.2	197.0	284.0	281.9	2.1
21.펄프, 종이및종이제품	6487.0	4243.2	1377.8	866.0	17666.2	16652.6	1013.6	316.0	316.0	-
22.출판,인쇄 및기록매체	2723.7	2403.3	117.8	202.6	5740.5	5104.8	635.7	283.8	283.8	-
23.코크스, 석유정제품 및 핵연료 제조업	7195.2	849.1	4779.3	1566.8	20620.0	19858.9	761.1	97.3	91.2	6.1
24.화합물 및 화학제품	27157.4	10839.2	5905.9	10412.3	52231.3	48558.6	3672.7	625.1	620.5	4.6
25.고무 및 플라스틱	6548.3	5370.3	659.7	518.3	13645.2	12006.2	1639.0	439.5	439.5	-
26.비금속 광물제품	16604.5	8594.9	5254.2	2755.4	34913.0	22228.3	12684.7	1773.0	1741.8	31.2
27.제1차 금속 산업	30242.3	10118.6	5183.9	14939.8	49374.0	47274.3	2099.7	558.6	558.6	-
28.조립금속제품 제조업	10154.5	8910.9	993.2	250.4	14417.2	12219.2	2198.0	1175.1	1128.1	47.0
29.달리 분류되지않은제조	15001.1	10734.2	4053.8	213.1	26169.6	19238.2	6931.4	1492.3	1492.3	-
30.사무계산 및회계용기계	760.2	724.9	34.9	0.4	1286.9	674.3	612.6	63.5	63.5	-
31. 달리 분류되지 않은 전기기계및전기변환장치	4160.1	3570.5	357.5	232.1	8625.3	6739.5	1885.8	360.6	360.6	-
32. 영상, 음향 및 통신장비 제조업	15188.3	8772.0	1292.8	5123.5	42959.9	36193.7	6766.2	439.8	439.8	-
33. 의료, 정밀,광학기기	1292.0	1049.4	73.5	169.1	1759.0	1190.4	568.6	124.5	124.5	-
34. 자동차 및 트레일러	17269.5	11476.8	2858.2	2934.5	32737.2	27260.2	5477.0	1026.1	1025.7	0.4
35. 기타 운송장비제조업	75132.7	2518.5	72334.9	279.3	55821.5	54383.7	1437.8	1011.5	805.1	206.4
36. 가구 및 기타 제조업	3766.6	3446.8	307.7	12.1	4532.2	3420.4	1111.8	509.1	509.1	-
37. 재생재료	178.6	138.4	39.0	1.2	221.4	204.6	16.8	58.7	58.7	-

Ⅲ. 참　　고

Ⅲ. 참고

참고 #1

	W6877G1	W7787G1	W8797G1
1	0.2421204	0.2486822	0.3571192
2	0.2428495	0.2595259	0.3557202
3	0.2435786	0.2703696	0.3543212
4	0.2443077	0.2812133	0.3529221
5	0.2450368	0.292057	0.3515231
6	0.2457658	0.3029007	0.3501241
7	0.2464949	0.3137444	0.3487251
8	0.247224	0.3245881	0.347326
9	0.2479531	0.3354318	0.345927
10	0.2486822	0.3462755	0.344528
11		0.3571192	0.343129

```
wg=w6877g1//w7787g1[2:11]//w8797g1[2:11]//w8797g1[11]//w8797g1[11]
ii95c12=ii95c1[,12];
```

	WG	II95C12
68	0.2421204	2636.2842
69	0.2428495	3254.1572
70	0.2435786	3282.7933
71	0.2443077	3365.4758
72	0.2450368	2971.0823
73	0.2457658	2880.5711
74	0.2464949	2653.0913
75	0.247224	3595.8603
76	0.2479531	4082.3361
77	0.2486822	5482.7416
78	0.2595259	6870.8592
79	0.2703696	7824.5564
80	0.2812133	7450.7992
81	0.292057	7394.3938
82	0.3029007	8486.6263
83	0.3137444	9689.3114
84	0.3245881	10698.727
85	0.3354318	11469.052
86	0.3462755	11117.631
87	0.3571192	11768.833
88	0.3557202	13634.701
89	0.3543212	14593.181
90	0.3529221	16668.403
91	0.3515231	20175.867
92	0.3501241	22563.172
93	0.3487251	22598.524
94	0.347326	23842.376
95	0.345927	24564.169
96	0.344528	28571.96
97	0.343129	29075.674
98	0.343129	29290.603
99	0.343129	29126.91

참고 #2

Deflator 1995

DEF95

연도	총합										
1968	0.0699181	0.069159	0.0520548	0.0847087	0.0873688	0.0699301	0.0718974	0.0764239	0.0739147	0.0664296	0.0604077
1969	0.0645862	0.0639413	0.0486726	0.0782024	0.0805921	0.0645527	0.066393	0.0706363	0.0682823	0.0595192	0.0563824
1970	0.0752981	0.0745329	0.0570175	0.0912038	0.0939197	0.0751121	0.0774749	0.082659	0.079589	0.0672504	0.0664096
1971	0.0805777	0.0812277	0.0610973	0.0972995	0.0988626	0.0793358	0.082277	0.087945	0.0829859	0.069243	0.0713308
1972	0.0906181	0.0884302	0.0713359	0.1092666	0.1115425	0.0908435	0.0938008	0.1004156	0.0923143	0.075487	0.0811847
1973	0.1061227	0.0970732	0.0822597	0.1326589	0.1270774	0.1044643	0.1074653	0.1158672	0.1011122	0.0856637	0.0962634
1974	0.1478621	0.1439742	0.1173848	0.1764087	0.1777162	0.1479374	0.1516347	0.16396	0.139047	0.1147816	0.1348917
1975	0.1815421	0.1656638	0.1497105	0.2192554	0.219398	0.1850038	0.1891148	0.2049201	0.1716446	0.1354427	0.1666222
1976	0.1969203	0.1891214	0.1615385	0.2314385	0.2306888	0.1970095	0.2002365	0.2179669	0.1828244	0.1406819	0.1813538
1977	0.2167238	0.2028823	0.180591	0.2534852	0.2512667	0.2169326	0.2199711	0.240037	0.2032348	0.149406	0.2020457
1978	0.2500336	0.2345139	0.2111601	0.2891075	0.2845823	0.2484655	0.251526	0.2755749	0.2402443	0.1701593	0.231606
1979	0.3043599	0.3013318	0.2577691	0.3443921	0.3371805	0.2979169	0.3003769	0.3303484	0.3019074	0.2055273	0.2815476
1980	0.394166	0.387696	0.3402756	0.4476861	0.4359666	0.3896146	0.3918163	0.4320621	0.3960002	0.2675951	0.3689215
1981	0.4478515	0.448861	0.3977336	0.4986041	0.4821817	0.440269	0.4451433	0.5076565	0.4473385	0.3056872	0.424132
1982	0.4690021	0.4888826	0.4257477	0.5313014	0.5111409	0.4723368	0.4729968	0.529377	0.4673631	0.3189047	0.4453024
1983	0.4849194	0.5050303	0.4511145	0.5537899	0.5276486	0.4918033	0.4882164	0.5554742	0.4806421	0.3245255	0.4560614
1984	0.497845	0.529482	0.4714728	0.5650498	0.5345532	0.508427	0.4674114	0.5728526	0.4962472	0.3344511	0.4730465
1985	0.5205053	0.5239189	0.5094614	0.5980458	0.563215	0.5288715	0.5303078	0.610217	0.5148701	0.342589	0.4877129
1986	0.5409512	0.5428372	0.5340809	0.6332914	0.5946814	0.5457813	0.5643265	0.6253291	0.5278363	0.3435839	0.4923481
1987	0.5610607	0.568565	0.5610045	0.6427168	0.6026565	0.5558521	0.5703929	0.6393393	0.5475833	0.3569391	0.5148927
1988	0.5981152	0.6283203	0.5902497	0.665167	0.6334376	0.580742	0.5939677	0.6812458	0.6131671	0.3904413	0.5507314
1989	0.6272605	0.6554182	0.7231448	0.6863833	0.6709145	0.6441771	0.6676547	0.7020973	0.6061702	0.4312744	0.5949014
1990	0.7046745	0.7187288	0.7239991	0.7241086	0.7241187	0.7241104	0.724108	0.7241129	0.7241098	0.5271142	0.7111272
1991	0.7890659	0.8022286	0.8089045	0.7826478	0.7955263	0.795588	0.8053881	0.7692411	0.8443112	0.6102068	0.8052179
1992	0.8543479	0.8821969	0.8543742	0.8331701	0.8438314	0.8460559	0.8750384	0.8234215	0.9277619	0.6795747	0.8772202
1993	0.8931365	0.9360959	0.856681	0.8694664	0.8538515	0.8725502	0.9049316	0.8388721	0.9414002	0.7437	0.9391698
1994	0.937232	1.0484868	0.9779319	0.9082025	0.8509268	0.9130682	0.987246	0.8742398	0.9933707	0.7937299	0.9806915
1995	1	1	1	1	1	1	1	1	1	0.8797614	1.063592
1996	1.0347396	1.221551	0.9781497	0.9842743	0.9886472	1.0273919	1.0767782	0.8931497	1.117747	0.9202145	1.0886433
1997	1.1040443	0.8213432	1.0838471	1.0492425	1.0860268	1.1092983	1.1152491	1.054272	1.226154	1.0347445	1.1979831
1998	1.1599927	0.5872373	1.1486579	1.1639362	1.1428336	1.1256273	1.0605665	1.195558	1.3721835	1.0668657	1.2351717
1999	1.155449	0.5716136	1.1275611	1.142704	1.1219947	1.0944902	1.0412341	1.1737519	1.3471533	1.0965879	1.2695829

참고 #3. 폐기율과 감가상각율의 계산

1) 다항식 기준년 접속법에서 폐기율과 감가상각율의 계산

o t기와 t-s기의 자본스톡이 있고, 이 기간중에 폐기율이 동일하다고 가정하면 다항식 기준년 접속 방정식은 다음과 같다.

$$\begin{aligned} S_t &= (1-d)S_{t-1} + I_t \\ &= (1-d)[(1-d)S_{t-2} + I_{t-1}] + I_t \\ &= (1-d)^2 S_{t-2} + (1-d)I_{t-1} + I_t \\ &= (1-d)^s S_{t-s} + (1-d)^{s-1} I_{t-s+1} + \cdots + (1-d)^2 I_{t-2} + (1-d)^1 I_{t-1} + I_t \end{aligned}$$

*t기의 스톡은 t-s기의 스톡과 t기~t-s기까지의 투자자료로 구해짐을 의미

2) polyroot

o 방정식 $ax^n + bx^{n-1} + cx^{n-3} + \cdots + gx + h = 0$ 를 풀어주는 함수

o 예 : di=polyroot(dsi)

- dsi벡터에는 x의 계수인 $a, b, c, \cdots, g, h$ 만을 대입
- 그러면 x의 값을 풀어서 di벡터에 넣어준다
- 이때 x의 근의 개수는 n개가 있다.

3) polyroot를 이용한 폐기율과 감가상각율의 계산(depr procedure)

o 다항식 기준년 접속방정식에서 S_t를 우변으로 이항한다.

$$0 = (1-d)^n S_{t-n} + (1-d)^{n-1} I_{t-n+1} + \cdots + (1-d)^2 I_{t-2} + (1-d)^1 I_{t-1} + I_t - S_t$$

o dsi벡터를 위와 같이 구성한다.

- c는 투자자료인데, 위 식에서 상수의 계수는 $I_t - S_t$이므로
  t년도 경우 t년도 투자자료에서 t년도 자본스톡을 빼야 한다.
  이것이 c[n,]=c[n,]-b; 가 필요한 이유이다.
- a는 위 식에서 n_{t-n}으로 t-n연도의 자본스톡
- a와 c를 합치면 바로 dsi벡터가 된다.

o SAS에서 j(n, 2*k, 0)는 횡이 n개, 열이 2*k개, 모든 값이 0인 벡터를 만드는 함수이다.

o polyroot에서 n개의 값을 실수부와 허수부로 나누어 제시하므로 산업수(k)보다 두배의 열이 필요하다.

- 이것이 d= j(n, 2*k, 0)

o polyroot(dsi)에서 계산된 값은 1-d이므로 di[,1]=1-di[,1]; 식이 필요함

o 11개 산업(k개)의 값을 동시에 보기 위해서 d[,2*i-1:2*i]=di; 식이 필요함

o 자산의 합계에 대해서만 감가율과 폐기율을 계산한다.

- r1=depr(w68gc[1,],w77gc[1,],i1c[,2:12]); 식에서 1이 들어간 이유

4) n차 방정식의 n개의 근 가운데 어느 것을 이용할 것인가의 문제

o 다행히 실근은 1개(9번째) 밖에 없다.

o 홀수번째 열은 실수부분, 짝수번째 열은 허수부분이므로 홀수번째 만 취한다.

참고 #4

1ST GROSS(68-77)

R1

0.1391154 0.7292099 0.1392084 0.7796374 0.1473056 0.6947279 0.0896507 0.7569979 0.0990908 0.7908754 0.0488621
: 0.8026283 0.0923936 0.7809821 -0.052525 0.8414482 0.1337477 0.7326611 0.1856494 0.7009506 0.221089 0.6581901

0.1391154 -0.72921 0.1392084 -0.779637 0.1473056 -0.694728 0.0896507 -0.756998 0.0990908 -0.790875 0.0488621
: -0.802628 0.0923936 -0.780982 -0.052525 -0.841448 0.1337477 -0.732661 0.1856494 -0.700951 0.221089 -0.65819

1.56811 0.9835235 1.5981969 1.0106818 1.5414178 0.9523175 1.5921088 1.0339842 1.603888 1.0241461 1.6365127
: 1.0975529 1.6078555 1.0443743 1.6462383 1.1456831 1.5715681 0.9873628 1.5460959 0.9414945 1.5161831 0.8946207

1.56811 -0.983523 1.5981969 -1.010682 1.5414178 -0.952317 1.5921088 -1.033984 1.603888 -1.024146 1.6365127
: -1.097553 1.6078555 -1.044374 1.6462383 -1.145683 1.5715681 -0.987363 1.5460959 -0.941495 1.5161831 -0.894621

2.0693712 0.3874488 2.1285787 0.4214902 2.0399711 0.3798691 2.1258635 0.4028593 2.122787 0.3992052 2.1918544
: 0.4359519 2.1320766 0.4118807 2.249826 0.457703 2.0713948 0.3891384 2.0226291 0.3685543 1.9696635 0.3498071

2.0693712 -0.387449 2.1285787 -0.42149 2.0399711 -0.379869 2.1258635 -0.402859 2.122787 -0.399205 2.1918544
: -0.435952 2.1320766 -0.411881 2.249826 -0.457703 2.0713948 -0.389138 2.0226291 -0.368554 1.9696635 -0.349807

0.8078636 1.1191675 0.8633398 1.1707078 0.800755 1.0792149 0.7934588 1.17556 0.7934214 1.1627279 0.7714771
: 1.2402436 0.7977823 1.1816538 0.7772011 1.2826102 0.8094382 1.1253069 0.8116856 1.0714137 0.8156682 1.0156802

0.8078636 -1.119168 0.8633398 -1.170708 0.800755 -1.079215 0.7934588 -1.17556 0.7934214 -1.162728 0.7714771
: -1.240244 0.7977823 -1.181654 0.7772011 -1.28261 0.8094382 -1.125307 0.8116856 -1.071414 0.8156682 -1.01568

-0.006743 0 0.1595149 0 0.0116773 0 -0.068356 0 0.0275657 0 -0.133433
: 0 -0.087813 0 -0.100829 0 -0.055393 0 0.0519717 0 0.121533 0

1ST NET

D1

0.1428067 0.7329379 1.5643671 0.9595378 0.1313459 0.676189 0.0845339 0.7567043 0.1232007 0.7605416 0.058291
: 0.7930853 0.1173599 0.7671461 2.2583916 0.4632605 0.1256039 0.7583065 0.2085026 0.6809739 0.2116138 0.6782948

0.1428067 -0.732938 1.5643671 -0.959538 0.1313459 -0.676189 0.0845339 -0.756704 0.1232007 -0.760542 0.058291
: -0.793085 0.1173599 -0.767146 2.2583916 -0.46326 0.1256039 -0.758306 0.2085026 -0.680974 0.2116138 -0.678295

1.5737842 0.9911774 0.4655802 0 1.5252303 0.9469851 1.5942484 1.043601 1.5812229 0.9881383 1.6397344
: 1.0992093 1.6008344 1.0274126 0.128247 0 1.5967959 1.0201481 1.5357237 0.9237023 1.5336179 0.9200717

1.5737842 -0.991177 2.1090879 0.4304136 1.5252303 -0.946985 1.5942484 -1.043601 1.5812229 -0.988138 1.6397344
: -1.099209 1.6008344 -1.027413 0.7809504 1.2603056 1.5967959 -1.020148 1.5357237 -0.923702 1.5336179 -0.920072

2.0806311 0.3892879 2.1090879 -0.430414 2.0416378 0.3821947 2.1400176 0.4014841 2.0818352 0.3840467 2.194693
: 0.4383684 2.1119022 0.4047928 0.7809504 -1.260306 2.1091402 0.4004829 2.0026881 0.3591485 1.9987473 0.3577373

2.0806311 -0.389288 0.9207618 1.1086852 2.0416378 -0.382195 2.1400176 -0.401484 2.0818352 -0.384047 2.194693
: -0.438368 2.1119022 -0.404793 1.6298567 1.1488856 2.1091402 -0.400483 2.0026881 -0.359149 1.9987473 -0.357737

0.8132259 1.1282097 0.9207618 -1.108685 0.7886004 1.0674972 0.7937771 1.1865316 0.7954317 1.1190855 0.7648719
: 1.2381465 0.8039392 1.1557247 1.6298567 -1.148886 0.8229582 1.1658626 0.8120416 1.0504602 0.8127807 1.0463306

0.8132259 -1.12821 0.1737955 0.7449344 0.7886004 -1.067497 0.7937771 -1.186532 0.7954317 -1.119085 0.7648719
: -1.238147 0.8039392 -1.155725 -0.093871 0.851258 0.8229582 -1.165863 0.8120416 -1.05046 0.8127807 -1.046331

0.1007867 0 0.1737955 -0.744934 0.1834601 0 0.0214637 0 0.1027547 0 -0.049322
: 0 0.0228474 0 -0.093871 -0.851258 0.0373807 0 0.1640642 0 0.1673398 0

2ND GROSS(77-87)

R2

0.0971244 0.6686135 0.0820316 0.7036868 0.0999504 0.672109 0.085244 0.6842333 0.0764877 0.719747 0.1057581
: 0.6689596 0.1008838 0.6567175 0.0660619 0.6941483 0.1189382 0.6452328 0.0624988 0.6902622 0.1165216 0.6504407

0.0971244 -0.668613 0.0820316 -0.703687 0.0999504 -0.672109 0.085244 -0.684233 0.0764877 -0.719747 0.1057581
: -0.66896 0.1008838 -0.656717 0.0660619 -0.694148 0.1189382 -0.645233 0.0624988 -0.690262 0.1165216 -0.650441

1.9157998 0.6649325 1.9600553 0.6947228 1.9147863 0.6650152 1.9400897 0.6848207 1.9483788 0.6888561 1.9039706
: 0.657215 1.9012968 0.6569957 1.9441361 0.681966 1.8881048 0.6442002 1.9445169 0.6852518 1.891214 0.6464206

1.9157998 -0.664932 1.9600553 -0.694723 1.9147863 -0.665015 1.9400897 -0.684821 1.9483788 -0.688856 1.9039706
: -0.657215 1.9012968 -0.656996 1.9441361 -0.681966 1.8881048 -0.6442 1.9445169 -0.685252 1.891214 -0.646421

1.3517359 1.076905 1.3733872 1.1237301 1.3578048 1.0759813 1.3651284 1.1083546 1.3660224 1.115147 1.3524223
: 1.0653401 1.3481359 1.0639114 1.3578061 1.0996581 1.3380178 1.0433446 1.3632398 1.112345 1.3433842 1.0505591

1.3517359 -1.076905 1.3733872 -1.12373 1.3578048 -1.075981 1.3651284 -1.108355 1.3660224 -1.115147 1.3524223
: -1.06534 1.3481359 -1.063911 1.3578061 -1.099658 1.3380178 -1.043345 1.3632398 -1.112345 1.3433842 -1.050559

0.6593373 1.0802515 0.6573721 1.1306719 0.6619108 1.0785269 0.6527372 1.1105494 0.6573834 1.1258041 0.6622095
: 1.0709 0.6584351 1.0579832 0.6484273 1.1091744 0.6676945 1.0455846 0.647269 1.1168334 0.6696243 1.0557411

0.6593373 -1.080251 0.6573721 -1.130672 0.6619108 -1.078527 0.6527372 -1.110549 0.6573834 -1.125804 0.6622095
: -1.0709 0.6584351 -1.057983 0.6484273 -1.109174 0.6676945 -1.045585 0.647269 -1.116833 0.6696243 -1.055741

-0.012399 0 -0.04032 0 0.0108982 0 -0.058738 0 0.0240393 0 0.0116104
: 0 -0.030332 0 -0.003771 0 -0.025158 0 -0.002689 0 0.1120459 0

2.1310679 0 2.1823792 0 2.1289958 0 2.1625188 0 2.1593589 0 2.1216161
: 0 2.1219618 0 2.1549315 0 2.0980666 0 2.1667602 0 2.1007666 0

2ND NET

D2

0.110525 0.6653438 0.1403067 0.6749958 0.1192103 0.6717277 0.1262504 0.6533555 0.1024357 0.7098013 0.1344011
: 0.6482977 0.1040139 0.6575638 0.0747164 0.7054982 0.1081513 0.6643079 0.0734399 0.683402 0.1204092 0.6481866

0.110525 -0.665344 0.1403067 -0.674996 0.1192103 -0.671728 0.1262504 -0.653356 0.1024357 -0.709801 0.1344011
: -0.648298 0.1040139 -0.657564 0.0747164 -0.705498 0.1081513 -0.664308 0.0734399 -0.683402 0.1204092 -0.648187

1.9132448 0.6627872 1.9461869 0.6814137 1.9137844 0.664888 1.9107498 0.6667881 1.927002 0.6736853 1.8729214
: 0.6366352 1.9008145 0.6590124 1.9532187 0.6831645 1.9127892 0.6597399 1.9362434 0.6787937 1.8889402 0.6444969

1.9132448 -0.662787 1.9461869 -0.681414 1.9137844 -0.664888 1.9107498 -0.666788 1.927002 -0.673685 1.8729214
: -0.636635 1.9008145 -0.659012 1.9532187 -0.683165 1.9127892 -0.65974 1.9362434 -0.678794 1.8889402 -0.644497

1.3525078 1.0742194 1.3758966 1.0988786 1.3691654 1.0740745 1.3572858 1.0782625 1.3577732 1.0905763 1.3446886
: 1.0326589 1.3525807 1.0677516 1.3575545 1.0976713 1.3476591 1.0706391 1.3618459 1.1049862 1.3435407 1.0490607

1.3525078 -1.074219 1.3758966 -1.098879 1.3691654 -1.074074 1.3572858 -1.078262 1.3577732 -1.090576 1.3446886
: -1.032659 1.3525807 -1.067752 1.3575545 -1.097671 1.3476591 -1.070639 1.3618459 -1.104986 1.3435407 -1.049061

0.6692299 1.0791758 0.6953202 1.1060924 0.677459 1.0775954 0.6689828 1.0793575 0.6714625 1.1039687 0.6748922
: 1.0410901 0.6612262 1.0552292 0.6576526 1.1169026 0.6703558 1.0753168 0.6569683 1.111676 0.6741747 1.0552473

0.6692299 -1.079176 0.6953202 -1.106092 0.677459 -1.077595 0.6689828 -1.079358 0.6714625 -1.103969 0.6748922
: -1.04109 0.6612262 -1.055229 0.6576526 -1.116903 0.6703558 -1.075317 0.6569683 -1.111676 0.6741747 -1.055247

0.0912239 0 0.1596552 0 0.1629709 0 0.0651132 0 0.1255389 0 0.1445555
: 0 0.0535369 0 0.1414603 0 0.0205196 0 0.1418596 0 0.1833954 0

2.1270869 0 2.1588166 0 2.1253254 0 2.1280267 0 2.1267977 0 2.0882202
: 0 2.1300018 0 2.1511659 0 2.1284366 0 2.1561437 0 2.0977309 0

3RD GROSS(87-97)

R3

0.0918429 0.6663135 0.1206506 0.6469958 0.2214587 0.5743482 0.0851161 0.6760271 0.0825522 0.6552861 0.0440197
: 0.719218 0.0563569 0.6999026 0.1065786 0.6476467 0.1048179 0.6474467 0.1009354 0.6603702 0.0791837 0.6860601

0.0918429 -0.666313 0.1206506 -0.646996 0.2214587 -0.574348 0.0851161 -0.676027 0.0825522 -0.655286 0.0440197
: -0.719218 0.0563569 -0.699903 0.1065786 -0.647647 0.1048179 -0.647447 0.1009354 -0.66037 0.0791837 -0.68606

1.9097273 0.6603049 1.880611 0.6416845 1.2967727 0.9157235 1.9240461 0.6710805 1.9021857 0.6600938 1.9597964
: 0.6962966 1.9573806 0.6944949 1.893235 0.6480122 1.3355042 1.0361899 1.9000267 0.6543724 1.9281494 0.6739942

1.9097273 -0.660305 1.880611 -0.641684 1.2967727 -0.915723 1.9240461 -0.671081 1.9021857 -0.660094 1.9597964
: -0.696297 1.9573806 -0.694495 1.893235 -0.648012 1.3355042 -1.03619 1.9000267 -0.654372 1.9281494 -0.673994

1.3480935 1.067532 1.3366472 1.0396722 1.7787964 0.5675597 1.3550607 1.0846453 1.3454234 1.0671261 1.3710481
: 1.1251489 1.3685146 1.1212291 1.341686 1.0500815 0.6571956 1.0398224 1.3454481 1.0577042 1.3581699 1.0894133

1.3480935 -1.067532 1.3366472 -1.039672 1.7787964 -0.56756 1.3550607 -1.084645 1.3454234 -1.067126 1.3710481
: -1.125149 1.3685146 -1.121229 1.341686 -1.050082 0.6571956 -1.039822 1.3454481 -1.057704 1.3581699 -1.089413

0.6512585 1.0688503 0.6604181 1.0394941 0.706246 0.9180673 0.6455685 1.0877681 0.6509728 1.0598447 0.634152
: 1.1215481 0.6404875 1.1249782 0.6544789 1.0506694 1.8865368 0.6411173 0.6578627 1.05526 0.6505643 1.0872536

0.6512585 -1.06885 0.6604181 -1.039494 0.706246 -0.918067 0.6455685 -1.087768 0.6509728 -1.059845 0.634152
: -1.121548 0.6404875 -1.124978 0.6544789 -1.050669 1.8865368 -0.641117 0.6578627 -1.05526 0.6505643 -1.087254

-0.021223 0 0.004963 0 0.1106946 0 -0.056474 0 -0.00662 0 -0.083922
: 0 -0.117203 0 0.0031513 0 0.0102858 0 0.0132458 0 0.0162365 0

2.1236446 0 2.0870374 0 1.9628552 0 2.142337 0 2.1180827 0 2.1849139
: 0 2.1799411 0 2.1058445 0 2.0915806 0 2.1136444 0 2.1481937 0

3RD NET

D3

0.0914984 0.6749716 0.1065857 0.6859124 0.2407933 0.5671588 0.1000128 0.6764135 0.0768481 0.6509635 0.0120427
: 0.7769335 0.0600657 0.711273 0.1163788 0.6289728 0.094092 0.6574979 0.0916855 0.681661 0.0860862 0.6858587

0.0914984 -0.674972 0.1065857 -0.685912 0.2407933 -0.567159 0.1000128 -0.676414 0.0768481 -0.650963 0.0120427
: -0.776933 0.0600657 -0.711273 0.1163788 -0.628973 0.094092 -0.657498 0.0916855 -0.681661 0.0860862 -0.685859

1.9142774 0.662756 1.9115802 0.6666995 1.2851623 0.8904023 1.9217268 0.6691331 1.8945546 0.6583082 2.0115197
: 0.7310169 1.9694381 0.7017637 1.8756412 0.6350471 1.8922291 0.6424862 1.9182795 0.6669358 1.9239429 0.6710489

1.9142774 -0.662756 1.9115802 -0.6667 1.2851623 -0.890402 1.9217268 -0.669133 1.8945546 -0.658308 2.0115197
: -0.731017 1.9694381 -0.701764 1.8756412 -0.635047 1.8922291 -0.642486 1.9182795 -0.666936 1.9239429 -0.671049

1.3506057 1.0706718 1.351736 1.0826876 0.7184686 0.8947425 1.3567892 1.0796139 1.342912 1.0634083 1.3969537
: 1.1799494 1.37635 1.1304562 1.3343198 1.0309322 1.3350456 1.0376642 1.3555059 1.0772907 1.3576979 1.0839345

1.3506057 -1.070672 1.351736 -1.082688 0.7184686 -0.894743 1.3567892 -1.079614 1.342912 -1.063408 1.3969537
: -1.179949 1.37635 -1.130456 1.3343198 -1.030932 1.3350456 -1.037664 1.3555059 -1.077291 1.3576979 -1.083935

0.6488748 1.0737958 0.6504687 1.0855984 1.7564071 0.5553322 0.6442927 1.0873978 0.6494059 1.0504371 0.6199121
: 1.1766257 0.6433715 1.1378937 0.6515972 1.0319488 0.651792 1.0448536 0.6554021 1.07381 0.653277 1.0804321

0.6488748 -1.073796 0.6504687 -1.085598 1.7564071 -0.555332 0.6442927 -1.087398 0.6494059 -1.050437 0.6199121
: -1.176626 0.6433715 -1.137894 0.6515972 -1.031949 0.651792 -1.044854 0.6554021 -1.07381 0.653277 -1.080432

0.0646667 0 0.092243 0 0.2484894 0 0.0504657 0 0.0862817 0 -0.077421
: 0 -0.073925 0 0.1695309 0 0.0875897 0 0.0870674 0 0.0814194 0

2.1283305 0 2.1222493 0 1.9363324 0 2.1397744 0 2.1110452 0 2.246435
: 0 2.1911441 0 2.0871582 0 2.0949473 0 2.1365546 0 2.1435641 0

참고 #5

예) $a=\begin{bmatrix} 0.05 & \underline{0} \\ 3 & -1.2 \\ 2 & \underline{0} \\ -4 & 3 \\ 6 & 0.5 \end{bmatrix}$ $z=\begin{bmatrix} 0 & \underline{1} \\ 0 & 0 \\ 0 & \underline{1} \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$

$c=\begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$ $d=\begin{bmatrix} 0.05 & 0 \\ 0 & 0 \\ 2 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$

$z=\begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$ $f=\begin{bmatrix} \underline{0.05} & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$ /*최종 적합한 근*/

참고 #6

W68G1

4703.743	160.098	33.338	715.616	119.847	37.656	172.734	93.077	24.35	1791.458	376.635	1178.934
2030.993	28.513	1.996	26.184	0.055	6.959	19.048	1.208	1.838	1791.458	123.996	29.737
867.631	12.17	6.419	234.833	40.028	4.52	106.764	12.351	17.535	0	175.352	257.66
772.75	5.071	8.94	30.526	34.532	0.167	1.685	0.253	0.295	0	4.414	686.867
299.171	89.108	3.14	23.217	0.504	4.789	10.695	73.293	1.064	0	6.38	86.981
733.198	25.236	12.843	400.856	44.728	21.221	34.542	5.972	3.618	0	66.493	117.689

W68G11=W68G1[1,]

4703.743	160.098	33.338	715.616	119.847	37.656	172.734	93.077	24.35	1791.458	376.635	1178.934

W68G11I=1/W68G11

0.0002126	0.0062462	0.0299958	0.0013974	0.008344	0.0265562	0.0057892	0.0107438	0.0410678	0.0005582	0.0026551	0.0008482

R1=W68G1#W68G11I

1	1	1	1	1	1	1	1	1	1	1	1
0.4317823	0.1780972	0.0598716	0.0365895	0.0004589	0.1848045	0.1102736	0.0129785	0.0754825	1	0.3292206	0.0252236
0.1844554	0.0760159	0.192543	0.328155	0.3339925	0.120034	0.6180833	0.1326966	0.7201232	0	0.4655754	0.2185534
0.1642841	0.0316743	0.2681625	0.042657	0.288134	0.0044349	0.0097549	0.0027182	0.012115	0	0.0117196	0.582617
0.0636028	0.5565841	0.0941868	0.0324434	0.0042054	0.1271776	0.061916	0.7874448	0.0436961	0	0.0169395	0.0737794
0.1558754	0.1576285	0.3852361	0.5601552	0.3732092	0.563549	0.1999722	0.0641619	0.1485832	0	0.1765449	0.0998266

W77G1

45236.7	1950.9	294.5	10796.4	1710.4	1010.1	2707.8	3477.1	3161.3	12862.2	1806.9	5459
13392.7	4.3	15.6	110.8	0.7	121.2	54.4	9.9	21.4	12862.2	49	143.3
12472.4	451.7	46	3394.1	691.4	313.5	1890.1	263.2	2866.6	0	1215.6	1340.4
6461.2	301.9	80.6	589.9	386.7	45.5	23.3	1315.8	21.5	0	99.1	3596.8
2986.6	696.6	39.7	406.8	4.7	122.6	159.7	1368	54.7	0	43.2	90.7
9923.8	496.4	112.6	6294.9	626.9	407.4	580.3	520.3	197.2	0	400	287.9

W77G11

45236.7	1950.9	294.5	10796.4	1710.4	1010.1	2707.8	3477.1	3161.3	12862.2	1806.9	5459

W77G11I

0.0000221	0.0005126	0.0033956	0.0000926	0.0005847	0.00099	0.0003693	0.0002876	0.0003163	0.0000777	0.0005534	0.0001832

R2

1	1	1	1	1	1	1	1	1	1	1	1
0.2960583	0.0022041	0.0529711	0.0102627	0.0004093	0.1199881	0.0200901	0.0028472	0.0067694	1	0.0271183	0.0262502
0.2757142	0.2315342	0.1561969	0.3143733	0.4042329	0.3103653	0.6980205	0.0756953	0.9067789	0	0.6727544	0.2455395
0.1428309	0.1547491	0.2736842	0.0546386	0.2260875	0.045045	0.0086048	0.3784188	0.006801	0	0.0548453	0.6588753
0.0660216	0.357066	0.1348048	0.0376792	0.0027479	0.1213741	0.0589778	0.3934313	0.017303	0	0.0239084	0.0166148
0.219375	0.2544467	0.382343	0.5830555	0.3665225	0.4033264	0.2143068	0.1496362	0.0623794	0	0.2213736	0.0527386

R1

1	1	1	1	1	1	1	1	1	1	1	1
0.4317823	0.1780972	0.0598716	0.0365895	0.0004589	0.1848045	0.1102736	0.0129785	0.0754825	1	0.3292206	0.0252236
0.1844554	0.0760159	0.192543	0.328155	0.3339925	0.120034	0.6180833	0.1326966	0.7201232	0	0.4655754	0.2185534
0.1642841	0.0316743	0.2681625	0.042657	0.288134	0.0044349	0.0097549	0.0027182	0.012115	0	0.0117196	0.582617
0.0636028	0.5565841	0.0941868	0.0324434	0.0042054	0.1271776	0.061916	0.7874448	0.0436961	0	0.0169395	0.0737794
0.1558754	0.1576285	0.3852361	0.5601552	0.3732092	0.563549	0.1999722	0.0641619	0.1485832	0	0.1765449	0.0998266

D1=R2-R1

0	-1.11E-16	0	0	1.11E-16	0	0	-1.11E-16	0	0	0	0
-0.135724	-0.175893	-0.0069	-0.026327	-0.00005	-0.064816	-0.090183	-0.010131	-0.068713	0	-0.302102	0.0010266
0.0912587	0.1555182	-0.036346	-0.013782	0.0702404	0.1903313	0.0799372	-0.057001	0.1866557	0	0.207179	0.0269861
-0.021453	0.1230747	0.0055218	0.0119816	-0.062047	0.0406102	-0.00115	0.3757006	-0.005314	0	0.0431257	0.0762582
0.0024189	-0.199518	0.0406179	0.0052358	-0.001457	-0.005803	-0.002938	-0.394013	-0.026393	0	0.0069689	-0.057165
0.0634995	0.0968182	-0.002893	0.0229003	-0.006687	-0.160223	0.0143346	0.0854743	-0.086204	0	0.0448287	-0.047088

E2=j(1,k+1,0)

0	0	0	0	0	0	0

참고 #7

ST11

1969	5034.5486	2097.9058	979.69951	815.09533	321.56424	820.28375		
1970	6731.4209	2703.4828	1378.1586	1073.774	431.75521	1144.2503		
1971	8160.8717	3154.5113	1753.5675	1282.3424	525.63391	1444.8167		
1972	10244.644	3805.4807	2305.1973	1585.3518	662.60104	1886.0128		
1973	13522.185	4819.0371	3179.8059	2060.3165	878.21943	2584.8056		
1974	21221.362	7242.8429	5205.4856	3182.8218	1383.9581	4206.2536		
1975	29291.835	9555.5585	7482.1443	4323.4249	1918.1492	6012.5583		
1976	35970.943	11191.954	9552.9591	5223.5066	2365.1921	7637.3317		1
1969	215.90804	34.232974	20.143301	9.7912828	115.38458	36.355898		
1970	319.22672	44.375649	35.298669	18.842131	163.52284	57.187427		
1971	401.70554	47.990213	51.360201	29.203697	196.86707	76.28436		
1972	494.36492	49.398166	71.749727	42.700391	231.31798	99.198656		
1973	622.61752	50.04525	101.1224	62.292388	277.52596	131.63152		
1974	1133.3338	68.946506	203.65414	128.88745	480.04846	251.79722		
1975	1365.8508	56.397969	269.03786	174.00823	548.25707	318.14969		
1976	1642.2284	35.714827	351.85459	231.67592	622.7899	400.19313		2
1969	33.00788	1.9509274	6.2221368	8.8717255	3.2578751	12.705215		
1970	40.815598	2.3811076	7.5290954	10.995294	4.2127012	15.697399		
1971	48.125311	2.7706443	8.6831381	12.99398	5.1843534	18.493195		
1972	61.033995	3.4670201	10.765739	16.51681	6.8504087	23.434017		
1973	77.858334	4.3630267	13.418944	21.117524	9.0901424	29.868698		
1974	125.60673	6.9424472	21.14116	34.14539	15.231756	48.145981		
1975	176.42589	9.6160185	28.982161	48.068495	22.190591	67.568622		
1976	221.74156	11.915916	35.530848	60.551119	28.891074	84.852604		3
1969	794.21048	26.736507	259.408	34.935927	26.228911	446.90195		
1970	1093.6651	33.618239	355.54226	49.5644	36.754694	618.18778		
1971	1389.9167	38.658955	449.72304	64.840772	47.519392	789.17888		
1972	1791.9603	44.599503	577.06468	85.982062	62.307216	1022.0142		
1973	2604.9059	57.212772	834.86851	128.45681	92.08911	1492.2921		
1974	4119.9679	78.437069	1314.1347	208.65457	148.04669	2370.7203		
1975	6157.966	99.223767	1954.7596	320.06644	224.86247	3559.0981		
1976	7926.0604	104.52791	2503.879	422.51681	294.03675	4601.1651		4
1969	136.90377	0.0620723	46.793296	38.502812	0.5535596	50.992026		
1970	189.74566	0.0849839	66.335367	52.055947	0.7364941	70.532872		
1971	250.72622	0.1109127	89.611051	67.057191	0.9325861	93.014481		
1972	349.78576	0.1528034	127.74542	91.139403	1.2443975	129.50374		
1973	476.21659	0.205407	177.63591	120.79887	1.6170687	175.95933		
1974	756.72515	0.3222238	288.17566	186.7368	2.4470353	279.04343		
1975	1072.4562	0.450749	416.78214	257.25605	3.2943458	394.67286		
1976	1273.0632	0.5280392	504.67846	296.60021	3.7044051	467.5521		5
1969	45.098542	8.0096238	6.3670986	0.4035023	5.7064438	24.61237		
1970	66.177688	11.276737	10.742614	0.8907096	8.3309731	34.93811		
1971	87.825793	14.333088	16.11408	1.5783704	10.999576	44.803577		
1972	126.58371	19.746709	25.902278	2.8460884	15.772112	62.322087		
1973	176.68609	26.290082	39.891058	4.7698327	21.900851	83.843989		
1974	304.40137	43.101284	75.163254	9.5911772	37.535312	139.03043		
1975	480.56437	64.583897	128.82463	17.3102	58.947845	210.9348		
1976	677.53465	86.175595	195.9548	27.46238	82.672069	285.32943		6

1969	201.01682	20.152582	126.03055	1.9352076	12.380533	40.517944	
1970	287.56726	25.948007	182.84882	2.7316885	17.617253	58.421498	
1971	366.60864	29.406572	236.36324	3.4356775	22.339882	75.06327	
1972	506.55847	35.556377	331.09217	4.6824859	30.702572	104.52487	
1973	693.21374	41.711822	459.24916	6.3192894	41.789456	144.14401	
1974	1144.725	57.409417	768.53952	10.288951	68.634486	239.85265	
1975	1676.7386	67.289004	1140.6126	14.856494	99.985112	353.99531	
1976	2100.5448	63.24845	1447.5665	18.343137	124.57121	446.81546	7

1969	106.80237	1.2659073	13.495879	4.7487209	79.42524	7.8669632	
1970	151.88233	1.6292572	18.230379	13.093352	106.30036	12.629959	
1971	207.28861	1.9902611	23.567916	26.522934	136.0035	19.205984	
1972	320.94674	2.7202487	34.457698	54.463453	196.52458	32.784867	
1973	537.87317	3.9533683	54.340888	113.7283	305.80694	60.052265	
1974	1079.171	6.717085	102.19286	273.23019	566.31565	130.73593	
1975	1732.1612	8.8315979	153.05761	510.86589	833.15196	226.29284	
1976	2504.0163	9.9482072	205.40131	843.03788	1094.7824	350.91046	8

1969	1966.4596	1901.9732	55.968631	0.5771507	1.7701318	6.1718285	
1970	2649.8441	2508.9029	125.24856	1.1249452	3.2178609	11.35351	
1971	3122.9901	2893.1885	206.33955	1.7350328	4.7736633	16.959842	
1972	3901.1842	3534.5541	331.11659	2.678565	7.1889157	25.656877	
1973	4847.872	4293.3989	502.63067	3.9638058	10.456612	37.438837	
1974	7588.0632	6565.4207	929.42731	7.1985948	18.75121	67.296888	
1975	10628.341	8979.1916	1501.6805	11.475513	29.603569	106.44103	
1976	12735.587	10499.72	2038.9035	15.419536	39.474452	142.14032	9

1969	382.03994	112.95151	186.66293	6.3079833	6.7673778	69.350143	
1970	480.321	125.88577	245.73953	10.232311	8.8802304	89.583163	
1971	544.18803	124.35775	290.94202	14.200488	10.482387	104.20538	
1972	635.22095	123.83816	354.23413	19.619795	12.727766	124.80109	
1973	763.80005	123.26661	443.5195	27.2511	15.895499	153.86734	
1974	1069.8535	136.74766	645.86499	43.297044	23.093209	220.85064	
1975	1356.7702	127.87847	850.30779	61.409884	30.336992	286.83709	
1976	1525.3638	92.567	991.08158	76.349898	35.287815	330.07753	10

1969	1150.1202	29.141401	254.81123	679.82471	77.550007	108.79518	
1970	1408.0344	35.836964	316.17453	844.20575	85.997279	125.82564	
1971	1568.6317	40.103374	356.94016	953.78518	85.842579	131.96995	
1972	1809.5601	46.469321	417.18902	1115.6111	87.533627	142.77178	
1973	2162.1801	55.771196	504.96775	1351.3251	90.857515	159.28047	
1974	3019.4715	78.228562	714.2382	1912.7019	107.70344	206.63634	
1975	3875.6041	100.85135	928.37215	2487.8626	113.625	244.94827	
1976	4445.9477	116.20001	1078.3247	2891.6537	102.10735	257.73425	11

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* 1991년 한국표준산업분류의 분류 항목 개정
* 구분류[3233 가죽 및 대용가죽제품 제조업]은 [(5) 가죽, 가방, 마구류 및 신발 제조업]으로 분류
* 구분류[35402 구리스 및 윤활유 제조업]은 [(9) 코크스, 석유정제품 및 핵연료 제조업]으로 분류
* 구분류[35591 고무신 제조업]은 [(5) 가죽, 가방, 마구류 및 신발 제조업]으로 분류
* 구분류[35607 플라스틱 성형 신발 제조업]은 [(5) 가죽, 가방, 마구류 및 신발 제조업]으로 분류
* 구분류[38121 금속가구 제조업]은 [(22) 가구 및 기타 제조업]으로 분류
* 구분류[3832 음향, 영상 및 통신장비 제조업]은 [(18) 영상, 음향 및 통신장비 제조업]으로 분류
* 구분류[3834 전자관 및 기타 전자부품 제조업]은 [(16) 사무, 계산, 회계용기계 제조업]으로 분류
* 구분류[3843 자동차 제조업]은 [(20) 자동차 및 트레일러 제조업]으로 분류

※ 산업비율은 1990년을 기준하여 분류하였다.

참고 #9

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} @ \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} \text{ make}$$

2 by 2 @ 2 by 2 = 4 by 4 matrix

$$\begin{bmatrix} 1* \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} & 2* \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} \\ 3* \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} & 4* \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} \end{bmatrix}$$

부록 . MANUAL ON CAPITAL STOCK STATISTICS

Version 2 of the Capital Stock Manual

This version of the Capital Stock Manual reflects the comments made at the Washington meeting of the Canberra Group.

I have extensively edited the entire document with a view to shortening it, improving the focus and the English. However, to avoid ploughing through the entire manual, readers who read the 1999 version may just want to concentrate on the new material. This is where they will find it:

Chapter 1
Chapter 8
Box 1
Paragraphs: 52-54, 64-66, 80-83, 136-147, 151-160, 162, 186-189, 208-209.

Both ABS and BLS/BEA have been very helpful in supplying material for this revised version. These contributions have been incorporated into Chapters 1 and 8 respectively. I have, however, extensively revised their contributions to make the style and content consistent with the rest of the Manual.

Only the main text of the Manual and Annex 1 are circulated at this point.

Annex 1 contains descriptions of the PIM methods used by 4 countries - Singapore, France, United States (BEA), and Australia. These descriptions were provided by the countries except for the description of the BEA methodology. This is identical to the description included in the first version of the Manual. In Washington, BEA staff said that that description was wrong but I have not yet received the necessary corrections. I will incorporate them later.

I am revising the *Glossary* and drawing up a chapter by chapter *Bibliography* (which will acknowledge the contributions from Canberra Group members as well as some of the big names in capital theory past and present). Peter Hill is finalising a "Research agenda" and Erwin Diewerts an annex on capital stock estimates under high inflation. All these materials will be circulated later.

I would like to get this task out of my in-tray before 2001. Comments and suggestions please.

VERSION 2 - 15/09/2000

MANUAL ON CAPITAL STOCK STATISTICS

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OECD, 15 September 2000.

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CHAPTER 1

CONCEPTS IN CAPITAL MEASUREMENT

Introduction

1. The capital stocks that are the subject of this *Manual* are produced assets used as inputs into the production process. While the national accounts are primarily concerned with the wealth aspects of capital – consumption of fixed capital and net capital stocks – these wealth aspects are not independent of capital's role in production. Indeed, it is the latter that influences the former, as capital assets only exist as wealth to the extent that the assets can be expected to be used in future production processes. The purpose of this Chapter is to explain the links between capital assets as an input into the production process and capital assets as components of the net worth – or wealth – of their owners.

2. This *Manual* is intended to be a practical guide to the measurement of capital stocks, consumption of fixed capital and capital services and this first Chapter is not strictly necessary to follow the guidelines contained in the rest of the *Manual*. However, the theoretical considerations presented here will help readers to understand the conceptual framework underlying those guidelines. It also introduces many of the technical terms that are used in the *Manual*. The Chapter is arranged as follows:

- **How asset values are determined.** This section introduces the standard equation relating asset values to the rentals that an asset is expected to earn during its lifetime. This equation is central to the theoretical basis of measuring capital stocks and flows.

- **Relationship between rentals and asset prices.** This section uses the standard equation for the value of an asset to show how the sequence of rentals generated by an asset determines the changes in the price of an asset over the course of its lifetime.

- **Age-efficiency and age-price profiles.** The standard equation for the value of an asset can be used to derive both an age-efficiency and an age-price profile for an asset. The age efficiency profile is relevant to the measurement of capital services, while the age-price profile is relevant to the measurement of the net capital stock and consumption of fixed capital.

- **Consumption of fixed capital.** This section explains that consumption of fixed capital is the difference between successive market values of assets and can be obtained *indirectly* by using age-efficiency profiles to obtain the age-price profiles of assets and then subtracting successive values of the assets. More commonly consumption of fixed capital is estimated *directly* by applying depreciation functions to the gross value of assets.

- **Aggregating assets to obtain stocks.** This section introduces the two stock concepts covered in this *Manual* - the gross capital stock and the net capital stock. It explains how the values of assets that have been acquired at different times must be converted to a common price basis before they are added up to obtain stocks of assets.

- **Volume index of capital services.** This index is used to represent the input of capital for productivity studies. This section explains how it is calculated using the age-efficiency profiles described earlier and the user costs of capital which are also derived from the standard equation for the value of an asset.

How asset values are determined

3. The value of an asset depends primarily on the value of the **rentals** that it is expected to earn during its lifetime. Rentals are the incomes earned by an asset during each accounting period. They are equal to the quantity of **capital services** produced by the asset, such as *tonne-kilometres* in the case of a truck or cubic metres of storage space in the case of a warehouse, multiplied by the unit price of those services. The lifetime of an asset is the total period that it is in productive use from the moment that it is first installed or constructed. During its lifetime the asset may remain with the original purchaser or it may be traded, as a second-hand asset, between several producers. The lifetime of an asset is referred to in this *Manual* as its **service life.**

4. Because the rentals generated by an asset are received over several years, they have to be discounted in calculating the value of the asset at any point in time. The rentals expected in future periods are discounted using a **discount rate,** which is often taken as the interest rate on long-term bonds.

5. When an asset is **discarded,** or **scrapped,** at the end of its service life it will have a **scrap value.** This will usually be a positive amount corresponding to the value of any parts or waste materials that can be recuperated from the asset minus the cost of dismantling the asset or removing it from the site. In some cases these costs may be so high that the scrap value becomes negative.

6. These three variables – the rentals, the discount rate and the scrap value – *determine* the value of an asset both when it is new and at all the later stages of its service life. The standard formula for the value of an asset can be written as follows:

$$V_t = \sum_t^T \frac{f_t}{(1+r)^t} + \frac{S}{(1+r)^{T-t}} \qquad (1)$$

Where V_t is the value of an asset at time t,

f_t is the rental in period t,

T is the service life of the asset,

r is the discount rate,

and S is the scrap value.

7. This is the central equation for understanding the conceptual framework of this *Manual*. As will be shown later it provides the link between stock measures and consumption of fixed capital on the one hand, and the measurement of capital services on the other. The equation also provides the user costs of capital that are needed to combine the capital services produced by individual assets to construct an overall index of the flow of capital services generated by a stock of assets.

8. Hitherto equation (1) has been described as the equation that determines the *value* of an asset. Value is to be understood as the *market price*, of an asset. In considering whether to purchase an asset, rational producers will first calculate the rentals they expect to receive from an asset and will then solve equation (1) for r. They will buy the asset only if the price at which it is offered implies a **rate of return** – as measured by r – which is at least as high as they can earn from alternative use of their funds. If an asset is offered for sale at a price that does not seem likely to generate a satisfactory rate of return, there will be no market for that asset. If an asset is offered at a price that seems likely to generate a very high rate of return, demand for the asset will rise and bid up the price until the rate of return falls to a "normal" level. In practice, manufacturers of capital goods will themselves calculate the rates of return that assets are likely to earn and will not produce assets that are unlikely to generate rates of return that are sufficiently high to ensure that there will be a market for them. Equation (1) can, therefore, be seen as a very plausible explanation of how asset prices are determined in a market economy.

Relationship between rentals and asset prices.

9. Table 1 shows how equation (1) can be used to calculate the price of an asset both when it is new and at every stage in its lifetime. In this example the asset is expected to have a service life of 8 years and the discount rate is 5%. Two simplifying assumptions are made. First, it is assumed that the rentals are received on the first day of each year, so that the first year's rental is not discounted. Second it is assumed that the scrap value is zero. This is not an unreasonable assumption since scrap values are usually small in relation to the discounted values of the rentals and have a negligible effect on the asset value.

Table 1. Relationship between Rentals and Asset Value (Discount Rate 5%)

				Value of Discounted Rentals at the Beginning of Year:							
Year (t)	Capital service	Price	Rental (f)	1	2	3	4	5	6	7	8
1	5.0	2	10.0	10.0							
2	4.5	2	9.0	8.6	9.0						
3	4.0	2	8.0	7.3	7.6	8.0					
4	3.5	2	7.0	6.0	6.3	6.7	7.0				
5	3.0	2	6.0	4.9	5.2	5.4	5.7	6.0			
6	2.5	2	5.0	3.9	4.1	4.3	4.5	4.8	5.0		
7	2.0	2	4.0	3.0	3.1	3.3	3.5	3.6	3.8	4.0	
8	1.5	2	3.0	2.1	2.2	2.4	2.5	2.6	2.7	2.9	3.0
Asset value (V)				45.8	37.6	30.1	23.2	17.0	11.5	6.9	3.0

To understand Table 1:

- The rentals that the asset is expected to earn each year are shown in the fourth column. They are the quantity of capital services produced by the asset multiplied by the unit price of those services. In this example the capital services are assumed to decline by half a unit each year.

- Because these rentals are generated in sequence and are not all available in the first year, their **present value** has to be obtained by discounting each year's rental by the discount factor

($1+r$), *i.e.* 1.05 in this example. The discounted rentals are shown in the right-hand triangular portion of the table.

- The fifth column shows the value at the start of year 1 of the rentals that are expected to be received in each of the 8 years of the asset's life. This example assumes that rentals are received at the beginning of each year and so the first year's rental of 10 is not discounted. However the rental of 9 expected at the beginning of the second year is worth only 9/1.05 = 8.6 at the beginning of year 1. The rental of 8 expected in year 3 is worth only $8/1.05^2 = 7.3$, etc. The total of these discounted rentals gives the value of the asset at the beginning of year 1, *i.e.* 45.8.

- The sixth column shows the discounted values of the rentals generated by the asset in the second year. The first year's value of 10 has been used up so the price of the asset will be lower for this reason, but this is partly offset by the fact that by the beginning of the second year all the rentals expected from year 2 through to year 8 are now one year nearer and so will be discounted one less time. The total of these discounted rentals gives the price of the asset at the beginning of year 2, *i.e* 37.6.

10. Table 1 shows that for a given rate of interest, there is one and only one sequence of asset prices for a given sequence of rentals. The reverse relationship also holds. For a given sequence of asset prices Table 1 can be used to work back to the sequence of rentals, provided that the discount rate is known. (This is done by first determining the diagonal values, starting at the bottom right-hand corner, and then discounting the values for the earlier years.)

Age-efficiency and age-price profiles.

11. Rentals are defined as the quantity of capital services generated by an asset multiplied by the price of those services. In general the *quantity* of services will decline during the service life of the asset because wear and tear reduce the efficiency of assets as they age. The *price* of the capital services, on the other hand, may move in either direction. For example, the price may rise in line with inflation or it may fall because newer assets which produce better capital services become available. Rentals can be expressed in either current or constant prices. Table 1 showed the rentals at constant prices with the result that the pattern of rentals during the service life is identical to the pattern of quantity of capital services.

12. The pattern of the quantity of capital services produced by an asset is described as the **age-efficiency profile** of an asset. As noted above, for any given pattern of rentals and a given discount rate there is one and only one pattern of asset prices. The pattern of asset prices over its service life is described as the **age-price profile** of an asset.

13. Table 2 shows the age-efficiency and age price profiles derived from Table 1 both at their original values and as coefficients standardised to unity in the first year. Note that the two profiles are different. Age-efficiency declines linearly in this example, while the age-price profile falls by decreasing amounts. Age-efficiency and age-price profiles are always different except for assets whose age-efficiency profiles decline geometrically and which have an infinite life.

Table 2. Age-Efficiency and Age-Price Profiles

		Year	1	2	3	4	5	6	7	8
Age-efficiency	Capital service quantities		5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5
	standardised		1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30
Age-price	At constant prices		45.8	37.6	30.1	23.2	17.0	11.5	6.9	3.0
	standardised		1.00	0.82	0.66	0.51	0.37	0.25	0.15	0.07

14. A linear decline in the quantity of capital services is only one of many possible age-efficiency profiles. Others include a constant flow of services (the "one-hoss shay" case), decline at a constant rate (geometric), and hyperbolic decline meaning that capital services fall by increasing amounts. The hyperbolic profile is generally agreed to be appropriate for most types of assets. The relationship between these age-efficiency profiles and age-price profiles is examined in Chapter 6.

15. The age-efficiency profile is relevant for the calculation of **volume indices of capital services**. The age-price profile is relevant to the **net capital stock** and **consumption of fixed capital**.

Consumption of fixed capital

16. It was noted in paragraph 1.11 that for a given rate of interest, there is one and only one sequence of asset prices for a given sequence of rentals. Since **consumption of fixed capital** is the difference between successive market values of an asset over its lifetime, consumption of fixed capital is jointly determined together with rentals and asset values. Chapter 5 explains how consumption of fixed capital can be estimated *indirectly* by using age-efficiency profiles to obtain the age-price profiles for different types of assets and obtaining consumption of fixed capital as the difference between successive asset values. This procedure ensures strict consistency between age-efficiency profiles and consumption of fixed capital, both of which enter into the calculation of volume indices of capital services.

17. In practice, most countries do not proceed in this way. Instead they estimate consumption of fixed capital *directly* by applying a **depreciation function** to the gross value of assets. Several different depreciation functions are available and each implies a different age-efficiency profile. Clearly the depreciation function selected should be at least broadly consistent with the age-efficiency profile used in calculating volume indices of capital services. This point is developed further in Chapter 6.

Aggregating assets to obtain stocks

18. Two kinds of capital stocks are described in this *Manual*. These are the **gross capital stock** and the **net capital stock**. In the gross capital stock, assets are valued at their "as new" prices regardless of their actual age and condition. In the net capital stock, assets are valued at their market prices. These are lower than their "as new" prices by the amount of accumulated consumption of fixed capital. Chapter 3 provides more details on these two stock concepts.

19. The assets in use at any one time will have been acquired over a number of preceding years. Because prices are constantly changing in a market economy, the **acquisition prices** of assets purchased in different years cannot be used in aggregating assets of different ages to obtain the stock of assets. This is true whether the stock is expressed at current prices or at constant prices. If the stock is to be valued at

current prices, assets acquired in years prior to the current year need to be converted to the prices of the current year. In the usual case where asset prices are rising, this will mean that the prices of assets acquired in earlier years must be raised up to current year price levels. If the stock is to be valued at the **constant prices** of a particular year, assets acquired in years other than that year need to be deflated or inflated to the price levels of the selected year.

20. The price indices that are used to convert assets to a consistent price basis must correctly decompose changes in the value of assets into their price and quantity components. When new models of assets are introduced, new features that enhance their efficiency in producing capital services must be treated as increases in the quantity of the assets and be deducted from any price increases that accompany the introduction of the new models. Constructing price indices for capital goods that correctly allow for technical improvements is a difficult task and it is identified as a subject for further study in the *Research Agenda* in annex X.

21. Note that conversion to a common price basis is required whether the capital stock estimates are derived using the **Perpetual Inventory Method (PIM)**, which is described in Chapter 5, or by **direct survey methods**, which are described in Chapter 7.

Volume indices of capital services.

22. In considering the contribution of a capital asset to the production process, it is now generally accepted that it is the value of the capital services produced by the asset that is relevant and not the value of the asset itself. The procedure recommended in this *Manual* involves the construction of an index that measures the volume of capital services produced each period by the capital stock. This approach is currently applied by statistical agencies in the United States, Canada and Australia.

23. Two steps are involved in compiling a **volume index of capital services**. The first step is to convert assets of a particular type into **standard efficiency units**.[1] This is done using the age-efficiency profile and is necessary because older assets are usually less efficient than newer ones due to wear and tear and so they will produce a smaller volume of capital services. The second step is to combine the standard efficiency units of different types of assets into an overall index. The **user costs of capital** relevant to the different types of assets are used as weights in compiling the index.

24. As an example of how assets are converted into standard efficiency units, consider a stock of trucks of a specified haulage capacity. The capital service produced by the trucks consists of *tonne-kilometres*. For a given amount of inputs – fuel, spare parts, repair services – new trucks can be expected to produce more *tonne-kilometres* than older vehicles. The older trucks are likely to need more frequent maintenance, use more fuel and experience longer periods of downtime while they are being repaired. Suppose, for example, that a truck lasts for 8 years and its age efficiency profile is the one shown in Table 1. This means that its efficiency in terms of *tonne-kilometres* produced for a given quantity of inputs, declines linearly by one tenth each year. Its age-efficiency profile can then be expressed as the series of coefficients 1.0, 0.9, 0.8, . . . 0.3, showing that the truck's initial efficiency of 1.0 declines by one-tenth each year to 0.3 in the last year of its service life.

1. The term *productive capital stock* is sometimes used to describe a group of assets that have been converted into standard efficiency units. The use of the word *stock* in this context may lead to confusion because it is a very different concept from the *net* and *gross stocks* of assets as these terms are usually understood. For that reason the term *productive capital stock* is avoided in this Manual.

25. If there is a stock of 3 trucks with ages of 2, 4 and 5 years, the above coefficients can be used to calculate the stock of trucks in **standard efficiency units** as 0.9 + 0.7 + 0.6 = 2.2. The three trucks together produce a flow of *tonne-kilometres* each year that could also be produced by 2.2 new trucks. In other words, 2.2 is a measure of the **capital services** that the three trucks provide now that they are no longer new.

26. In practice, statisticians work with reported **values** of gross fixed capital formation rather than with numbers of assets installed. These values are first expressed in constant prices before being written down by the age-efficiency coefficients to convert them into standard efficiency units. Moving the example a step nearer to reality, the GFCF data will almost certainly refer not to specific types of trucks but to some much broader asset class such as "road freight vehicles" or even "transport equipment".

27. Once the different asset types have been converted into standard efficiency units, the next step is to aggregate each type of asset to obtain an overall measure of capital services for an institutional sector or kind of activity. This is done by weighting the different types of assets by their annual **rentals**. In this context the rentals are usually referred to as the **user costs of capital**. The overall measure so obtained is expressed as an index and is here referred to as a **volume index of capital services**.

28. Chapter 8 explains how user costs of capital are calculated in practice and gives the theoretical basis for using them to aggregate stocks of different types of assets after they have been converted into standard efficiency units. Here it is useful to note that there is a close parallel between the use of *user costs of capital* to aggregate these stocks of different types of assets in productivity analysis and the use of *compensation of employees* to aggregate different types of employees. For productivity analysis, labour services are (ideally) measured by first classifying workers into categories defined by the factors that determine their efficiency in production – education level, gender, experience etc. After standardising for hours worked, each separate category is then aggregated to obtain overall measures of labour inputs using the rate of employee compensation relevant to each category. Employee compensation is used for aggregation because it reflects the *marginal productivity* of the different categories of workers. In exactly the same way, user costs of capital reflect the *marginal productivity* of different types of assets.

CHAPTER 2

COVERAGE AND CLASSIFICATION OF CAPITAL STOCKS AND FLOWS

Coverage

29. The stock and flow measures considered in this *Manual* relate to the "produced" objects that are included in gross fixed capital formation as defined in the 1993 SNA. Table 3 gives the full listing of non-financial assets recognised in that system, and those which form the subject of this *Manual* are printed in bold. They are tangible and intangible fixed assets (code AN 11) plus land improvement (part of AN 211).

Classifications

30. This section deals with the classifications used for publishing capital stock statistics. Three classifications contained in the 1993 SNA are relevant – the Classification of Assets, the Classification of Institutional Sectors, and the International Standard Classification of All Economic Activities (ISIC, Revision 3). These are used in different combinations for the gross and net capital stocks and the two flow measures covered in this *Manual* - consumption of fixed capital and the volume index of capital services.

31. The net capital stock and consumption of fixed capital appear as entries in the 1993 SNA and this determines the classifications to be used. Both are to be classified by the **institutional sector** that owns the assets. This is the appropriate classification for the net capital stock, which is needed for the Balance Sheets of the system and for the consumption of fixed capital, which appears in the Production Account, in the Distribution and Use of Income Accounts and in the Accumulation Accounts.

32. Capital stock statistics also serve a number of analytic uses, such as calculating capital output ratios and studying capital and multifactor productivity. For these purposes, it is usually preferable to classify assets according to the **kind of activity** of the owner and **by type of asset**. This involves a cross-classification by the ISIC and by the Classification of Assets.

Users versus owners

33. For some purposes it may be useful to classify assets according to the kind of activity of the **user** of the asset rather than that of the **owner**. It should be noted, however, that when assets are classified by user, the statistics cannot be related to other flows in the national accounts because these are compiled on an ownership basis. In particular, the distribution of value added among different kinds of activities depends on asset ownership rather than on asset use. If assets are rented on an operational lease[2], the income generated by the asset appears in the value added of the owner and not that of the user. This is because the rental payment is deducted as intermediate consumption from the gross output of the user and appears in the gross output of the owner.

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2. If assets are rented on a *financial lease* the user is considered to be the owner of the asset. It is only in the case of an operational lease that the user and owner are separate institutional units.

Table 3. SNA Classification of Non-Financial Assets

AN.1	Produced assets
AN.11	**Fixed assets**
AN.111	**Tangible fixed assets**
AN.1111	**Dwellings**
AN.1112	**Other buildings and structures**
AN.11121	**Non-residential buildings**
AN.11122	**Other structures**
AN.1113	**Machinery and equipment**
AN.11131	**Transport equipment**
AN.11132	**Other machinery and equipment**
AN.1114	**Cultivated assets**
AN.11141	**Livestock for breedi draught, etc.**
AN.11142	**Vineyards, orchards plantations of trees repeat products**
AN.112	**Intangible fixed assets**
AN.1121	**Mineral exploration**
AN.1122	**Computer software**
AN.1123	**Entertainment, literary or artistic originals**
AN.1129	**Other intangible fixed assets**
AN.12	Inventories
AN.121	Materials and supplies
AN.122	Work-in-progress
AN.1221	Work-in-progress on cultivated assets
AN.1222	Other work-in-progress
AN.123	Finished goods
AN.124	Goods for resale
AN.13	Valuables
AN.131	Precious metals and stones
AN.132	Antiques and other art objects
AN.139	Other valuables
AN.2	Non-produced assets
AN.21	Tangible non-produced assets
AN.211	**Land[3]**
AN.2111	Land underlying buildings and structures
AN.2112	Land under cultivation
AN.2113	Recreational land and surface water
AN.2119	Other land and assoc water
AN.212	Subsoil assets
AN.2121	Coal, oil and natural gas reserves
AN.2122	Metallic mineral reserves
AN.2123	Non-metallic mineral reserves
AN.213	Non-cultivated biological resources
AN.214	Water resources
AN.22	Intangible non-produced assets
AN.221	Patented entities
AN.222	Leases and other transferable contra
AN.223	Purchased goodwill
AN.229	Other intangible non-produced asset

3. Only "land improvement" is included in the capital stock and not the land itself. Land improvement covers levelling, terracing, fencing, drainage and similar works.

Classification by type of asset

34. The part of the 1993 SNA *Classification of Assets* covering non-financial assets is given in Table 3 above. At its most detailed level it distinguishes 12 types of assets. Most countries use an asset breakdown for publication purposes that is far less detailed than this. The standard questionnaire that is used by the international organisations to collect annual statistics according to the 1993 SNA uses a three-way breakdown – *machinery and equipment, buildings and structures* and *other assets*. Many users would certainly want more detail than this. National publications usually distinguish transport equipment from other types of machinery and equipment and dwellings from other buildings and structures. It is also common for non-residential buildings to be shown separately from other structures. Intangible assets are a new feature of the 1993 SNA, so it would be useful to show these separately to provide comparison with earlier series which excluded these assets. Finally, there is an increasing demand for separate identification of *information technology* assets.

With these considerations in mind, the following asset classification is recommended:

- Dwellings
- Non-residential buildings
- Other structures (including land improvement)
- Transport equipment
- Computers and office equipment

  Communications equipment
- Other machinery and equipment
- Cultivated assets
- Computer software
- Other intangible assets

Classification by institutional sector

The 1993 SNA identifies five institutional sectors:

- Non-financial corporations
- Financial corporations
- General government
- Households

- Non-profit institutions serving households

These five sectors are further broken down to give a total of 36 sub-sectors at the most detailed level.

35. The level of detail to be used for classifying the net capital stock and consumption of fixed capital depends on the degree of sector detail that is used in the balance sheets (for net stock) and in the non-financial accounts (for consumption of fixed capital). The few countries that compile balance sheets at the present time mostly classify stocks according to the five institutional sectors, but with some breakdown of *general government* by level - central, local, social security funds, for example. A similar breakdown is used by most countries for the non-financial accounts, although the *financial corporations* sector is sometimes broken down to distinguish between depository institutions and other financial institutions.

36. The annual 1993 SNA questionnaire used by the international organisations to collect national accounts statistics calls for the non-financial accounts to be sub-sectored as follows and this determines the institutional sector detail for classifying consumption of fixed capital:

- Non-financial corporations
- Financial corporations
- Central government
- State government
- Local government
- Social security funds
- Households
- Non-profit institutions serving households

Classification by kind of activity

37. For most kinds of analytic studies, capital stocks and flows will need to be classified by kind of activity. As a general rule, the more detailed the activity breakdown, the more useful will the statistics be for such purposes. However, practical considerations limit the amount of detail that can be shown. For example, if the PIM is used, the kind of activity breakdown cannot be more detailed that the kind of activity classification used for collecting statistics on gross fixed capital formation. If the latter is very detailed, transfers of used assets between producers in different kinds of activities will affect reliability and reduce the amount of detail that can reasonably be shown.

38. The annual 1993 SNA questionnaire calls for capital stock statistics to be broken down by 17 kinds of activities. These are the 17 *tabulation categories* of the ISIC (revision 3). It would be possible to make this list more useful by distinguishing the principal activities within manufacturing (which is a single tabulation category) and by grouping some of the categories covering service activities. A classification that may be useful for countries starting capital stock statistics is given in Table 4.

Table 4. Suggested activity classification for capital stock statistics

ISIC Tabulation Categories	Description
A + B	Agriculture, hunting, forestry and fishing
C	Mining and quarrying
D	Manufacturing, with 4 or 5 important activities separately identified.
E	Electricity, gas and water supply
F	Construction
G + H	Wholesale and retail trade, repair of vehicles and household goods, hotels and restaurants
I	Transport, storage and communications
J + K	Financial intermediation, real estate, renting and business activities
L	Public administration, defence and social security
M,N + O	Education, health and social work, other community, social and personal service activities

CHAPTER 3

CAPITAL STOCKS AND FLOWS: BASIC DEFINITIONS AND USES

39. This chapter gives the definitions and describes the main uses of the gross and net capital stocks and of two flow measures related to them, namely consumption of fixed capital and capital services. It starts by considering the three different ways in which stocks can be valued.

Valuing capital stocks

40. Capital assets can be valued at three kinds of prices:

- **Historic prices**, which means that the assets are valued at the prices at which the assets were originally acquired. The term *acquisition prices* is used as a synonym for historic prices.

- **Current prices**, which means that the assets are valued at the prices of the current year. Valuation at current prices is sometimes referred to as valuation at current "replacement" cost, but the qualifier "replacement" raises questions about what exactly is being replaced. For this reason the word "replacement" is not used in this *Manual*.

- **Constant prices**, which means that the assets are valued at the prices of a selected year. As in the case of valuation at current prices, the qualifier "replacement" is sometimes used in referring to constant prices, but it is avoided here.

41. Note that price indices are required for valuation at **current prices** as well as valuation at **constant prices**. In the first case, assets acquired in earlier periods have to be revalued each year to bring them to the prices of the current year; in the second case, assets acquired in years other than the selected year have to be revalued to convert the prices actually paid to those of the selected year. It is only in the case of valuation at historic prices that no price indices are required because the prices at which the assets were originally acquired continue to be used in every year in which the assets remain in the capital stock.

42. Table 5 shows how the stock of a group of assets is valued at each of these three kinds of prices. The assets are assumed to each have a life of five years and to have been acquired in three successive years. In Table 5, the stocks of assets are valued "gross" *i.e.* before deducting consumption of fixed capital.

Table 5. Calculation of a capital stock at historic, current and constant prices

Year	1	2	3	4	5	6	7
		At actual prices paid i.e. at historic prices					
Assets purchased in year 1	10.0	10.0	10.0	10.0	10.0		
Assets purchased in year 2		20.0	20.0	20.0	20.0	20.0	
Assets purchased in year 3			5.0	5.0	5.0	5.0	5.0
Stock at historic prices	10.0	30.0	35.0	35.0	35.0	25.0	5.0
Asset price	100	103	105	110	112	114	118
		At prices of the current year					
Assets purchased in year 1	10.0	10.3	10.5	11.0	11.2		
Assets purchased in year 2		20.0	20.4	21.4	21.7	22.1	
Assets purchased in year 3			5.0	5.2	5.3	5.4	5.6
Stock at current prices	10.0	30.3	35.9	37.6	38.3	27.6	5.6
		At constant prices of year 1					
Assets purchased in year 1	10.0	10.0	10.0	10.0	10.0		
Assets purchased in year 2		19.4	19.4	19.4	19.4	19.4	
Assets purchased in year 3			4.8	4.8	4.8	4.8	4.8
Stock at constant prices	10.0	29.4	34.2	34.2	34.2	24.2	4.8
Ratio of current to constant price stocks	100	103	105	110	112	114	118

43. Table 5 shows that the **asset price** has been rising over the period from 100 in year 1 to 118 in year 7. In order to obtain the value of the stock at **current prices** the assets need to be re-valued in line with the rise in asset prices. Note that in year 2, the assets acquired in that year (to the value of 20) are already at the prices of year 2 and do not therefore need to be re-valued in that year. For subsequent years, however, they must be multiplied by $p_t/103$ where p_t is the asset price in year t. Similarly the assets, valued at 5, acquired in year 3 must be multiplied by $p_t/105$ for years 4 through 7.

44. In order to obtain the value of the stock at **constant prices** – in this example at the prices of year 1 – all assets acquired after year 1 must be deflated to bring them down to year 1 prices. Thus the assets acquired in year 2 are multiplied by 100/103 and those acquired in year 3 by 100/105. The assets acquired in year 1 are, by definition, already at year 1 prices.

45. The last line of Table 5 shows the ratio of the asset stock at current prices to the stock at constant prices. It is of course identical to the asset prices given in the table. This means that the laborious procedure described above for calculating the capital stock at current prices can be avoided by first estimating the stock at constant prices and inflating with price indices. This is an important point to bear in mind when the capital stock is estimated using the *perpetual inventory method* (PIM).

46. Valuation at **historic, or acquisition, prices** is the usual procedure in company accounts. This is done because historic prices can be objectively verified by examining the invoices relating to asset purchases. Commercial accountants may also prefer historic prices because they give a conservative valuation of assets. These advantages, however, are offset by the fact that assets which have been acquired at different dates are being valued at different prices so that when prices are rising/falling assets acquired

more recently are implicitly given a higher/lower weight than those acquired in earlier periods. Capital stocks valued at historic prices cannot be compared with national accounting or other economic statistics that are expressed at either current or constant prices.

Gross fixed capital stock

47. The gross fixed capital stock is the value, at a point in time, of assets held by producers with each asset valued at "as new" prices – *i.e.* at the prices for new assets of the same type - regardless of the age and actual condition of the assets. It is a "gross" measure of the stock in the sense that it is calculated before deducting consumption of fixed capital.

48. Two points should be noted about the coverage of the assets to be included in the gross capital stock.

- First, the assets included in the stock may be owned by the enterprises that use them in production or they may be rented out to producers by their owners. Certain types of assets, such as commercial and residential buildings, road vehicles and construction equipment are commonly rented in many countries.

- Second, not all the assets included in the gross stock may actually be in use to produce goods and services. Some assets may have been "moth-balled" or held in reserve to meet unexpected surges in demand. Others may be kept in reserve as insurance against the breakdown of critical pieces of equipment. Assets that are rented to producers may spend idle periods between customers. In order to be counted as part of the capital stock all that is required is that assets are present at production sites and capable of being used in production or that they are available for renting by their owners to producers.

49. The gross capital stock is not a part of the System of National Accounts but it is the conventional starting point for calculating consumption of fixed capital and the net capital stock. The gross capital stock is also widely used as a broad indicator of the productive capacity of a country. Although it is not recommended here for this purpose, the gross capital stock is frequently used as a measure of capital input in studies of multifactor productivity. In this *Manual* it is recommended that capital inputs for this purpose should be measured by **volume indices of capital services** as described below.

Consumption of fixed capital

SNA definition

50. The general definition of consumption of fixed capital is given in the 1993 SNA, paragraph 6.179.

[Consumption of fixed capital] may be defined in general terms as the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage. It excludes the value of fixed assets destroyed by acts of war or exceptional events such as major natural disasters which occur very infrequently. Such losses are recorded in the System in the account for "Other changes in the volume of assets".

51. Some clarifications are needed.

- First, the change in the current value of the stock of assets must be calculated using inflation-adjusted prices to value the opening and closing stocks. Changes in the value of fixed assets arising from changes in the price level are recorded in the revaluation accounts and do not form part of consumption of fixed capital.

- Second, "used by a producer" must be interpreted to include situations where assets have been purchased by a producer but which for any reason have not yet been employed in a production process. This clarification is needed because consumption of fixed capital can occur in respect of assets which are available at the producer's establishment for use in production but which are kept idle for some reason. For example, in some centrally planned economies it was customary for producers to hold a surplus stock of assets for use in the event of unexpected breakdown of working assets, as insurance against interruption in the future supply of particular kinds of assets, or to cannibalise for spare parts. Assets held by producers but which have not been, or may never be, employed for productive purposes may nevertheless fall in value because of obsolescence and these falls in value must be included in consumption of fixed capital.

- Third, "physical deterioration" refers to wear and tear that is not made good by repairs or by replacing worn components. Some assets may not suffer any physical deterioration because the asset owner makes good all wear and tear through careful maintenance. In such cases the fall in asset value over time measured by consumption of fixed capital will be due only to obsolescence or to normal accidental damage.

- Fourth, "normal accidental damage" refers to the kinds of accidents that are commonly insured against. Accidental damage includes cases where the asset has been so badly damaged that it has to be prematurely scrapped. Transport equipment is particularly vulnerable to damage of this kind and when service lives are estimated for such assets they must reflect the probability of premature scrapping through accidental losses.

- Fifth, the above definition implies, without explicitly stating so, that abnormal obsolescence is also excluded from consumption of fixed capital. Abnormal obsolescence here means unforeseen obsolescence and it may occur either because of unexpected technological breakthroughs or because of sudden changes in the relative prices of inputs. The introduction of electronic calculators in the 1960s is an example of an unforeseen technological development, which resulted in a sudden and sharp fall in the existing stock of electromechanical calculators. The 1974 oil-shock is an example of a drastic shift in relative input prices, which led to premature replacement of inefficient oil-using equipment by more efficient models or by assets using alternative energy sources. Premature scrapping of assets, which arises from abnormal obsolescence, is treated in the same way as losses of assets due to wars or natural calamities and is shown in the account for "Other changes in the volume of assets".

52. The inclusion of normal obsolescence in consumption of fixed capital is a controversial issue for some authors. Consider a group of assets, which are strictly homogeneous but are of different ages. An example could be farm tractors of a particular make and model which were put into operation at different times. If the market prices of the different vintages are available from second-hand tractor dealers, they will show a declining age-price profile. But this decline in price clearly cannot be due to obsolescence. Since all the tractors are of the same make and model they must all be equally obsolete compared with newer, more efficient tractors, which have subsequently appeared on the market. The prices of older tractors are lower than those of newer tractors only because of wear and tear. The consumption of fixed capital that occurs in this case can be described as a "cross-section" measure. For the national accounts,

however, there is now broad agreement that a "time-series" measure which includes normal obsolescence is required (see box)

Box 1. Obsolescence

Obsolescence occurs when an asset is retired before its physical capability is exhausted. Obsolescence can occur due to technical innovation. For example, a personal computer that is several years old may not be able to support the software that a new computer can, in which case the old computer may be withdrawn from use in production even though it may still be operational. Technical innovation is not the only cause of obsolescence. For example, all immovable assets at a remote mine site become obsolete when the mine is worked out, irrespective of their potential physical lives.

In considering obsolescence a distinction needs to be drawn between that which is foreseen and that which is not. If obsolescence is foreseen then the owner will factor it in when determining an asset's expected economic life and hence its consumption of fixed capital in future periods. Therefore, when the event causing the foreseen obsolescence occurs there should not be an abrupt fall in the value of the asset. As pointed out in the 1993 SNA para. 6.187 foreseen obsolescence is included in consumption of fixed capital in the national accounts because it is an expected cost of production. Both the computer and mine asset examples given above are potentially cases of foreseen obsolescence. Unforeseen obsolescence, on the other hand, should not be included in consumption of fixed capital. Instead, it should be recorded in other changes in the volume of assets accounts (SNA93 para. 12.43).

Consumption of fixed capital in the SNA

53. Consumption of fixed capital has three roles in the 1993 SNA:

- It is deducted from gross measures of product, income and saving to arrive at net measures of these aggregates. In recognition of the difficulties that many countries have in calculating consumption of fixed capital, the SNA provides for all balancing items in the Production Account and in the Distribution and Use of Income Accounts to be recorded on either a gross or net basis. However, SNA para. 6.203 indicates a preference for the net measures: "In general, the gross figure is obviously the easier to estimate and may, therefore, be more reliable, but the net figure is usually the one that is conceptually more appropriate and relevant for analytical purposes." As the terms are used in economics, saving and income are almost always understood as after deducting consumption of fixed capital.

- Consumption of fixed capital is one of the cost items required to estimate output and value-added of government and other non-market producers. Some countries at the present time use consumption of fixed capital at historic prices taken from accounting records to estimate government output and value added. This is likely to lead to underestimation of both aggregates. It should also be noted that the 1993 SNA has considerably expanded the scope of consumption of fixed capital for government by transferring some durable military goods from intermediate consumption to capital formation and by requiring that consumption of fixed capital be calculated in respect of roads, dams, bridges and similar structures.

- Finally, consumption of fixed capital is an entry in the Capital Account. It is one of the transactions that explain the differences between the opening and closing stocks of fixed assets.

Consumption of fixed capital and the age-efficiency profile.

54. The consumption of fixed capital measures the decline in the market value of assets as they age. This decline in market values can be described as the **age-price profile** of an asset. The age price profile is related to, but different from, the decline in the **efficiency** of assets as they age. This decline is referred to as the **age-efficiency** profile.

55. The relationship between age-efficiency and age-price profiles has been explained in Chapter 1 and is explored further in Chapter 5. It is mentioned here for two reasons:

- Age-efficiency profiles determine the flows of **capital services**. The measurement of these capital services should be done in a way that is consistent with the measurement of consumption of fixed capital and net capital stocks. This means that in selecting a procedure for calculating consumption of fixed capital, such as "straight-line" or "double declining balance", it is important to remember that the method selected has implications for the shape of the age-price profile.

- The conventional way of measuring consumption of fixed capital is to do it **directly** by applying a depreciation formula to the capital stock. An alternative, however, is to use the age-efficiency profile to generate age-price profiles for assets and to then derive consumption of fixed capital **indirectly** as the difference between successive values of the net capital stock. This approach ensures strict consistency between the measurement of capital services, consumption of fixed capital and net capital stocks. At least one country, Australia, has already adopted an integrated approach of this kind. It clearly has merit for countries that wish to produce capital services as a regular part of their programme of capital stock statistics. The integrated approach is described in Chapter 5. Annex 2 explains how it is applied by the Australian Bureau of Statistics.

Net capital stock

Illustrative calculation

56. The net capital stock is the value at a point in time of assets at the prices for new assets of the same type less the cumulative value of consumption of fixed capital accrued up to that point. Table 6 shows how both consumption of fixed capital and the net capital stock can be derived from the gross capital stock. Consumption of fixed capital is here obtained using straight-line depreciation. (Note that Table 6 describes the conventional approach in which consumption of fixed capital is estimated directly from the gross capital stock. The newer, integrated approach starting from the age efficiency profile uses a quite different set of calculation.)

57. In Table 6, annual consumption of fixed capital is obtained by dividing the gross capital formation series by 5 because the assets last for five years and straight-line depreciation is being used. When valued at constant prices, consumption of fixed capital is constant for each asset throughout its lifetime. For the calculations at current prices, consumption of fixed capital rises in line with the re-valued prices of the assets.

Table 6. Gross and net stocks and consumption of fixed capital at current and constant prices

Year	1	2	3	4	5	6	7
	Gross capital stock at historic prices						
Assets purchased in year 1	10.0	10.0	10.0	10.0	10.0		
Assets purchased in year 2		20.0	20.0	20.0	20.0	20.0	
Assets purchased in year 3			5.0	5.0	5.0	5.0	5.0
Gross capital stock at historic prices	10.0	30.0	35.0	35.0	35.0	25.0	5.0
Asset price (year average)	100.0	103.0	105.0	110.0	112.0	114.0	118.0
	Gross capital stock at prices of the current year						
Assets purchased in year 1	10.0	10.3	10.5	11.0	11.2		
Assets purchased in year 2		20.0	20.4	21.4	21.7	22.1	
Assets purchased in year 3			5.0	5.2	5.3	5.4	5.6
Gross capital stock at prices of the current year	10.0	30.3	35.9	37.6	38.3	27.6	5.6
	Consumption of fixed capital at prices of current year						
CFC on assets purchased in year 1	2.0	2.1	2.1	2.2	2.2		
CFC on assets purchased in year 2		4.0	4.1	4.3	4.3	4.4	
CFC on assets purchased in year 3			1.0	1.0	1.1	1.1	1.1
Total CFC at prices of the current year	2.0	6.1	7.2	7.5	7.7	5.5	1.1
	Net capital stock at prices of the current year						
Assets purchased in year 1	8.0	6.2	4.2	2.2	0.0		
Assets purchased in year 2		16.0	12.2	8.5	4.3	0.0	
Assets purchased in year 3			4.0	3.1	2.1	1.1	0.0
Net capital stock at prices of the current year	8.0	22.2	20.4	13.9	6.5	1.1	0.0
	Gross capital stock at prices of year 1						
Assets purchased in year 1	10.0	10.0	10.0	10.0	10.0		
Assets purchased in year 2		19.4	19.4	19.4	19.4	19.4	
Assets purchased in year 3			4.8	4.8	4.8	4.8	4.8
Gross capital stock at prices of year 1	10.0	29.4	34.2	34.2	34.2	24.2	4.8
	Consumption of fixed capital at prices of year 1						
CFC on assets purchased in year 1	2.0	2.0	2.0	2.0	2.0		
CFC on assets purchased in year 2		3.9	3.9	3.9	3.9	3.9	
CFC on assets purchased in year 3			1.0	1.0	1.0	1.0	1.0
Total CFC at prices of year 1	2.0	5.9	6.8	6.8	6.8	4.8	1.0
	Net Capital stock at prices of year 1						
Assets purchased in year 1	8.0	6.0	4.0	2.0	0.0		
Assets purchased in year 2		15.5	11.7	7.8	3.9	0.0	
Assets purchased in year 3			3.8	2.9	1.9	1.0	0.0
Net capital stock at prices of year 1	8.0	21.5	19.5	12.6	5.8	1.0	0.0

58. The net capital stock is obtained from the gross capital stock and consumption of fixed capital as follows. The net stock at current prices for year 3 is shown in Table 6 as 20.4. This is derived from the gross capital stock at current prices, *i.e.* 35.9 by deducting accumulated consumption of fixed capital on the assets purchased in year 1 (2.1 x 3), plus accumulated consumption of fixed capital on the assets purchased in year 2 (4.1 x 2) plus accumulated consumption of fixed capital on the assets purchased in year 3 (1.0 x 1). Observe that accumulated consumption of fixed capital at current prices is calculated using the prices of the year in question; it cannot be obtained by adding up the consumption of fixed capital calculated for earlier years because these amounts are valued at the prices of several different years.

59. As noted earlier, current price estimates of consumption of fixed capital and the net capital stock can more easily be obtained by first calculating them at constant prices and inflating to current year prices using the relevant price indices. This is the usual procedure in practice.

60. The net capital stock at prices of the current year was calculated in Table 6 using the **year average** prices of the asset. In the SNA balance sheets however, the net capital stock must be valued at **year-end** prices because all entries in the balance sheets refer to the market values of assets and liabilities at the end of each year. The net capital stock at current prices shown in Table 6 must therefore be multiplied by the ratio of end-year to year average prices. End-year prices are not usually calculated directly but are obtained by averaging December/January or fourth/first quarter prices if these are available or by averaging year-average prices for adjacent years.

61. Note that year-average prices are the correct ones to use for valuing consumption of fixed capital, both at current and constant prices. Consumption of fixed capital is a flow that occurs regularly throughout the year. Ideally it would be valued at the prices prevailing each moment that it occurs, but as this is not practical, the average of prices throughout the year – or failing that mid-year prices – are an acceptable approximation.

Net capital stocks in the SNA

62. The net stock, at current prices, appears in the opening and closing balance sheets of the 1993 SNA. Table 7 shows the connection between these opening and closing balances in the system.

Table 7. Links between opening and closing stocks of fixed assets

The net value of the stock of the asset at its current price at the beginning of the period
plus gross fixed capital formation, *i.e.*, acquisitions *less* disposals of the asset in transactions with other units
minus consumption of fixed capital incurred during the period
plus the total value of *other* positive or negative changes in the quantity of the asset : *i.e.*, changes which are not attributable to the use of the asset in production or to transactions with other units (*e.g.* the physical destruction of an asset as a result of a natural disaster or the premature scrapping of assets because of unforeseen obsolescence),
plus the total value of the positive or negative holding gains accruing during the period as a result of changes in the price of the asset,
equals the *net* value of the stock of the asset at its current price at the end of the period.

63. The net stock is the market value of fixed assets owned by the different institutional sectors and the nation as a whole. As such, it is a measure of wealth and it is usually the largest part of national net worth in industrialised countries.

Capital services

64. For any given type of asset there is a flow of productive services from the cumulative stock of past investments. This flow of productive services can be measured by constructing a **volume index of capital services.** This is done by first converting each type of asset into **standard efficiency units** and then weighting each one by its **user cost of capital** to obtain an overall index. Assets are converted to standard efficiency units using coefficients derived from the age-efficiency profile assumed to be appropriate for each type of asset. These coefficients represent an asset's declining ability to produce capital services as it gets older. User costs of capital are the sum of depreciation, the net return on the asset and the nominal capital gain (or loss) from holding the asset for each accounting period.

65. Chapter 1 gave a simple example of how assets are converted into standard efficiency units and a short explanation of why they are weighted by their user costs to obtain the overall index. A fuller explanation is given in Chapter 8.

66. The volume index of capital services does not appear in the national accounts. It is not part of the 1993 SNA nor of any country's own national system of accounts. It is included in this *Manual* because there is now general agreement that a volume index of capital services is a better way to represent the input of capital into the production process than the gross or net capital stocks which have usually been used for this purpose in the past.

CHAPTER 4

OVERVIEW OF MEASUREMENT METHODS

67. This chapter reviews the methods that are available for measuring gross and net capital stocks, consumption of fixed capital and capital services.

Gross capital stock

68. The **gross capital stock** can be estimated in at least three ways. By far the commonest is the **perpetual inventory method** (PIM) which involves accumulating past capital formation and deducting assets that have reached the end of their estimated service lives. Both capital formation and discards of assets ("scrapping") are revalued either to the prices of the current year (current prices) or to the prices of a single year (constant prices).

69. Survey methods can also be used. Enterprises are asked to report the historic or acquisition values of all assets still in use and the dates when they were installed or constructed. The assets are then revalued to current or constant prices either by the statistical agency or by the respondents themselves using revaluation coefficients supplied by the statistical agency.

70. A method that lies between the PIM and survey methods is the "balance of fixed assets". In many centrally planned economies, enterprises were required to keep a running inventory of their fixed capital assets, tracking outflows as well as inflows. The results of these calculations were reported regularly to the central statistical agency which obtained the total capital stock by simple addition. Although they have moved away from central planning, several of these countries have continued to calculate the balance of fixed assets. Correctly applied, this method can be seen as an ideal form of the PIM; ideal because it substitutes actual retirements for the assumed retirements used in the conventional PIM.

71. Finally, the gross stocks of certain kinds of assets can be estimated using administrative records on the numbers of assets together with price information obtained by the statistical agency. Assets for which administrative records are often available include road vehicles, maritime shipping, commercial aircraft and dwellings

Net capital stock

72. The net capital stock is a concept familiar to commercial accountants and company balance sheets invariably record the value of assets on a net basis. Unfortunately company accounts use a number of conventions in calculating net asset values which render them unsuitable for national accounts purposes. The main problem is the use of historic valuation, which means that the stock of assets is valued at a mixture of prices.

73. For use in national accounts, the net stock is usually derived from the gross stock (obtained from one of the sources described above) by deducting accumulated consumption of fixed capital. Consumption

of fixed capital is obtained using a depreciation function such as straight-line, geometric or sum-of-the-year's-digits The net stock can also be derived by first estimating age-efficiency profiles for assets and using a discount rate to obtain the corresponding age-price profiles. The age-price profiles provide a direct estimate of the net stock without first having to calculate consumption of fixed capital.

74. There are two other possible sources for net stock estimates. First, insurance companies record the current values of commercial properties insured against damage by fire or other catastrophes. However, properties are sometimes under-insured so that insurance values will understate the net stock. Under-insurance is less likely to happen with assets exposed to a high risk of loss, such as road vehicles and ships. Insurance values for assets of this kind may provide a realistic estimate of net stocks and could be used as a cross-check on net asset stocks estimated by other methods.

75. Second, an estimate of the market values of a company can be obtained by multiplying the number of shares outstanding by the share price. To obtain the net value of the tangible fixed assets owned by the company, both the value of financial assets (less liabilities) and the market value of land, valuables and non-produced intangible assets must be deducted. This method is only applicable for companies with publicly quoted shares and such companies may cover only a small part of the capital stock in some countries. Another problem is that share prices can be heavily influenced by future profit expectations. For these reasons, this is not likely to be a very useful approach.

76. Note that while the gross capital stock may be derived from a survey, survey methods are not suitable for obtaining the net capital stock. This is because a consistent method must be used to estimate consumption of fixed capital, but companies' accounts may use a variety of depreciation methods.

Consumption of fixed capital

77. As noted, company accounts routinely report **consumption of fixed capital**, or **depreciation** as it is usually called. Unfortunately, in almost all countries it is calculated by reference to the historic cost of assets and so is effectively calculated using a mixture of prices. When there is inflation, use of historic prices will lead to substantial understatement of depreciation. Another problem is that most countries allow companies to use a variety of depreciation methods so stocks reported by different companies cannot be added up to obtain the total stock. Finally many countries have used "accelerated depreciation" schemes as a means of encouraging investment, with the result that reported depreciation bears no relation to the actual declines in asset values. Despite these problems, several countries use depreciation reported by companies in their national accounts. Such estimates cannot even be justified as crude approximations to consumption of fixed capital as defined in the SNA. They are misleading statistics and have no place in the accounting system

78. For the national accounts, consumption of fixed capital can be obtained either directly by applying depreciation factors to the estimated gross values of assets (see Chapter 6) or indirectly as the difference between successive values of the net stock derived from age-price profiles (see Chapter 5).

Capital services

79. Capital services are the contribution of capital to production. Transactions in capital services occur when assets are leased by their owners to other producers. (Capital service transactions occur only in the case of "operational leasing". In the case of a "financial lease" the asset is treated as being owned by the user and the payments involved are considered to be loan repayments.) Operational leasing is quite common for certain kinds of assets – road vehicles, aircraft, buildings and many types of construction equipment are examples. The price of a lease will include other costs in addition to the pure price of the

capital service, such as insurance and the cost of storing equipment in a convenient location and transporting the assets to and from the producer's site. These costs could of course be estimated so that, in principle, capital services for several types of assets could be obtained by direct observation. In practice, national statistical offices have not used this approach. As explained in Chapter 1, capital services are measured by first converting each type of asset into standard efficiency units and constructing a volume index of capital services with user costs of capital as weights. This is further developed in Chapter 8.

CHAPTER 5

PERPETUAL INVENTORY METHOD

Two ways of applying the Perpetual Inventory Method

80. The Perpetual Inventory Method (PIM) generates an estimate of the capital stock by accumulating past purchases of assets over their estimated service lives. The standard, or traditional, procedure is to use the PIM to estimate the gross capital stock, use a depreciation function to calculate consumption of fixed capital and obtain the net capital stock by subtracting accumulated capital consumption from the gross capital stock. The first part of this chapter describes the standard application of the PIM. There is however, an alternative way of applying the PIM. This method has been pioneered by the United States Bureau of Labor Statistics (BLS) and is now also applied by the Australian Bureau of Statistics (ABS). It is described in the last section of this chapter.

81. The traditional application of the PIM requires the direct estimation of depreciation from which the net capital stock is obtained indirectly. The alternative approach is to start by estimating **age-efficiency profiles** for each type of asset which are then used to generate age-price profiles for the assets. The age price profiles are used to directly estimate the net capital stock from which depreciation is obtained indirectly.

82. This method has the important advantage that all stock and flow data are necessarily consistent with each other. This is because the age-efficiency profiles (used to estimate capital services) determine the age-price profiles (used to estimate the net capital stock and depreciation). All three measures, capital services, the net stock and consumption of fixed capital are based on identical assumptions - namely the age-efficiency profile and the discount rate. as measured by the volume index. Because it generates measures of capital services at the same time as the stock estimates and consumption of fixed capital, it can be described as an *integrated approach.*

83. Annex 2 describes the PIM methods used by four countries – Singapore, France, the United States (Bureau of Economic Analysis) and Australia. The first three use the traditional approach, although there are several differences in how it is applied. Australia uses the alternative, integrated approach.

Standard application of the PIM

Gross capital stock

84. The basic requirements to apply the PIM to estimate the Gross Capital Stock are:

- An initial benchmark estimate of the capital stock.

- Statistics on gross fixed capital formation (GFCF) extending back to the bench-mark, or, if no bench-mark is available, back over the life of longest-lived asset.
- Asset price indices.
- Information on the average service lives of different assets.
- Information on how assets are retired around the average service life (mortality functions).

Initial estimate of the capital stock

85. Provided the capital stock series go back as many years as the longest-lived asset, it is possible to estimate the capital stock without having an initial benchmark estimate. However, as the longest lived assets, usually structures, may have service lives in excess of 100 years, most countries need to start their PIM estimates with a bench-mark estimate, at least for assets with long lives. Possible sources for benchmark estimates include:

- Population censuses.
- Fire insurance records.
- Company accounts.
- Administrative property records.
- Share valuations.

None of these sources will give an accurate estimate of precisely what is required – namely the "as new" values of assets in place at a point in time.

86. **Population census** records usually provide information on the numbers of dwellings of different types. Estimated values will have to be assigned to the various types of dwellings identified in the Census records. **Fire insurance** records normally give the net values of assets at current prices and will have to be adjusted to gross valuation. They are incomplete because small companies may not insure their assets at all and very large enterprises and government bodies often prefer to bear the risks themselves and so will also be excluded from fire insurance records. **Company accounts** give asset values at depreciated historic costs and will need adjusting both to bring them up to current or constant prices and to "as new" values. An additional problem is that they are only available for the corporate sector. **Administrative property records** typically record residential and commercial buildings at values which purport to be current market prices but which are usually historic prices that are revalued to current prices at irregular intervals. The **share valuation** of a company's fixed assets can be obtained by multiplying the number of shares issued by a company by the share price and subtracting financial assets net of liabilities. The resulting values should reflect the current market values of the company's fixed capital assets but the valuation will also be affected by various unquantifiable factors such as "good-will", differences in entrepreneurial skill and the general business climate. In addition, this approach can only be used in countries with active stock markets and then will only provide valuations for corporate enterprises.

87. It is clear that a bench-mark estimate based on any of these sources will be highly approximate but the importance of errors introduced into the stock figures will diminish over time as the base period is left further behind.

Gross fixed capital formation

88. Gross fixed capital formation is defined as the acquisition, less disposals, of tangible and intangible fixed assets plus land improvement. These are the assets denoted in bold in Table 3 of the Chapter 2. The assets acquired may be new or they may be used assets that are traded on second-hand markets. The assets disposed of may be sold for continued use by another producer, they may be simply abandoned by the owner or they may be sold as scrap and be broken down into reusable components, recoverable materials, or waste products.

89. Assets acquired are valued at prices, which include installation costs and transfer fees. Disposals are valued at the amounts received by the sellers before deducting any costs born by the sellers to dismantle the equipment or remove it from their property. (These latter costs are treated as negative capital formation and not as current production expenses.)

90. The fact that GFCF involves transactions in used assets, which are valued at less than the prices of new assets, causes problems for PIM estimates of the gross capital stock. Suppose, for example, that enterprise A sells a used asset to enterprise B. Enterprise A will report the sale of the asset at its current market value and not at the "as new" price which is required for valuation of the gross capital stock. This means that the GFCF reported by Enterprise A (its acquisitions less disposals of assets) will be too large for use in the PIM because its disposals are valued at (low) market prices instead of at (high) "as new" prices. At the same time, Enterprise B will report its acquisition of the used asset from A at the current market price which is lower than the "as new" price required for the gross capital stock. B's reported GFCF (its acquisitions less disposals) will be too small for use in the PIM.

91. The errors caused by the way that A and B report transactions in a used asset will cancel out if the records for the two enterprises are consolidated because the overstatement of A's reported GFCF is exactly matched by the understatement in B's reported GFCF. There are, however, circumstances in which there will be no compensating errors of this kind:

- Capital stock statistics need to be classified by institutional sector and by kind of activity. If transactions in used assets occur between units that are classified to different institutional sectors or kinds of activities, errors will be introduced into the sector or activity distribution of the capital stock.

- Second, used assets may move into and out of the domestic economy via imports and exports. If a used asset is imported, the acquisition will be recorded at the current market value of the asset and GFCF will be understated for PIM purposes. If a used asset is exported, the disposal will be valued at current market value and GFCF will be overstated for PIM purposes. In neither case are there any offsetting errors because the other partners to the transactions are outside the domestic economy.

- Finally, used assets may move from productive to non-productive uses. In particular, they may move between the government or corporate sectors and the household sector. Perhaps the commonest example is the sale of used vehicles by car-hire companies to households. In this case there is no offsetting entry to the overstatement of GFCF by the car-hire companies because the purchase of the used cars by households does not count as capital formation.

92. How important are the errors that may be introduced into the gross stock estimates because of transactions in used assets? And what can be done about them?

93. As regards errors in the distribution of the stock by sector and activity, the size of the problem depends partly on the degree of detail in the sector or activity breakdowns that are used. This suggests that countries should be modest in the amount of activity detail given in their stock estimates, at least in the initial stages of developing these statistics. The importance of the problem also depends on the extent to which assets can be used in different industries. Most plant and machinery is industry-specific but buildings may often move between sectors and activities. A shop may become a bank, a factory may be used for different types of manufacturing or a railway station may become a museum. In order to make corrections for movements of assets between sectors and activities it is necessary to identify transactions in used assets separately from transactions in new assets.

94. Imports and exports of used assets may be quite significant for some countries but they do not cause problems additional to those mentioned above. Whether a producer sells a used asset to another domestic producer or to abroad, all that is required is to identify the sale as that of a used asset and make whatever upward adjustment is required to the disposal value. Similarly, if a producer purchases a used asset from abroad, exactly the same kind of adjustment is required as when the asset is acquired from a domestic source.

95. As regards movement of assets from producers to households, it seems likely that in most countries, the only significant transactions are in used vehicles sold by producers to households. A reasonable assumption that could be made here is that all sales of used passenger cars by producers are to households. Provided that sales of used cars can be identified in the records of producers it is possible to adjust disposal values to "as new" prices and eliminate this source of error.

Asset price indices

96. The problems of separating value changes into price and volume components are generally agreed to be more difficult for capital goods than for other goods and services because many capital goods are unique. This is the case, for example, with most buildings, construction work, special purpose industrial plant, aircraft and ships. The errors that may be introduced into capital stock estimates through incorrect price deflators may be as large as errors caused by the use of incorrect service lives and mortality functions. (Note, too, that direct survey methods are equally affected by errors in price deflators because these have to be used to move from historic to current and constant prices.)

97. For unique capital goods, such as ships, aircraft, and most structures the preferred method of calculating price indices is through *model pricing*. This involves asking manufacturers and construction firms to estimate the selling price, in successive periods, of a standard model - such as a closely specified ship, car park, aircraft or building. This is an expensive procedure and many countries instead use a cost approach in which the change in price of the finished asset is calculated from price changes of labour and material inputs. Problems with asset price indices are not confined to unique goods. A particular difficulty concerns the calculation of price indices for goods subject to rapid technological changes, notably computers and related equipment. For these goods there is general agreement that *hedonic* techniques provide the most reliable measure of price changes over time.

98. In calculating real (volume) capital measures there are choices in the index number formula to use in aggregation. The SNA93 recommends the use of chaining and "superlative" index formulae, such the *Fisher Ideal Index* and the *Tornqvist Index*. The advantage of chain indexes is that the weights remains up-to-date and hence reflect the relative prices on which economic decisions are based. In contrast, in times of rapid changes in relative prices the weights in fixed weight indexes can quickly become out-of-date and so give rise to biased volume measures. Although chain *Fisher* and *Tornqvist* indexes are

conceptually superior to chain *Laspeyres* indexes, the latter closely approximates the other two in most cases.

Service lives of assets

99. The accuracy of capital stock estimates derived from a PIM is crucially dependent on **service lives** – *i.e.* on the length of time that assets are retained in the capital stock, whether in the stock of the original purchaser or in the stocks of producers who purchase them as second hand assets. The first section below looks at the sources that are available to estimate service lives, the next section considers evidence that service lives may be changing over time, and a final section looks at how errors in service life assumptions may affect reliability of capital stock estimates. Annex 3 shows the service lives used by four countries that have investigated service lives with particular care. These are the United States, Canada, the Netherlands and the Czech Republic.

Sources for estimating service lives

100. The main sources for estimating service lives are asset lives prescribed by tax authorities, company accounts, statistical surveys, administrative records, expert advice and other countries' estimates.

- Tax-lives

101. In most countries, the tax authorities specify the number of years over which the depreciation of various types of assets may, under normal circumstances, be deducted from profits before charging taxes. Many countries – including Australia, United States, and Germany for example – make some use of them, either to estimate the service lives of assets for which no other source is available, or to provide a general credibility check on service life estimates obtained by other methods.

102. The interesting question is what sources are used to estimate tax-lives in the first place. In general, it appears that tax-lives are based on a variety of sources of differing reliability including expert opinion, ad hoc surveys of particular assets in particular industries and advice from trade organisations. In general, the accuracy of tax-lives will depend on the extent to which they are actually applied in tax calculations. Some governments use various systems of accelerated depreciation to encourage investment with the result that tax-lives become irrelevant to the calculation of tax liabilities, and neither tax collectors nor tax payers have any incentive to see that they are accurate and kept up-to-date. In many countries, however, tax-lives are based on periodic investigations by the tax authorities and can be assumed to be realistic.

103. In some cases, the statisticians have concluded that the pattern of tax lives across industries or asset types are fairly realistic but that there is a tendency for an overall bias in one direction or the other. They therefore systematically apply an upward or downward correction factor before using them for their PIM estimates.

- Company accounts

104. Company accounts often include information on the service lives that they are using to depreciate assets. Singapore and Australia have both made use of service lives reported in company accounts. The International Accounting Standards Committee (ICAS) has for some years been encouraging member countries to adopt common standards for company accounting and ICAS rules require companies to report

asset service lives used to calculate depreciation in their accounts. Company accounts could, therefore, become a better source of information in the future.

105. Company accounts almost always record stocks of assets at historic (or ''acquisition'') values, and while this is a disadvantage for many purposes, it does not necessarily prevent them from being used to estimate asset lives. Current price estimates of GFCF are, by definition, also valued at acquisition prices and are therefore consistent with stock estimates in company accounts. If the latter can be converted to a gross basis by adding back depreciation (which is also recorded at historic prices in company accounts) service lives can be estimated by comparing the gross stock in each year with the sum of investments during a varying number of previous years until finding how many years' cumulated investments most nearly equal each year's capital stock. This technique has been used in France, Italy and the United States.

- Statistical surveys

106. Two kinds of surveys are relevant to the estimation of asset service lives – those which ask producers about discards of assets during some previous accounting period and those which ask respondents to give the purchase dates and expected remaining lives of assets currently in use. The Netherlands has been carrying out a discards survey for some years and the Czech Republic has recently added questions about discards to its annual capital expenditure survey. The United Kingdom, on the other hand, recently investigated the feasibility of a discards survey but concluded that very few respondents would be able to provide reliable information about assets that had already been discarded from the stock.

107. The results of the Netherlands discards survey have been used directly to estimate asset service lives, but Statistics Netherlands now prefers to use an indirect approach. The value, at "as new" prices, of reported discards of a given type of asset installed in a given year are divided by each year's gross stock of assets each year of that same asset and same vintage. This gives an estimate of the "hazard rate" defined as the probability that an asset of that particular type and *i.e.* year of installation (vintage) will be discarded in each year following its installation. The hazard rates are then used to estimate the parameters of a Weibull probability function which has been found to give a good approximation to the way in which a group of assets installed in a given year are discarded. The average service life of the assets is determined from the estimated Weibull parameters.

108. Several countries carry out surveys of the second kind – *i.e.* those asking respondents about expected lifetimes. Korea and Japan have carried out large-scale investigations of capital stocks and asset service lives covering most kinds of activities. Canada, Italy and Spain have added questions about expected service lives to ongoing surveys of capital investment or industrial production. The United States carried out a number of industry-specific surveys in the 1970s with a view to updating the service lives used for tax purposes. A recent survey carried out in New Zealand on behalf of the tax authorities concentrated on 250 specified types of plant, machinery, transport and other types of equipment. For each asset type, a target group of producers was identified which could be expected to use that particular type of equipment and respondents were asked to report the year of purchase and expected remaining life of one individual asset of that type. By confining the investigation to a single asset the survey achieved a good response rate; an example of the questionnaire used for this survey is attached in Annex 3.

109. Producers of capital goods need to know the age structure of the asset stock in order to forecast future demand. For this reason, trade associations and publishers of technical journals sometimes carry out surveys, which may provide information on service lives. Information from these sources does not seem to have been widely used by statistical agencies but it may well be that similar information on particular kinds of assets is available from trade and technical publications in some countries.

- Administrative records

110. For some assets, government agencies maintain administrative records that can be used to estimate service lives. In almost all countries vehicle registration records track the service lives of road vehicles. Aircraft and ships are often subject to similar controls. Regulatory bodies in power industries, railways and telecommunications are also a possible data source.

- Expert advice

111. Most countries appear to base at least some of their asset lives on ''expert advice''. This may involve seeking advice from a panel of production engineers familiar with conditions in a representative cross-section of industries, or asking firms that produce capital assets for the expected or normal service lives of different sorts of equipment. As already noted, producers of capital equipment need to have realistic estimates of the usual working lives of the assets they produce because sales to replace existing assets are a significant part of their total market. Asset-producers are therefore a potential source of reliable information on service lives.

- Other countries' estimates

112. Most countries periodically review estimates used by other countries to ensure that their own estimates are not too far out of line with those of neighbouring or similar countries. Certainly, when countries first estimate capital stocks, they usually search the literature or contact other statistical offices to find out the service lives used elsewhere. There is a danger here that if countries systematically copy other countries service lives, an impression is created that there is a well-based consensus on the matter when in fact few, if any countries, have actually investigated service lives in their own countries. It should also be noted that asset service lives must be strongly influenced by country-specific factors such as the relative prices of capital and labour, interest rates and government investment policies. Other countries' estimates may provide a broad credibility check but should not adopted without question.

Changes in service lives

113. Estimates of service lives are rarely updated in most countries. The "fixity" of service lives has been criticised because it is alleged that service lives are tending to fall over time. Two main reasons are given for this:

- It is argued that "product cycles" are becoming shorter. Consumer tastes in many countries may be changing more rapidly than in the past so that manufacturers are forced to introduce new versions and models more quickly and to bring new products onto the market more often than before. This could require producers to retool their production lines more frequently.

- It is also argued that capital goods prices are rising less rapidly than in the past and in some cases are actually falling. This is certainly the case with computers and related equipment and may also be true for the increasing range of assets that incorporate computer technology; numerically-controlled machines, communications equipment, and robotised production systems are examples. If the price of an asset rises more slowly than the prices of the goods and services it is producing, the initial investment can be recouped over a shorter period than before and service lives will fall.

114. As against this, some assets are certainly becoming more durable. Road vehicles and commercial aircraft are two examples. In addition, there has been considerable progress in recent year in the development of "flexible" production systems, which allow manufacturers to rapidly switch between alternative models without the need to retool. Shorter production cycles do not, therefore, necessarily imply shorter asset lives.

115. There have been a few empirical studies relevant to the question of changes in asset lives. In Germany the Federal Ministry of Finance first began to publish tables of service lives to be used for tax purposes in 1957 and they have been regularly updated since then. The German *Statistisches Bundesamt* notes that officials of the Ministry of Finance are in regular contact with firms about changes in asset lives. The information obtained by the officials may be impressionistic rather than scientifically-based, but the Statistisches Bundesamt considers that it is nevertheless sufficiently well-founded to detect the direction of changes in service lives and the approximate size of such changes. A number of changes to tax lives are reported in these tables and, with the exception of commercial aircraft, all are reductions. Examples include farm-buildings (from 50 to 25 years), wood-working machinery (reduced by one or two years), machines in the precision industries (reduced from 10 to 8 years), and machines in the optical industries (reduced from 8 to 7 years).

116. Most countries appear to keep asset lives fixed for their PIM estimates, but there are some exceptions. In the capital stock estimates of the United Kingdom, the lives of most assets are assumed to have been gradually declining since the 1950's and service lives of most types of long-life assets are reduced by just over 1% each year. The German Statistisches Bundesamt uses falling service lives for housing, farm buildings, motor vehicles and certain types of industrial equipment. Finland assumes that service lives for machinery and equipment were falling by 0.8% to 1% per year from 1960 to 1989 and at about half that rate since 1990.

117. Some of these reductions in asset lives are introduced not because the statisticians believe that service lives of particular kinds of assets are falling but rather that the asset **groups** identified in their PIM models are thought to contain increasing shares of shorter-lived assets. In particular, assets containing computerised components are generally assumed to have shorter lives than other types of equipment and the share of such assets in some asset groups is almost certainly rising in all countries. Thus, even in the absence of information about asset lives of **specific** assets, it may be right to assume declining service lives for **groups** of assets. Clearly the importance of this composition effect will depend on the degree of detail in the asset classification that is being used.

118. The United States uses a rather detailed asset classification for stock estimates and certain changes in the service lives of specific assets lives are incorporated in its current PIM model. For example the Bureau of Labor Statistics assumes the service lives of main frame computers have fallen from 8 years prior to 1970, to 7 years between 1970 and 1979 and to 5 years since 1980. Terminals were assumed to last 9 years prior to 1981, for 8 years up to 1985 and for only 6 years since then. Similar reductions are assumed for other computer related equipment. (The changes are discrete, rather than continuous as the examples given above.)

119. There are fewer examples of increasing service lives. In Germany the service lives of commercial aircraft are assumed to have been between 5 to 8 prior to 1976 and 12 years for aircraft purchased since then. In the United States electric light and power equipment was assigned a service life of 40 years before 1946 and 45 years for all later years. Commercial aircraft are also assigned longer lives in later years – 12 or 16 years prior to 1960 and 15 or 20 years since then. Australia cites evidence from vehicle registration records that the service lives of road vehicles are increasing and this may be a fairly widespread phenomenon.

Effect of errors in service life estimates

120. Ideally, what is required for accurate implementation of the PIM is a set of service lives for narrowly-defined asset groups that are used in different sectors and kinds of activity. Moreover, this set of service lives should be updated regularly to reflect cyclical or longer term changes in the lengths of time that assets remain in the stock. From the review of the sources above it is clear that the information actually available falls far short of this ideal. Service life estimates are generally available only for broad asset groups, there is limited information available on differences in lives of asset groups between sectors and kinds of activity and service lives are updated at rare intervals in most countries. This section considers how errors in service lives may affect levels and growth rates of capital stocks derived from the PIM.

121. The effect of errors in the average service lives used in the PIM can be gauged through "sensitivity studies" by running the PIM model with alternative estimates of service lives. Results of recent sensitivity studies for Canada and the Netherlands are described below.

122. Statistics Canada has estimated the **gross capital stock** in manufacturing with its standard PIM model but using service lives that increased from 0.5T to 1.5T, with T the average service life presently being used in Canada. The tests were run for the period 1950 to 1998. Predictably, changing service lives changes the level of the capital stock in the same direction. Using the shortest lives (0.5T) reduced the level of the stocks by up to 50% and using the longest lives (1.5T) increased the level by up to 40%. With less extreme changes – 0.9T and 1.1T – the size of the stock is reduced by about 8% and raised by about 7%; assuming that service lives used for PIM estimates are not usually wrong by more than 10%, the Canadian study therefore suggests that stock levels may have error margins of +/-8%.

123. Analytic studies often focus on growth rates rather than stock levels. The effect of changing service lives has an unpredictable effect on growth rates because service lives act like weights. An upward revision to the service life of a particular asset increases the share of that asset in the total stock. An upward revision to a faster (slower) growing component of the stock will raise (lower) the growth rate of the capital stock as a whole. In the Canadian study, reducing service lives generally increased capital stock growth rates during the period 1950 to 1970 but decreased them from 1971 to 1998.

124. The study carried out by Statistics Netherlands focused on stocks of machinery in the chemical industry and covered the period 1978 to 1995. Five different service lives were used – 10, 15, 20, and 25 years (the average service life actually used is 19 years). While the Canadian study deals only with estimates of the gross capital stock, the Netherlands study looked at the effects on both gross and net stocks and on consumption of fixed capital.

125. The level of the **gross stock** again changes in the same direction as the changes to service lives. **Consumption of fixed capital**, however, generally changed in the opposite direction; that is, increasing the service lives reduced the amount of consumption of fixed capital. This happened because, with longer service lives, each asset is written off over a longer period and this outweighs the increase due to the fact that longer service lives mean that there are more assets in the stock. In some years, however, the increase in the number of assets in the stock due to the use of longer service lives outweighed the reduction in the amounts of consumption of fixed capital charged to each asset and total consumption of fixed capital increased with longer service lives.

126. Net capital stock is obtained by deducting accumulated consumption of fixed capital from the gross stock. Since longer service lives will always increase the gross capital stock and will usually decrease consumption of fixed capital, the **net capital stock** will tend to increase when longer service lives are used.

Moreover, the increase in net capital stock as service lives are lengthened will be relatively larger than in the case of the gross capital stock.

127. A final conclusion from the Netherlands study is that growth rates of gross and net stocks and of consumption of fixed capital becomes less volatile as service lives are lengthened. With longer service lives any lumpiness in investment flows into and out of the stock tends to be dampened by the larger size of the stock.

128. To summarise the results of these two sensitivity studies:

- Longer service lives always increases the size of the gross capital stock.
- Longer service lives usually reduce consumption of fixed capital.
- Longer service lives usually increase the size of the net capital stock and by relatively more than in the case of the gross capital stock.
- Longer service lives have an unpredictable effect on growth rates.
- Longer service lives reduce the volatility over time in the growth of stocks and capital consumption.

Mortality patterns

129. This section looks at the assumptions made about the distribution of retirements around the average service life. "Retirements" and "discards" are here used interchangeably to mean the removal of an asset from the capital stock, with the asset being exported, sold for scrap, dismantled, pulled down or simply abandoned. As used here retirements and discards are distinguished from "disposals" which also includes sales of assets as second-hand goods for continued use in production.

130. Four types of mortality patterns are discussed – simultaneous exit, linear, delayed linear, and bell-shaped. The mortality functions and survival functions corresponding to these four patterns are displayed in Figure 1. The mortality functions (first column) show rates of retirement over the lifetimes of the longest-lived member of a group of assets of a particular type that were installed in a given year. They are probability density functions with the area under each curve equal to unity. The survival functions (in the second column) show what proportion of the original members of the group of assets are still in service at each point during the lifetime of the longest-lived member of the group.

Simultaneous exit

131. The simultaneous exit mortality function assumes that all assets are retired from the capital stock at the moment when they reach the average service life for the type of asset concerned. The survival function therefore shows that all assets of a given type and vintage remain in the stock until time T, at which point they are all retired together. This retirement pattern is sometimes referred to as ''sudden exit'' but this term is ambiguous. Whatever mortality pattern is used, individual assets are always retired suddenly; the distinguishing feature of this mortality function is that all assets of a given type and vintage are retired **simultaneously**.

Linear

132. With a linear retirement pattern, assets are assumed to be discarded at the same rate each year from the time of installation until twice the average service life. The mortality function is a rectangle whose height – the rate of retirement – equals 1/2T where T is the average service life: the survival function shows that the surviving assets are reduced by a constant amount each year, equal to 50/T% of the original group of assets. A linear retirement pattern assumes that retirements start immediately after they are installed and this is generally regarded as an unrealistic assumption.

Delayed linear

133. A delayed linear retirement pattern makes the more realistic assumption that discards occur over some period shorter than 2T. Retirements start later and finish sooner than in the simple linear case. Suppose for example that it is assumed that the assets are retired over the period from 80% to 120% of their average service life. The rate of retirement in the mortality function is then equal to 1/T (1.2-0.8) or 250/T% per year during the period when the retirements are assumed to occur.

Bell-shaped

134. With a bell-shaped mortality pattern, retirements start gradually some time after the year of installation, build up to a peak around the average service life and then taper off in a similar gradual fashion some years after the average. Various mathematical functions are available to produce bell-shaped retirement patterns and most provide considerable flexibility as regards skewness and peakedness (or *kurtosis*). They include gamma, quadratic, Weibull, Winfrey and lognormal functions. The last three are probably most widely used in PIM models and are described here.

- Winfrey curves

135. Winfrey curves are named after Robley Winfrey, a research engineer who worked at the Iowa Engineering Experimentation Station during the 1930s. Winfrey collected information on dates of installation and retirement of 176 groups of industrial assets and calculated 18 "type" curves that gave good approximations to their observed retirement patterns (see box). The 18 Winfrey curves give a range of options for skewness and kurtosis. They are used in PIM models by several countries.

136. The Winfrey symmetrical curves are written as:

$$y_x = y_o\left(1-\frac{x^2}{a^2}\right)^m \qquad (1)$$

where y_x is the ordinate of the frequency curve at age x, y_o is the ordinate of the frequency curve at its mode, and a and m are parameters ranging from, respectively, 10 to 7 and 0.7 to 40.0, which determine the peakedness (kurtosis) and the skewness of each curve.

Two widely used Winfrey curves are the symmetrical S2 and S3 curves; the S2 curve is flatter than the S3. For these curves the parameters are as follows:

S2 yo = 11.911; a = 10; m = 3.700

S3 y0 = 15.610; a = 10; m = 6.902

Table 8. Application of the Winfrey S3 mortality function

For GFCF of 8 700 with an average service life of 12 years

Per cent of average service life	Winfrey probability of discard at a given percent of average life	Amount of an investment of 8700 discarded after a given percent of average life (8700 * *col 2*)	Actual service life for that part of the 8700 investment shown in *col 3* (*col* 1/100 * 12)
column 1	*column 2*	*column 3*	*column 4*
45	0.012	104.4	5.4
50	0.012	104.4	6.0
55	0.017	147.9	6.6
60	0.024	208.8	7.2
65	0.032	278.4	7.8
70	0.040	348.0	8.4
75	0.050	435.0	9.0
80	0.059	513.3	9.6
85	0.066	574.2	10.2
90	0.072	626.4	10.8
95	0.077	669.9	11.4
100	0.078	678.6	12.0
105	0.077	669.9	12.6
110	0.072	626.4	13.2
115	0.066	574.2	13.8
120	0.059	513.3	14.4
125	0.050	435.0	15.0
130	0.040	348.0	15.6
135	0.032	278.4	16.2
140	0.024	208.8	16.8
145	0.017	147.9	17.4
150	0.012	104.4	18.0
155	0.012	104.4	18.6

137. When Winfrey curves are used in a PIM model, the usual procedure is to calculate the percentage of assets of a given vintage that are discarded at different ages measured in percentages of the average service life. Table 8 shows how the Winfrey S-3 curve can be applied. Discards start at 45% of the average age and continue to 155% of the average, by which time all the assets of a given vintage have been discarded.

- Weibull distribution

138. The Weibull function has been widely used in studies of mortality in natural populations. It is a flexible function that can adopt shapes similar to those designed by Winfrey and it is used by several countries for PIM estimates. The Weibull frequency function is written as:

$$f\left(x\right)=\alpha\lambda*\left(\lambda x\right)^{\alpha-1}*\exp(-(\lambda x)^{\alpha}) \qquad (2)$$

where x is the number of years since the asset was installed, and λ and α are parameters which jointly determine kurtosis and skewness.

139. The frequency function at (2) can be used to calculate the percentage of assets of a given vintage that are discarded at different ages as shown in Table 8 above for the Winfrey mortality pattern.

140. Statistics Netherlands has used data from surveys of discards to estimate Weibull discard patterns for a wide range of assets. They report values of λ ranging from 0.015 to 0.033. The α parameter can be interpreted as a measure of changes in the risk of an asset being discarded.

$0 < \alpha < 1$	indicates that the risk of discard decreases over time,
$\alpha = 1$	indicates that the risk of discard remains constant through the lifetime of the asset,
$1 < \alpha < 2$	indicates that the risk of discard increases with age but at a decreasing rate,
$\alpha = 2$	indicates a linearly increasing risk of discard, and
$\alpha > 2$	indicates a progressively increasing risk of discard.

141. Most of the α values reported by Statistics Netherlands lay between 1 and 2 except for computers where values just over 2 were reported. The older the computer, the higher the risk that it will be obsolete and have a high risk of being discarded.

Lognormal distribution

142. The normal distribution is widely used in many branches of statistics. The normal frequency distribution is symmetrical and has the useful property that 95% of the probabilities lie within two standard deviations around the mean. The lognormal distribution has this same property and is widely used as a mortality distribution for the PIM. The lognormal distribution is left-skewed and gives zero probability of discard in the first year of an assets life. The right-hand tail of the distribution, however, approaches but never reaches zero and must be arbitrarily set to zero when the probabilities become small.

The normal frequency distribution is:

$$f_x = \frac{1}{\sqrt{2\pi} * s} * \exp\left(-(x-m)^2 / 2s^2\right) \qquad (3)$$

x are years 1,2,3,...,T,

m is the mean of the distribution,

s is the standard distribution.

The lognormal frequency distribution is:

$$f_x = \frac{1}{\sqrt{2\pi} * \sigma} * \frac{1}{x} * \exp(-(\ln x - \mu)^2 / 2\sigma^2 \qquad (4)$$

x are years 1,2,3,.....T

σ is the standard deviation of the lognormal distribution, calculated as:

$$\sigma = \sqrt{\ln(1 + \frac{1}{(m/s)^2})} \quad (5)$$

μ is the mean of the lognormal distribution, calculated as:

$$\mu = \ln m - 0.5\sigma^2 \quad (6)$$

143. The lognormal frequency distribution is used in an ongoing study of capital stocks in the European Union. With ***m*** as the estimated average service life, the standard deviation *s* is set to between *m/2* to *m/4* to give more and less peaked distributions of retirements.

Which mortality pattern is the best?

144. Of the four discard patterns considered above, the first two – simultaneous exit and linear decline – are clearly unrealistic. It is simply not plausible to assume that all assets of a given vintage will all be withdrawn from the stock at the precise moment when they reach the average service life for that asset type. Like people, some assets will be discarded before they reach the average age because they are overworked, poorly maintained or fall victim to accidents, while others will continue to provide good service several years beyond their average life expectancy. **Simultaneous exit** must be regarded as an inappropriate retirement pattern.

145. It is almost as implausible to assume that an equal number of assets of a given vintage are discarded each year beginning in the first year that they are installed. Assets are by definition expected to remain in use for several years and discards in the years immediately after installation are likely to be rare for most assets. **Linear retirement** also fails the test of plausibility.

146. The remaining discard patterns – delayed linear and bell-shaped – are clearly more realistic models. **Delayed linear** assumes that once retirements begin, equal parts are discarded until the entire vintage has disappeared and this is probably less plausible than the assumption of a gradual build-up of discards in the early years and a gradual slowdown in later years, which is implied by **bell shaped distributions**.

147. Winfrey curves were specifically developed to reflect the way that assets are discarded and they are used by several countries in their PIM models. Both Weibull and lognormal mortality patterns have some empirical support. Statistics Netherlands and the French INSEE respectively, have shown that they can satisfactorily replicate observed discard patterns.

Consumption of fixed capital

148. Consumption of fixed capital is not generally observable and is usually estimated on the assumption that asset prices decline in a systematic way over the course of the asset's service lives. Note that consumption of fixed capital almost always has to be estimated in this way whether the capital stock is obtained by the PIM or by some kind of survey method.

149. Business accountants have devised several methods for calculating consumption of fixed capital, which are also used for national accounting and these are explained in the next chapter. The commonest of these are "straight-line depreciation", "geometric depreciation" and "sum of the year's digits depreciation".

Net capital stock

150. The net capital stock is defined as the value of fixed assets at their market prices. Market prices are lower than the "as new" prices used for the gross capital stock because of consumption of fixed capital. These market values are estimated by deducting accumulated consumption of fixed capital from the gross capital stock. Chapter 3 contains an illustrative calculation showing how this is done.

Alternative application of the PIM

151. The alternative way of applying the PIM that is described here exploits the relationship between age-efficiency and age-price profiles. Age-efficiency profiles are estimated for each service life for each type of asset and together with an assumption about the discount rate these profiles generate the age-price profiles that are used to estimate the net capital stock.

152. It will be recalled from Chapter 1 that under competitive market conditions, the market price of an asset is related to the rentals that the asset is expected to earn through the following equation (as in Chapter 1, the discounted value of any eventual scrap value is ignored):

$$V_t = \sum_t^T \frac{f_t}{(1+r)^t} \qquad (7)$$

Where V_t is the market value of an asset at time t,

f_t is the rental earned in period t,

and r is the discount rate.

153. In Chapter 1, it was shown how equation (1) can be used to derive age-price profiles corresponding to any given age-efficiency profile. In the example in Chapter 1, a linear fall in efficiency was used as the age-efficiency profile. Table 9 shows the age-efficiency profiles corresponding to three additional age-efficiency profiles. These are the one-hoss shay (no loss in efficiency), geometric decline (efficiency falls at a constant rate) and hyperbolic decline (efficiency falls at an any increasing rate with age). The discount rate has been set at 5%.

Table 9. Four age-efficiency and age-price profiles.

Discount rate 5%

	Year	1	2	3	4	5	6	7	8
Linear (1 unit per year)	Age-efficiency profile	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30
	Age-price profile	1.00	0.82	0.66	0.51	0.37	0.25	0.15	0.07
One-hoss shay (constant efficiency)	Age-efficiency profile	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Age-price profile	1.00	0.89	0.80	0.68	0.56	0.43	0.29	0.15
Geometric (falls by 10% per year)	Age-efficiency profile	1.00	0.90	0.81	0.73	0.66	0.59	0.53	0.48
	Age-price profile	1.00	0.84	0.69	0.55	0.43	0.31	0.20	0.10
Hyperbolic (□ = 0.5)	Age-efficiency profile	1.00	0.93	0.86	0.77	0.67	0.55	0.40	0.22
	Age-price profile	1.00	0.83	0.67	0.51	0.37	0.24	0.13	0.05

154. Of the four age-efficiency profiles shown in Table 9, the hyperbolic profile is the most widely used. For this table it has been calculated by a hyperbolic function of the form:

$$V_t = V_o(T-(t-1))/(T-\beta(t-1)) \qquad (2)$$

t are the years $1, 2, \ldots, T$,

and β is the slope-coefficient which has been set at 0.5 in this example.

155. The hyperbolic age-efficiency and age-price profiles shown in Table 9 are used to calculate the stock of an asset in standard efficiency units and at market values as shown in Table 10.

Table 10. Calculation of stocks in standard efficiency units and at market values

Hyperbolic decline in efficiency: 5% discount rate.

Year	GFCF at constant prices	Age-efficiency coefficient	Converted to standard efficiency units	Age-price coefficients	At market prices
1	100	0.22	22.22	0.05	4.70
2	90	0.40	36.00	0.13	11.63
3	120	0.55	65.45	0.24	28.61
4	60	0.67	40.00	0.37	22.08
5	80	0.77	61.54	0.51	41.04
6	120	0.86	102.86	0.67	80.37
7	100	0.93	93.33	0.83	82.81
8	80	1.00	80.00	1.00	80.00
		Stock at beginning of year 8 in standard efficiency units	501.41	Net stock at beginning of year 8	351.24

156. To understand the table:

- The second column shows gross fixed capital formation in a specified type of asset which has a service life of 8 years. The GFCF series have been converted to constant prices.
- The third column gives the age-efficiency coefficients for an asset whose efficiency declines hyperbolically as shown in Table 9
- The fourth column shows each year's constant price GFCF converted to standard efficiency units. For example the GFCF of 100 that occurred in year one is multiplied by the age-efficiency coefficient 0.22, which measures its ability to produce capital services now that it has been in use for 7 years.
- The fifth column gives the age-price profiles corresponding to an asset that lasts 8 years and whose age-efficiency declines hyperbolically on the assumption that the discount rate is 5%.
- The last column shows the net value, at the beginning of year 8, of the assets remaining from GFCF in earlier years. It is obtained by multiplying each year's GFCF by the corresponding age-price coefficient. For example, the GFCF of 100 that occurred in year 1 has declined to only 0.05 of its original value by the beginning of year 8.
- Finally, the stock of this particular asset at the beginning of year 8 is obtained by addition. The total of column 4 gives the stock in standard efficiency units and the total of column 6 gives the net stock in constant prices.

157. If the same calculations are performed in year 9 the change in the two capital stock measures can be calculated. The proportionate change in the stocks expressed in standard efficiency units represents the real proportionate change in capital services during the period. The change in real net capital stocks can be decomposed into two elements – the increase attributable to gross fixed capital formation during the year and the decrease due to consumption of fixed capital. The latter can then be revalued using the price index in order to derive a current price estimate of consumption of fixed capital during period 8 for inclusion in the national accounts.

158. This method of applying the PIM has the advantage that the standard efficiency units of each type of asset are measured consistently with the net capital stock and consumption of fixed capital. The standard efficiency units used to calculate the **volume index of capital services** as explained in Chapter 8. This index is the recommended measure of capital inputs for productivity analysis.

159. Note that capital consumption is here being derived indirectly from the changes in the net stock (after deducting gross fixed capital formation during the year). The method does not therefore require any assumptions about the form of the depreciation function which are needed when the PIM is applied in the standard way described in the previous section. Instead the alternative method requires assumptions about the form of the age-efficiency profiles appropriate to each type of asset.

160. The two agencies that currently use this alternative PIM method (the Australian Bureau of Statistics and the US Bureau of Labor Statistics) use hyperbolic functions for almost all types of assets. The slope-coefficient is set at 0.5 for machinery and equipment and at 0.75 for buildings and structures. The higher value of β used for buildings and structures implies that they lose their efficiency more slowly than in the case of machinery and equipment. With β set at 1.0, the hyperbolic function gives a constant,

or "one-hoss shay" age-efficiency profile. The ABS uses this value of □ for mineral exploration implying that there is no efficiency decline in exploration knowledge.

CHAPTER 6

MEASURING CONSUMPTION OF FIXED CAPITAL

Introduction

Terminology

161. In the previous chapters the term *consumption of fixed capital* has been used in line with the terminology of the 1993 System of National Accounts. As it is defined in this System, consumption of fixed capital is in fact identical with *depreciation*, as this term is understood in economics. In this chapter the two terms are used interchangeably.

Direct versus indirect measurement of depreciation

162. The traditional application of the PIM involves estimation of the gross capital stock, application of a depreciation function to obtain annual depreciation and finally estimation of the net capital stock by subtracting accumulated depreciation from the gross capital stock. This application of the PIM requires the **direct** estimation of depreciation which is used to obtain the net capital stock indirectly. The alternative, integrated approach described in Chapter 5, is to start by estimating age-efficiency profiles for each type of asset which are then used to generate age-price profiles. The age-price profiles are used to directly estimate the net capital stock from which depreciation is obtained **indirectly**. This chapter is relevant only to countries that apply the PIM in the traditional way.

Layout

163. The aim of this chapter is to identify the depreciation methods that are most likely to reflect the ways in which assets lose their value over time. The chapter is divided into three sections:

- The first reviews the empirical evidence about how assets lose their value during the course of their service lives. This evidence comes from studies, mainly carried out in North America, on the prices of second-hand assets.

- The next section shows that there are many age-efficiency profiles that will produce age-price profiles for assets that are consistent with the empirical evidence drawn from the prices of second hand assets.

- The third section describes three common depreciation methods - straight-line, sum-of-the-digits and geometric – and compares the age-price profiles implied by each method with the empirically-consistent age-price profiles identified in the previous section.

Empirical evidence

164. If the price level is stable, depreciation is simply the change in the market value of an asset from one accounting period to the next. This change is referred to as the age-price profile. The prices of second-hand assets, after being adjusted to eliminate changes in price levels, can be used to establish age-price profiles for assets. For example they can be used to show how the market values of farm tractors of a particular model decline as they get older.

165. Virtually all studies of second hand asset prices have been made in the United States, perhaps because second-hand asset markets are more highly developed in that country. It is not certain that the age-price profiles identified for assets in the United States are also typical for other countries, although the few studies carried out elsewhere, in Canada, United Kingdom and Japan, for example, have found similar age-price profiles.

166. Ideally, these studies should use actual transaction prices. A few studies have done this by using auction prices. This is often the case in studies of farm equipment because auctions are a common way of disposing of assets when farms go out of business. Other studies have tried to obtain transaction prices from second-hand asset dealers through surveys. Most studies, however, have been based on "list prices". These are the offer prices published by dealers and, because bargaining is common in asset markets, they may overstate actual transaction prices. In almost all cases, the first price in the age-price profile – the new price of the asset – is almost always a list price even when the subsequent observations are genuine transaction prices. Finally, at least one study has used insurance values. This was a study of fishing boats and because they run substantial risks of accidental loss, both owners and insurers have a shared interest in ensuring that insured values are realistic; this is not always the case for assets which face lower accident risks.

167. Questions have sometimes been raised whether assets traded on second-hand markets are representative of the entire asset stock, including the large majority of assets that remain in the possession of their original owners until they are scrapped. In particular, it has been suggested that assets are put on the second-hand market because they are defective in some way; this is sometimes referred to as the "lemons" theory. Even if most second hand assets are in fact not lemons (*i.e.* not defective), so long as some prospective buyers fear that there may be some defective ones among the assets on offer, prices will be depressed and the prices of assets traded on second-hand markets will understate the market values of assets not so traded. An additional point is that there may be an inverse relationship between the lemons effect and the age of an asset. If an asset is put on the market while it is still relatively new, prospective buyers may be more suspicious about possible defects than if an asset is traded towards the end of its normal service life. The opposite suggestion has also been made, namely that used assets are usually put on the market in order to raise finance and so firms will sell their best assets rather than their worst ones. Attempts to determine the validity of these and other theories about the extent to which second-hand assets are representative of the total asset stock are inconclusive.

168. A significant source of bias, about which there is no dispute, arises from the fact that second-hand asset prices necessarily refer only to assets that have not yet been retired from the capital stock. Within the entire group of farm tractors of a given make, model and year of manufacture, there will be some whose second-hand prices are zero because they have been scrapped. A minority of studies has tried to correct for this bias by adding some (unobserved) zero prices to the set of prices that have been observed. It is usually assumed that the assets with zero prices were withdrawn from the stock following a bell-shaped mortality function. While this is a reasonable assumption, it means that the studies are no longer strictly empirical since they include assumptions about the pattern of discards.

169. Three main conclusions about age-price profiles can be drawn from these studies:

- First, different kinds of assets exhibit a very wide range of age-price profiles. If price is plotted on the vertical axis and age horizontally, studies have found age-price profiles that are concave to the origin, that are horizontal lines, that fall in a straight line and that are convex to the origin. The studies have covered a wide range of industrial, agricultural and construction machinery, commercial and industrial buildings and transport equipment and it is therefore no surprise that they have not identified a single, standard pattern for the age-price profile of assets.

- Second, notwithstanding the above, by far the commonest age-price profile is a line which falls over time with some convexity towards the origin. This is almost always the case for machinery and equipment and is generally the case for buildings.

- Third, the downward sloping convex curve, which is most often detected in these studies, does not follow any simple mathematical law. Some of the studies have tested whether their observed age-price profiles follow one of two simple models – geometric (*i.e.* asset prices falling by a constant rate each year) or straight-line (*i.e.* asset prices falling by a constant amount each year) Statistical tests almost invariably reject both of these simple models, although straight-line is usually rejected more firmly than the geometric model. Some studies have successfully fitted Box-Jenkins curves to the asset price data; these are flexible functions which can take a range of forms including straight lines and geometric curves. The fact that Box-Jenkins curves may fit the data quite well is simply confirmation that age-price profiles follow complex paths. This is again not a cause for surprise. It would be astonishing if the multitude of factors that may influence asset prices – shifts in demand, relative factor prices, technological developments to mention a few – combined to produce age-price profiles that follow some simple mathematical model.

Age efficiency profiles, asset prices and depreciation

170. The relationship between the value of the rentals, or capital services (f), produced by an asset and the price of that asset (V) is described by equation (1) which was introduced in Chapter 1.

$$V_t = \sum_t^T \frac{f_t}{(1+r)^t} \qquad (1)$$

171. In this section, equation (1) is used to show how the age-price profile of an asset will change from year 1 to T (the last year of its service life) under alternative assumptions about the age-efficiency profile of the asset over its lifetime. The purpose is to identify age-efficiency profiles which seem plausible on *a priori* grounds and which generate age-price profiles which are consistent with the empirical evidence discussed above – namely that age-price profiles are usually downward sloping and with some convexity towards the origin. The depreciation patterns implied by these age-efficiency profiles are then compared with those produced by three standard depreciation methods – straight-line, geometric and sum-of-the-years-digits.

172. Table 1 in Chapter 1 showed how equation (1) can be used to generate the value of an asset over its lifetime and how these are determined by the age-efficiency profile and the discount rate. The calculation explained in Chapter 1 is here repeated for five age efficiency profiles as described below. First

however, it will be useful to consider how the efficiency of assets may be expected to change as they get older.

- Most assets suffer from what can be termed **input decay** meaning that they require more labour or material inputs to maintain their performance. For, example a freight truck may use more oil as it ages or require more extensive maintenance work and therefore more inputs of labour. Input decay will result in a declining efficiency profile.

- Assets may also suffer from **output decay** as they age. This may take several forms. An older asset may produce more defective products which have to be rejected, or its productive capacity could be lowered because it needs to spend more time under repair and less time in production.

- Some assets may require a running-in period during which technical adjustments are made to maximise performance. Others may require the operators to learn new skills. In either situation the efficiency profile could be expected to rise during the early period of use. This could be described as **negative output decay**.

173. The five age-efficiency profiles used here are:

- *Constant age-efficiency.* This is also referred to as the "one-hoss shay" pattern after the mythical horse-drawn cart in "The Deacon's Masterpiece", a poem by Oliver Wendell Holmes (see Box). The deacon built his cart so well that it ran perfectly for a hundred years without need for repair, thus providing a constant stream of transport services until the day when it suffered catastrophic failure. During its service life neither input decay nor output decay reduced the quantity of services provided. There are probably rather few assets that maintain constant efficiency throughout their working lives. Light bulbs are sometimes cited as potential one-hoss shays, but light-bulbs are too short-lived to be classified as capital goods. More serious contenders might be bridges or dams. With a constant level of maintenance these structures may continue to provide constant rentals for very long periods. In general, however, the one-hoss shay, is regarded as a textbook curiosity with few examples in the real world.

- *Age-efficiency falls at a constant rate each year.* This is usually referred to as geometric decline. There is some evidence that assets that are particularly vulnerable to obsolescence, such as computer equipment, exhibit age-efficiency profiles of this kind. Note that geometric decline implies that the rentals generated by the asset fall by a decreasing absolute amount each year. Since input decay can be expected to increase in absolute terms with age, the geometric profile may not be relevant for assets that experience significant input decay.

Box 2.The Deacon's Masterpiece or the Wonderful "One-Hoss Shay"

Oliver Wendell Holmes' poem tells of a Deacon who decides to build a "shay" that would have no weak spots so that it would never break down. (Shay is a corruption of the French *chaise,* which is an old English abbreviation of "post-chaise" or stage-coach.)

Now in building of ***chaises****, I tell you what,*
There is always somewhere a weakest spot,-
In hub, tire, felloe, in spring or thill,
In panel or cross-bar, or floor or sill,
In screw, bolt, thoroughbrace, - lurking still,
Find it somewhere you must and will.

The Deacon assembles the hardest timbers, the finest steel, the toughest leather and the work begins.

Seventeen hundred and fifty-five,
Georgius Secundus *was then alive.-*
Stuffy old drone from the German hive.
That was the year when Lisbon town
Saw the earth open up and gulp her down,....
It was on that terrible Earthquake day
That the Deacon finished the one-hoss shay.

The shay outlives the Deacon:

She was a wonder and nothing less,
Colts grew horses, beards turned gray
Deacon and deaconess dropped away,
Children and grandchildren - where were they?
But there stood the wonderful one-hoss shay
As fresh as on Lisbon Earthquake day!

But still, nothing last for ever, and by its hundredth year:

There are traces of age in the one-hoss shay,
A general flavour of mild decay,
But nothing local as one may say.
There couldn't be- for the Deacon's art
Had made it so like in every part
That there wasn't the chance for it to start.

Finally, disaster:

First of November fifty-five,
This morning the parson takes a drive....
The parson was working his Sunday's text,-
Had got to "fifthly", and stopped perplexed...
All at once the horse stood still.
Close by the meet'n'-house on the hill.
First a shiver and then a thrill,
Then something decidedly like a spill,-
And the parson was sitting upon a rock,
At half-past nine by the meet'n'-house clock,-
Just the hour of the Earthquake shock!

Notice that while the one-hoss-shay suffered neither input decay nor output decay during its hundred year service life, this does not mean that it was immune to wear and tear. It clearly did suffer wear and tear, which is why it suddenly fell apart. The wear and tear took the form of metal fatigue and similar subtle changes in the molecular structure of the wood and leather. These changes were imperceptible to the naked eye (although they could have been discovered by microscopic investigation), and they in no way affected the ability of the shay to provide a steady flow of unchanged transport services. But the changes nevertheless guaranteed that, sooner or later, the shay would fall apart.

This point is not trivial because it is sometimes alleged that one-hoss shays, such as light-bulbs, lose their value only because the failure point grows nearer as each year passes. From this it has been concluded that the passage of time is a cause of depreciation in itself, in addition to the causes identified in the SNA, namely wear and tear, obsolescence and accidental damage. This is a mistake. If the light-bulb is not suffering wear and tear - through leakage of the inert gas or oxidisation of the filament, for example - it will go on working forever and the passage of time becomes irrelevant. Ageing, or *exhaustion* as it sometimes called, may be a useful rule of thumb for determining how much wear and tear has occurred but is not, in itself, a cause of depreciation.

- *Age-efficiency falls fall by a constant amount each year.* The linear pattern means that efficiency falls at a faster rate as the asset ages. In the example below, the rental is assumed to fall each year by a constant amount equal to 5% of the initial value of the asset. A linear decline in efficiency can be seen as a compromise between the geometric profile and the hyperbolic profile described next.

- *Age-efficiency falls hyperbolically.* With this profile, efficiency declines slowly in the earlier period and at an increasing rate towards the end of the assets life. There is some evidence from the United States that this may be a common efficiency profile for many kinds of assets including both structures and plant and machinery. The hyperbolic function was explained in Chapter 5. Here β is set at 0.5, a commonly used value for age-efficiency profiles of machinery and equipment.

- *Two-step age-efficiency.* In many countries there is an increasing trend towards integrated production systems in manufacturing. There may be many separate pieces of equipment in such a system, each of which must operate without failure since the entire system will shut down if any single component malfunctions or produces defective outputs. Many of these systems are robotised, operating with little human intervention and they may be operated almost continuously rather than in shifts. Typically, the component machines in such a system will be expected to operate without failure for several years, at which point the investment manager will decide either to undertake necessary repair work in order to keep the machines in the integrated system or to remove them from the main production system. In the latter case it may either be sold to another producer or it may be assigned a less demanding role, such as developing prototypes or filling special orders. Assets incorporated into integrated production systems may be expected to have an age-efficiency profile that:

  - Increases in the first period as the system is run-in, *i.e.* negative output decay.

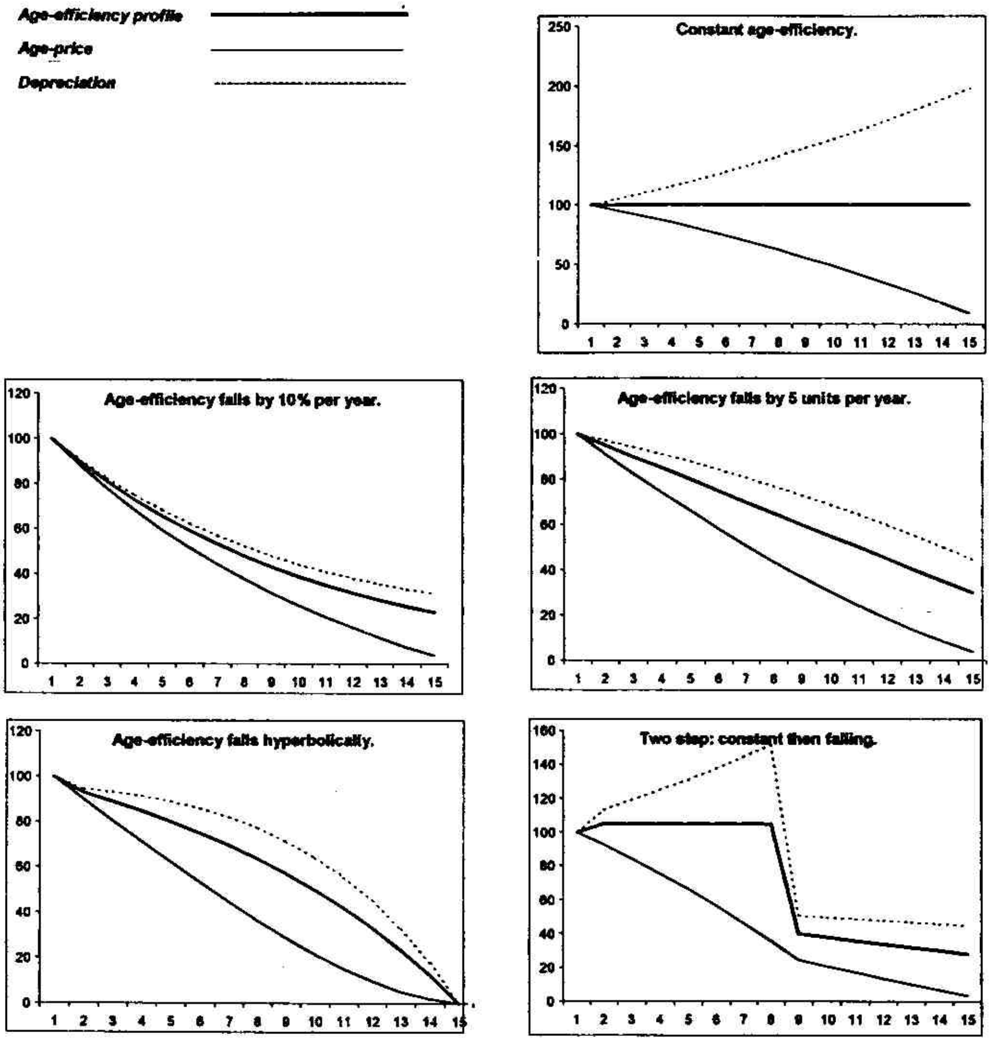
  - Remains constant during the several years in which it is a part of an integrated system, *i.e.* a one-hoss shay profile.

  - Declines abruptly when the machine is withdrawn from the integrated system.

174. In the example given below, the rental is assumed to rise by 5% in the first year, to remain steady for the next 7 years when it is operating in an integrated system, to fall abruptly when it is withdrawn from the system and then to decline linearly for the remainder of the asset's service life. This "two-step" value profile may be appropriate for an increasing proportion of plant and machinery in manufacturing industries.

175. The age- price and depreciation profiles for these five age-efficiency profiles are shown in Figure 1 with all three flows scaled to equal 100 in the first year. The service life is 15 years and a 5% discount rate is used.

Figure 1. Age-price and depreciation profiles by five age-efficiency profiles



176. The empirical evidence on second hand assets that was reviewed in the first section of this chapter shows that asset values generally fall over time with some convexity towards the origin. The first age-efficiency profile in Figure 1 – one hoss shay – gives an age-price profile for the asset which is the opposite shape – *i.e.* it is concave to the origin. It can therefore be concluded that one-hoss shays are rare in the real world. The other four age-efficiency profiles, however, all produce age-price profiles that are consistent with the empirical evidence. The two-step profile gives a time profile for the asset value that has an inflection towards the origin rather than the smooth convexity produced by the other age-efficiency profiles but it is still broadly consistent with the empirical evidence.

177. As explained, the calculations underlying Figure 1 used a service life of 15 years and a discount rate of 5%. How far are these results sensitive to these two assumptions? Annex 5 graphs the results of calculations based on service lives of 15 and 50 years and discount rates of 5% and 10%. These alternative calculations show that the overall shape of the age-price profiles is not affected by a longer service life or

by a higher discount rate. The only exception is with the hyperbolic profile where the asset price loses its convexity when the service life is extended to 50 years and the discount rate is set at 10%.

178. The conclusion of this section is that there are several age-efficiency profiles that are consistent with the empirical evidence based on studies of second hand asset prices. In reality, it is unlikely that any assets have age-efficiency profiles that correspond precisely with any of these patterns. It is much more likely that their age-efficiency profiles are combinations of these and other patterns during different parts of their life cycles. There will, therefore, be an infinite number of age-efficiency and depreciation profiles that are consistent with the empirical evidence on asset values.

Depreciation methods

179. In calculating depreciation, business accountants face the same problem as national accountants; except in the usually rare circumstance where they are buying or selling used assets, they do not know the market values of their company's asset stock. They have, therefore, devised a number of methods for estimating how asset values decline over their lifetimes. Some of these methods use information about the usage or performance of the asset; for example, depreciation may be assumed to be proportional to the hours of usage in the accounting period compared to the total hours that the asset was expected to be in use when it was originally purchased; another method essentially involves an annual updating of the present value of expected capital service flows over the remaining service life of the asset using the standard equation for the value of an asset (equation (1) above). In the vast majority of cases, however, business accountants use one of the following three depreciation methods which all assume a systematic decline in the value of an asset over time and which depend only on the initial value of the asset and its expected lifetime:

- Straight-line depreciation.
- Sum-of-the-digits depreciation.
- Geometric depreciation.

180. With **straight-line** depreciation, the market value of an asset is assumed to decline by the same amount each period. This amount is equal to $1/Tth$ of the initial value of the asset, where T is the average service life for that type of asset.

181. With the **sum-of-the-digits** method, the market value is assumed to fall by an amount which declines linearly over the lifetime of the asset. Specifically, depreciation (D) in year t is calculated as:

- $D_t = V[T-t+1] / [T(T+1)/2]$, where V is the initial price of the asset, T is the service life and t takes values of $1,2...T$
- For example, if the service life is 15 years, depreciation in the first year will be 15/120th of V, in the second year it will be 14/120th of V, etc. The denominator is the standard formula for the sum of an arithmetic progression – *i.e.* 15 + 14 + 13 +...+ 1 = 120. This gives the method its name and ensures that the total depreciation calculated over the lifetime of the asset fully exhausts its initial value.

182. With **geometric** depreciation, the market value is assumed to decline at a constant rate in each period. The depreciation factor can be written as R/T where T is the service life and R is the "declining balance rate". Depreciation for period t is obtained by multiplying the written down value of the asset in

the period *t-1* by the depreciation factor, *R/T*. There are several ways of calculating the declining balance rate (*R*):

- A method commonly used by commercial accountants is known as the "double declining balance" method. With this method, *R* is set at 2. The effect of this is that, in the first period, depreciation will be twice as large as depreciation calculated by the straight-line method. (It is for this reason that the method is referred to as double-declining.)

- Another approach is to set *R* at a value that ensures that the asset's initial value will have been reduced to a predetermined percentage (*g*) of that value by the time it reaches the end of its expected service life. In other words, a value of *R* is required such that:

  $V(1 - R/T)^T = gV.$

  Dividing by *V* and solving for *R* gives:

  $$R = T\left(1 - g^{\frac{1}{T}}\right)$$

183. With *g* set at 0.1 (*i.e.* 10% of the initial value remains at time *T*) a service life of 15 years gives *R* = 2.135 which implies slightly more rapid depreciation than the double-declining method; *R* increases as service lives get longer and for a 50 year service life, *R* rises to 2.250.

184. A third approach is to use evidence drawn from empirical studies of second-hand asset prices to determine the declining balance rate appropriate to each asset. This has been done in the United States where the Bureau of Economic Analysis (BEA) uses *R* values that range from 0.8892 for most office and commercial buildings to 2.1832 for office machinery. An *R* value of 1.6500 is used for most types of industrial machinery and equipment.

185. Geometric depreciation will never exhaust the full value of an asset because the depreciated value of the asset falls asymptotically, approaching, but never reaching, zero. This is a disadvantage for commercial accountants because accounting rules almost always require that, whatever system of depreciation is used, total depreciation calculated over the expected life of the asset must equal the initial price of the asset. It can also be seen as a disadvantage for national accountants because it is clearly not the case that a group of assets installed in a given year will continue contributing to production in all future periods. There are at least three ways of dealing with this problem.

- The first is to ignore it. The new PIM-based estimates by the United States BEA calculate consumption of fixed capital using the standard "infinite" version of geometric depreciation.

- The second approach is to treat all the remaining value of the asset as depreciation in the last year of the asset's service life. This is the standard approach of commercial accountants and is also used by some countries that use geometric depreciation for their PIM estimates. These countries also set the declining balance rate (*R*) so that a predetermined portion of the original asset value remains at the end of the service life. Ten percent – *i.e.* *g* = 0.1 – is usually selected as the share of the original asset value that is to remain at age *T*.

- The third approach is to arbitrarily adjust the rate of geometric depreciation so that the full initial value of the asset is exhausted when it reaches the end of its service life. Several adjustment techniques are available but what they all have in common is that they necessarily change the depreciation pattern so that it is no longer geometric. If it succeeds in fully exhausting the initial asset value, the adjusted depreciation pattern must be faster than geometric over at least some part of the asset's lifetime.

How well do depreciation methods perform in practice?

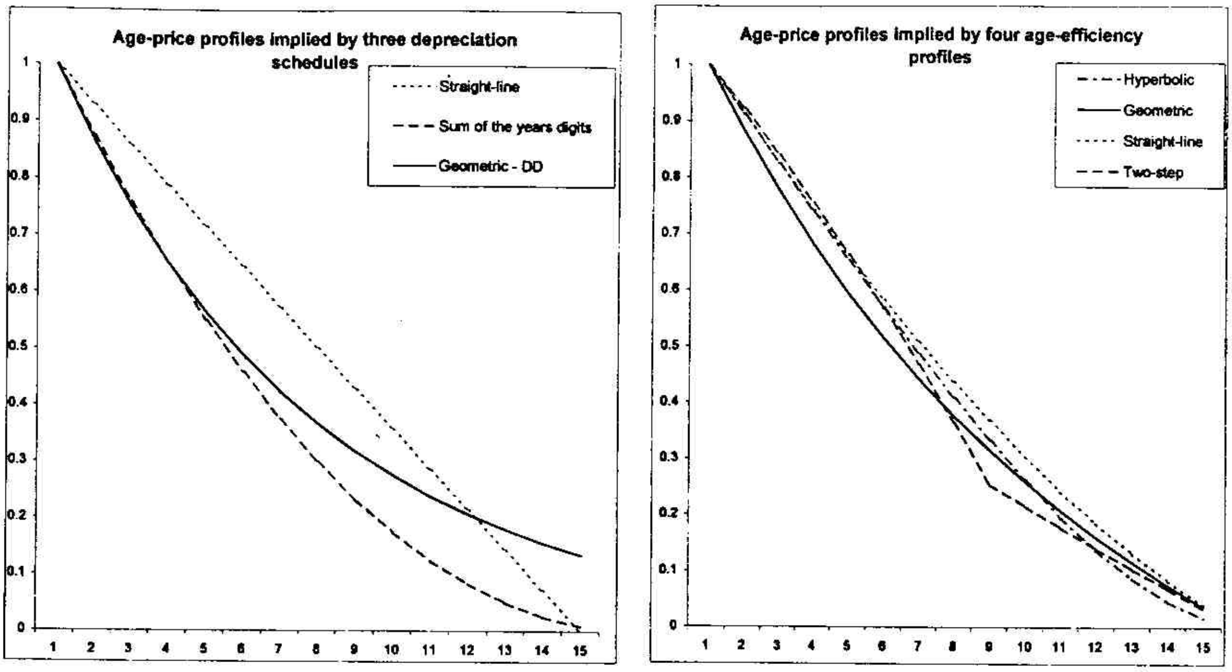
186. The left-hand part of Figure 2 shows the age-price profiles implied by the three depreciation methods for an asset that lasts for 15 years. For geometric depreciation the double declining method is used. (For an asset that lasts 15 years the double declining model gives virtually the same results as setting the depreciation factor so that 10% of the initial value remains at the end of the service life.) The right hand panel shows the age price profiles for assets with the same 15 year service life but with four different age-efficiency profiles. These age-efficiency profiles are those identified in the previous section as being consistent with the empirical evidence on age-price profiles from second-hand asset prices. These age-price profiles were obtained as explained for Figure 1 above.

187. None of the three depreciation methods produce age-price profiles that are identical to any of the four age-price profiles shown in the right-hand panel. If the two graphs are superimposed, the age-price profiles generated using the four age-efficiency profiles lie between the age-price profiles implied by the straight-line and sum-of-the-years-digits depreciation methods. This suggests that either of these two methods will give a reasonable approximation to depreciation in practice.

188. There is, however, another consideration in choosing between the three depreciation methods, namely the shape of the *age-efficiency profiles* that each one implies. Geometric depreciation implies that the age-efficiency profile will itself be approximately geometric (and will be exactly geometric for assets with infinite service lives). Sum-of-the-years-digits depreciation implies that age-efficiency declines in a similar way as geometric - i.e. down a path that is convex to the origin. It has already been noted that for most assets it is implausible to assume that the largest losses in efficiency occur at the beginning of the service life. Straight-line depreciation, on the other hand, implies a linear decline in age-efficiency. This closer to the preferred hyperbolic decline in efficiency.

189. To summarise, both sum-of-the-years-digits and straight-line depreciation give reasonable approximations to the decline in the values of assets observed from studies of second hand asset prices. In addition to its simplicity, however, straight-line depreciation has the added advantage that it implies a more realistic age-efficiency profile.

Figure 2. Comparing the Performance of Three Depreciation Schedules



CHAPTER 7

SURVEYS AND OTHER DIRECT MEASUREMENT METHODS

Introduction

190. Most countries estimate capital stocks and consumption of fixed capital by the *perpetual inventory method* (PIM), which was described in Chapter 5. The PIM is a cheap and convenient method, but it requires many assumptions and the estimates obtained are probably less reliable than most other official statistics. This chapter reviews other ways to estimate capital stocks that may be more reliable.

191. One way to proceed would be to make an inventory of all the objects considered to be capital assets through physical inspection by teams of enumerators. This was the main methods used to compile the Domesday Book in England, but seems not to have been tried since then. Four possible data sources are reviewed in this chapter:

- Use of published company accounts.
- Enterprise surveys used in centrally planned economies to measure the "balance of fixed assets".
- Statistical surveys carried out in market economies.
- Administrative records on the stocks of particular types of assets.

Published company accounts

192. In almost all countries enterprises are required to keep accounts for tax purposes and the accounts compiled by corporate enterprises normally include balance sheets showing the opening and closing stocks of their capital. Can this be used to estimate capital stocks for national accounts purposes?

193. A first problem is that accounts including balance sheets are usually only available for corporate enterprises. Unincorporated enterprises are not generally required to keep accounts for their capital assets and so even if company accounts can be used for the corporate sector it would be necessary to devise other methods to cover capital stocks of unincorporated enterprises.

194. In general, capital assets are defined in company accounts as covering physical objects of the kind defined in the SNA as tangible fixed assets. There are some differences from SNA definitions, and between countries, in the treatment of capital repairs and transfer costs and in the capitalization of interest payments on loans used to purchase assets. These differences, however, are relatively minor and do not rule out the use of company accounts for direct estimates of capital stocks.

195. A more serious problem lies in the way that assets are valued. In virtually all countries the standard method of valuing assets is "depreciated historic cost". A few countries that have experienced long periods of high inflation specify that assets must be revalued to current purchasing power using the consumer price index or other general inflation measure; current *purchasing power* is a different concept from current prices as required for national accounts. Most countries also allow companies to revalue assets to current prices. Usually companies have considerable freedom to decide whether to revalue assets to current prices, but several place tight restrictions on this option and only allow revaluations after extended periods of high inflation, or as part of the restructuring of a company following a merger or bankruptcy.

196. Methods by which historic costs are depreciated in the accounts also vary. Most countries allow companies to use any method to depreciate fixed assets provided that it will exhaust the full value of the asset and will do it in a systematic way. In practice "straight-line", "sum-of-the-digits" and "double-declining balance" are the commonest methods.

197. It is clear from the above that asset values reported in company accounts cannot simply be aggregated to obtain estimates of the capital stock. Historic costs are not suitable for national accounts purposes because assets are then being valued at a mixture of prices, and the use of different depreciation methods adds a further element of non-comparability from one company to another. The same problems also render depreciation reported in company accounts unsuitable for national accounts purposes.

198. The above comments refer to the **published** accounts of companies. Of course, companies keep many other records relating to the purchase and use of capital assets and these have been found, in several countries, to be suitable for capital stock estimates appropriate for national accounts purposes. As explained below, these records provide the essential basis for statistical survey methods.

Balance of Fixed Assets

199. The "balance of fixed assets" is the term used to describe the annual enquiries traditionally carried out by the centrally planned economies of central and eastern Europe. They were comprehensive surveys of all fixed assets used in state enterprises. These enterprises accounted for most production in these countries so that the total balance of fixed assets was virtually the same as the nation's total capital stock. The main omission was assets used on private farms, where these were permitted. Several transition countries have continued these surveys.

200. To obtain the "balance of fixed assets", enterprises were required to report the stock of fixed assets at the beginning of the year, the acquisitions during the year (including new assets), withdrawals (including liquidation) of fixed assets and the value of the stock of fixed assets at the end of the year. The balance is compiled at both full (non-depreciated) replacement value and remaining replacement value, *i.e.* after subcontracting consumption of fixed capital. The full replacement value is defined as the value of expenditures which is needed to acquire and put into operation new fixed assets in the present circumstances.

201. Until the changes which started in 1990s, the prices of domestically produced assets were "plan prices" which would reflect the "plan cost" of producing them. Imported assets were valued at the prices paid, which could be market prices if imported from market economies. Prior to transition, prices were relatively stable so that for many assets there was little difference between historic costs and current prices. In the early 1990s, however, most of these countries experienced rapid inflation and it became necessary to revalue assets each year to current replacement costs. The revaluations are carried out by the enterprises themselves either using coefficients supplied to them by the statistical agency or on the basis of

information about the current market prices of the assets. The coefficients varied from one type of an asset to another but not from one enterprise to another. Thus, the gross value of an asset at the beginning of each would either be equal to its original price of acquisition multiplied by the cumulative product of all the revaluation coefficients applied up to that point of time or, alternatively, it would be equal to the estimated current market price of a replacement asset.

202. These countries used a definition of capital consumption that was narrower than the one required for national accounts. It covered only wear and tear and excluded any fall in value due to obsolescence. Estimates of capital consumption obtained from these surveys is not, therefore, suitable for national accounts purposes but, provided revaluations were carried out regularly, the balance of fixed assets could, in principle, be used as an estimate of the gross capital stock.

203. In practice, there are at least three problems with these data:

- First, the coverage of the surveys has deteriorated with the growth of private sector enterprises. These new enterprises may be included in the surveys but are often unwilling or unable to supply detailed data on their asset stocks.

- Second, the very high rates of inflation in the early years of transition made it very difficult for the statistical agencies to provide realistic coefficients for revaluing assets. The current replacement costs at which the balance of fixed assets is supposed to be valued are highly suspect in many of the countries concerned. (The unreliability of asset price indices will affect PIM estimates in exactly the same way).

- Third, doubts have been raised about the true values of many of the assets held by state enterprises. Much of the older plant and equipment in heavy industries may no longer have been used in production but was still being included in the balance of fixed assets at its revalued historic costs.

204. This said, even if these statistics are now of doubtful value, the balance of fixed assets which was calculated in the early 1990s before inflation became rampant could be used as bench-mark estimates of the gross capital stock and could then be updated by the PIM for the current period.

Statistical surveys in market economies

205. In addition to the centrally planned economies, two other countries, Japan and Korea, have traditionally carried out surveys of the capital stock. Both are described as "National Wealth Surveys" and are designed to provide estimates of the national balance sheet. In addition to fixed assets they also covered inventories and net foreign financial assets. Both surveys were carried out at approximately 10-year intervals. The last Japanese survey was held in 1983 and there are no plans to repeat the survey; the Korean surveys are continuing and the latest was held in 1998.

206. The Korean survey covers all sectors, including general government, government business enterprises, incorporated and unincorporated enterprises and non-profit institutions serving households. It has a reasonably detailed coverage of fixed assets, including buildings, other structures, machinery and equipment, ships, vehicles and other transport equipment, tools and furniture, and construction work in progress. Almost 25 000 incorporated enterprises, and 60 000 unincorporated enterprises were sampled in the last survey, along with 5 000 households. A comprehensive survey of the government sector is conducted.

207. The Netherlands is the only other country that carries out capital stock surveys on a regular basis. There is an annual survey covering mining, quarrying and manufacturing. However the survey does not cover all mining and manufacturing activities each year. Instead, different subsectors are covered each year in such a way that all activities within mining, quarrying and manufacturing are surveyed every five years. (This is described as a *rolling benchmark* method by Statistics Netherlands.) The survey covers only firms employing 100 or more employees and capital stocks for smaller firms are assumed to be proportional to employment.

208. Statistics Netherlands carries out two other annual surveys, one on capital formation and the other on disposals of assets. Results from these surveys are matched up, on a firm by firm basis, with the results of the stock survey to obtain stock estimates between the five-yearly surveys. This can be seen as a superior perpetual inventory approach, superior because it requires no assumptions about service lives or mortality functions.

209. Statistics Netherlands also surveys capital assets held by a sample of firms in transport, storage and communications but the coverage is less complete than for mining, quarrying and manufacturing. The survey data are used in conjunction with registration data on road vehicles, aircraft and ships.

210. The Netherlands stock surveys uses eight asset classes: sites (only purchase and sale), industrial buildings, civil engineering, external means of transport, internal means of transport (e.g. assembly lines, cranes, pulleys), computers, other machinery and other equipment, and other tangible fixed assets (e.g. furniture, silos, etc).

211. Both the Korean and Netherlands surveys collect the following information:

- Type of asset.
- Original (historic) value.
- Year when the asset was installed or constructed.
- Whether the assets were purchased new or second hand.
- Whether the assets are owned or leased.

In both cases, revaluation to current and constant prices is done by the statistical agencies using asset price indices.

212. Like all statistical inquiries, the reliability of the results depends on the quality of the survey procedures and the ability of respondents to supply the information requested.

213. Both the Korean and Netherlands surveys involve visits by enumerators. Experience has shown that it is not usually possible to collect the necessary information by mail questionnaire. For the Korean survey, the work of enumeration is so great that is divided up between several government agencies. In the Netherlands the high cost of on-site investigation by enumerators is the main reason that the five-year "rolling benchmark" method is used.

214. The ability of respondents to provide the information depends on the quality of their accounting records. The following problems have been encountered in the Netherlands:

- Companies do not always capitalize major alterations to assets.

- Most companies use value cut-off points in deciding whether expenditure is capital or current. In some cases these are so high that they exclude some items that should be treated as capital assets according to the SNA.

- Company records do not always distinguish new from second-hand assets.

- Some companies pick arbitrary dates, such as the end of the Second World War, as installation dates for very old assets; others may report the year of a revaluation as the installation date for assets that were actually installed before that date.

- Large installations consisting of several separate pieces of equipment, which were actually acquired at different times, may be assigned a single installation date.

- Replacement parts may be capitalized but the part it replaces may not be recorded as a discard.

- An asset may cease to be used in production but is not physically removed from the site and so is not recorded as a discard.

215. Some of these difficulties may be alleviated in the future by an interesting development reported in the United Kingdom. Most large companies now maintain computerized asset registers using standard software developed for this purpose. These records may improve the accuracy of the records and, equally important, may make it possible to measure capital stock without the need for on-site investigation by enumerators. The high cost of doing this is one of the main impediments to the wider use of surveys to measure capital stocks.

216. Finally, mention should be made of a survey procedure developed in Canada, called the "Fixed Asset Accounting Simulation Model"(FAASM). The essential feature of FAASM is that it uses enterprise records on asset stocks and gross fixed capital formation, both valued at historic values, to estimate service lives. These latter are the service lives that will reconcile past capital formation with the value of the stock of assets reported by the company. Gross capital formation is then revalued to current or constant prices and the gross capital stock is obtained by applying the estimated service lives to each year's capital formation. The estimated service lives are also used to calculate consumption of fixed capital and the net capital stock. FAASM has been tested in Canada and the results are said to be encouraging.

Administrative records

217. In most countries, administrative records are maintained on the stocks of certain types of assets. This may be done because ownership or use of the asset in question is taxed; examples are motor vehicles and residential buildings. Administrative record may also be kept on assets that represent health hazards or whose use is regulated for safety or environmental reasons; examples include nuclear fuel rods, passenger aircraft and fishing vessels. Most governments also keep detailed records of publically-owned assets including roads, bridges and public buildings.

218. These records usually give the numbers rather than values of the assets concerned, but if the records give additional information on their technical specifications they can be valued either at current values to obtain the net capital stock or at historic values updated to the current year to obtain the gross stock. Several countries use administrative sources where they are available and estimate other asset stocks by the PIM.

219. In some cases administrative records may be available only for selected years. For example, detailed information on the housing stock may be available only for population census years. In these cases the stock of assets in the inter-censal periods can be obtained by the PIM or by using records on new construction and demolitions. Using a combination of benchmark estimates and PIM estimates provides an opportunity to test the critical parameters of the PIM mode, notably service lives and mortality functions.

Summary

220. There are a number of alternatives to the PIM for estimating capital stocks. The first method considered, use **of published company accounts**, is clearly an inferior method and is not recommended here. Although accounting practices vary between countries a common feature is that stock and depreciation are calculated using historic costs. For national accounts purposes current or constant prices must be used. Several countries do in fact use data from company accounts, particularly for their estimates of consumption of fixed capital, but these will be crude approximations to what is required for the national accounts.

221. A survey method that is well-established in central and eastern Europe is the **balance of fixed assets**. Provided that prices are correctly revalued each year, this method can, in principle, provide suitable estimates of the gross capital stock. In practice, there are severe practical difficulties in applying this method at the present time; these include growing rates of non-response, difficulties in measuring asset prices under high inflation and the over-valuation of older assets. It may, of course, be possible to overcome these problems by redesigning the surveys and improving enumeration procedures and these surveys would then be a valid alternative to the PIM.

222. Korea and the Netherlands are the only two other countries that use **statistical surveys** at the present time. Both appear to be successful although the costs are high, particularly for the National Wealth Survey carried out in Korea. The success of survey methods depends crucially on the quality of the asset records maintained by companies. These vary so significantly from country to country that generalizations cannot be made about the potential of survey methods for any particular country.

223. There is no doubt that capital stock surveys can be expensive and it is probably not cost-effective to apply it to all sectors, for all asset types and for every time period. The most cost-effective strategy is likely to be using survey methods selectively and periodically. Estimates for non-survey years can be obtained either by the PIM or, as in the Netherlands, by collecting annual information on disposals as well as capital formation.

224. FAASM is an original approach but is still in the experimental stage. As with other surveys, much depends on the quality of the records maintained by enterprises. FAASM appears to be feasible in Canada but may not be exportable to other countries.

225. **Administrative records** are used in several countries to estimate stocks of certain types of assets, notably road vehicles, dwellings, aircraft, and nuclear fuel rods. The stocks of publicly owned assets, including roads, public buildings and other structures may also be taken from government records. Such estimates are usually to be preferred to estimates based on the PIM, but they will only cover a small part of the total stock.

CHAPTER 8

CAPITAL SERVICES

Introduction

226. Chapter 1 has already introduced the concept of **capital services** and outlined how these can be measured by a **volume index of capital services**. This chapter starts by considering the measurement of capital as an input into the production process and describes how the volume index of capital services is constructed in practice.

227. Studies of **multifactor** (or **total-factor**) productivity examine how much of the growth in output or value added is accounted for by increases in factor inputs and, in some cases, intermediate goods and services. The growth in output or value added that cannot be explained by the growth of factor or intermediate inputs is termed multifactor productivity. It is a measure of "disembodied" technological progress and makes an important contribution to rising living standards. Typically multifactor productivity studies use a production function, here denoted as H, which describes the amount of output (Q) which can be produced by various combinations of volumes of inputs:

$$Q = H(k_1, k_2, \ldots, k_n; L, M, t) \qquad (1)$$

228. The inputs include the various different types of capital inputs (k_1, k_2, ...k_n), labour input (L), and intermediate input (M), and where the function can shift over time, t. Shifts in the function are generally associated with changes in technology. In many studies the dependent variable is value added rather than gross output, in which case intermediate inputs are excluded from the function.

229. In general, the function could be defined for sub-categories of each major type of input (labour and materials as well as capital). Ideally, the list would be detailed enough that each category described a homogeneous input. Data availability limits the number of sub-categories. This chapter will discuss only sub-categories of capital. The OECD *Productivity Manual* discusses the measurement of the other variables in the production function.

230. The role of capital in production resembles the role of labour in that capital stocks and workers are used but not consumed. The relevant inputs of capital and labour are service flows just as materials and outputs are flows rather than stocks. Labour is measured in hours worked, and the k_i refer to the service flows associated with various types of capital. These capital service flows are distinct from capital stocks. (See box)

231. The production model typically involves three general assumptions. First, it is assumed that the producer always produces a unique quantity of output from any given set of inputs. Second, it is assumed that the production function is "smooth", that is, inputs and outputs are related in a continuous way. Third, it is assumed that aggregate behaviour reflects the behaviour of "representative competitive firms". The assumptions are somewhat controversial but while they are not always precise representations of reality, the model-based approach represents a consistently grounded framework which, in turn, facilitates the exposition of complex issues.

Box 3. Stocks or flows

Except in the United States, Canada and (more recently) Australia, most studies of multifactor productivity use the capital stock (gross or net) to represent the contribution of capital to production. The gross stock has generally been preferred to the net stock because it was believed that valuing assets at their "as new" prices was more likely to approximate their contribution to production than valuing them at (depreciated) market prices. However, the net capital stock has also been used, either alone or averaged with the gross capital stock. There are several problems with using the gross or net capital stocks for productivity studies.

The first problem in using **stocks**, whether net or gross, is that the other variables in the growth accounting model are all **flows**. These include labour inputs and intermediate consumption (where relevant) as independent variables and value added or gross output as dependent variables. The "dimensions " of the variables are therefore inconsistent. In practice, almost all growth accounting models and productivity studies relate the **changes** in the independent variables – capital, labour and intermediate consumption – to **changes** in the dependent variable – value added or gross output. **Changes** in the capital stock can, of course, be regarded as **flows**; the change in the gross capital stock is gross fixed capital formation less discards and the change in the net capital stock is gross fixed capital less consumption of fixed capital (or "net capital formation" as it is usually termed). But the dimension problem remains because a first-order flow – namely a change in a stock - is now being used together with second-order flows, such as changes in the flow of labour inputs or the flow of value added.

A second problem with using the net or gross capital stock is that neither measure reflects the **productive efficiency** of capital assets. The gross capital stock values all assets in use as if they were still new, implying that older assets are just as productive as new ones; the net capital stock uses market prices to value older assets but these prices usually decline quite rapidly in the early years of their life even though the assets may be nearly as productive as when they were new.

Finally, in calculating the net or gross capital stock, each asset in the stock is weighted by its market value. This implies that two assets with the same market value are assumed to make an equal contribution to production. Suppose, however, that one of the assets is a truck with a life of seven years and the other is a structure with a fifty-year service life. It is clear that in order for the owners to recoup their investment, the shorter-lived asset must generate its contribution to production at a **faster rate** than the asset with the longer life. Weighting them both by their (identical) market values will understate the **annual** contribution of the truck into the production process and overstate that of the structure.

Volume index of capital services

Stocks of assets in standard efficiency units

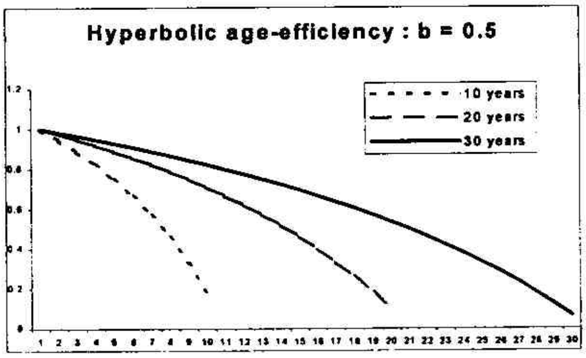
232. Chapter 1 introduced the concept of a stock of a particular type of asset in standard efficiency units. A stock in standard efficiency units is obtained by converting the gross stock of the assets to constant prices and then applying age-efficiency coefficients to the different vintages to convert them into standard efficiency units. A worked example of the procedure was given in Chapter 5.

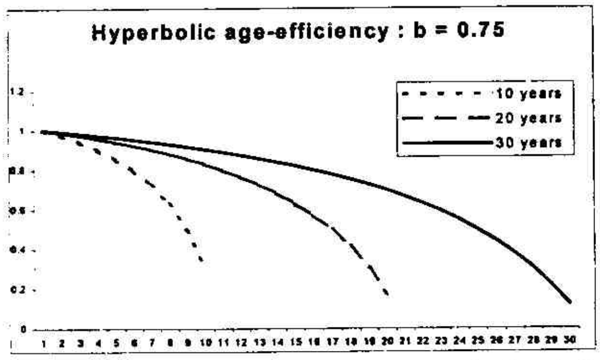
233. There is relatively little empirical evidence on the way in which different assets lose their productive efficiency with age. Some authors have used a geometric pattern of efficiency loss but there is now general agreement that it is more realistic to assume that most assets lose their efficiency by

increasing absolute amounts as they age rather than by the *decreasing* amounts implied by the geometric pattern. For this reason a hyperbolic function is used of the form:

$$E_t / E_0 = (T - t)/(T - \beta t), \text{ with } \beta \leq 1 \qquad (2)$$

234. Here E_0 is the value of a new asset, T is the service life and β is a slope coefficient. E_t / E_0 gives the efficiency of an asset relative to a new asset of the same type. As already noted, both the US Bureau of Labor Statistics (BLS) and the Australian Bureau of Statistics (ABS) set β at 0.50 for most types of plant and equipment and at 0.75 for structures. Both values of β give an accelerating fall in asset values reflecting the way that their efficiency is declining with age, but the higher β value for structures results in a slower fall than for plant and machinery. The charts below show how efficiency is assumed to decline using the hyperbolic function for different service lives and the two standard slope coefficients.





235. Stocks converted to standard efficiency units and valued at constant prices, are calculated for each type of asset. This is done at the most detailed level of the asset classification. Because these stocks consist of standardised efficiency units they can be taken as measures of the capital services that the different types of assets contribute to the production process.

236. The next step is to aggregate these separate stocks to obtain overall measures of capital services for different kinds of activities, for institutional sectors or for the economy as a whole. This is done using the **user costs of capital** as weights. The user cost of capital is assumed to measure the marginal productivity of different kinds of assets in exactly the same way as employee compensation is assumed to measure the marginal productivity of different kinds of labour.

User costs

237. The standard expression for the user cost of an asset, in *real terms*, is:

$$V_t(d_t + r_t) \qquad (3)$$

In this expression V_t designates the market price of a new asset, d_t is the rate of depreciation and r_t is some measure of the cost of financial capital. This expression is derived from the standard equation relating the value of an asset to the discounted real flows of rentals expected over its lifetime. (See Box 4)

238. For weighting stocks of specific asset types in standard efficiency units, user costs in *nominal*, rather than in real terms, are required. This parallels the procedure used for labour inputs which are

weighted by the shares of each type of labour in the *nominal* wage bill. When (3) is converted to nominal terms it becomes:

$$V_t(d_t + r_t - \Delta p_t) \qquad (4)$$

Here Δp_t is the change in the price of the asset from periods *t-1* to *t*.

239. The user cost of capital measures the cost of financing the asset. It comprises $V_t r_t$ the nominal interest payment if a loan was taken out to acquire the asset or the opportunity cost of employing capital elsewhere than in production if the acquisition of the asset was financed from equity capital. To the interest cost has to be added $V_t d_t$ the nominal cost of depreciation or the loss in value of the asset as it ages. The third term - Δp_t - is the nominal gain from holding the asset for each accounting period. A positive gain reduces the user cost of holding the asset while a negative gain, *i.e.*a holding loss, increases the user cost. This nominal holding gain - Δp_t - is measured by the price index for the particular kind of asset concerned.

Box 4. Derivation of User Cost from the Standard Equation for the Value of an Asset.

The value of an asset at any time during its service life can be written as:

$$V_t = \frac{f_t}{(1+r)} + \frac{f_{t+1}}{(1+r)^2} + \frac{f_{t+2}}{(1+r)^3} + \dots\dots + \frac{f_T}{(1+r)^T} + \frac{S}{(1+r)^{T-t}}, \qquad (1)$$

Here V_t is the constant price value of the asset, f_t is the rental - *i.e.* user cost - in period t measured at constant prices, r is the real discount rate and S is the scrap value of the asset, again measured in constant prices. t are years *1, 2, ..., T*, the year when the asset is scrapped.

The value of the asset in the next period is:

$$V_{t+1} = \frac{f_{t+1}}{(1+r)} + \frac{f_{t+2}}{(1+r)^2} + \dots\dots\dots + \frac{f_T}{(1+r)^{T-1}} + \frac{S}{(1+r)^{T-(t+1)}} \qquad (2)$$

Dividing (2) by $(1+r)$ gives:

$$\frac{V_{t+1}}{(1+r)} = \frac{f_{t+1}}{(1+r)^2} + \frac{f_{t+2}}{(1+r)^3} + \dots\dots\dots + \frac{f_T}{(1+r)^T} + \frac{S}{(1+r)^{T-t}} \qquad (3)$$

Subtracting (3) from (1) gives:

$$V_t - \frac{V_{t+1}}{(1+r)} = \frac{f_t}{(1+r)} \qquad (4)$$

Rearranging the terms gives:

$$f_t = V_t - V_{t+1} + rV_t \qquad (5)$$

However, since:

$$V_t - V_{t+1} \equiv D_t\ , \qquad (6)$$

where D_t is depreciation in year t, *i.e.* the fall in the value of the asset between the beginning and end of the year, equation (6) can be rewritten as:

$$f_t = V_t(d_t + r) \qquad (7)$$

where d_t is the rate of depreciation in period t.

240. As noted above, the logic behind the use of user costs to weight asset stocks converted to standardised efficiency units is that, given the usual assumptions about competitive markets, they measure the marginal productivity of the different types of assets. Note that for two assets of the same original value but with different service lives, the shorter-lived asset will tend to have a higher user cost because it will depreciate more rapidly. The owner must recoup the initial outlay on the shorter-lived asset over a shorter period than in the case of the longer-lived asset.

241. $V_t d_t$ is the amount of depreciation in current prices for each type of asset or (in practice) each asset group. The calculation of current price depreciation has been explained earlier. The holding gain - Δp_t - is measured by the price index for the asset. Neither need further explanation. The calculation of $V_t r_t$ will now be considered.

Interest rate (r)

242. There are essentially two approaches to the measurement of the interest rate. These are the use of national accounts statistics on operating surplus or the use of market interest rates. The BLS uses the first approach. The methodology is as follows.

- Net operating surplus is obtained from the production account by deducting compensation of employees from net value added. This operating surplus, Ψ_t, is assumed to be the total rent received from the various assets in each time period, t:

$$\Psi_t = \sum_i f_{i,t} K_{i,t} \qquad (4)$$

  Here $K_{i,t}$ is the stock, measured in standard efficiency units, of the i the asset and $f_{i,t}$ is its user cost.

- User cost was defined in (3) above[4]. BLS solves (3) and (4) for r by substituting user cost equations (3) for each type of asset i into the formula for the sources of property income, equation (4). This system of equations can be solved with the data on capital stocks expressed in standard efficiency units, $K_{i,t}$, and estimates of property income Ψ_t.

243. The method used by BLS requires that the underlying production function exhibit constant returns to scale, that markets are competitive and that the expected rate of return equal the *ex-post*, realised rate of return. There is also a practical problem because net value added includes *mixed income* as well as *operating surplus* and *compensation of employees*. Mixed income includes the labour income attributable to the self-employed. Mixed income can be artificially divided into "compensation of employees" and "operating surplus" either by assuming that the self-employed receive similar rates of compensation as those earned by employees in similar jobs or by assuming that unincorporated enterprises earn similar rates

4. The user cost equation used by BLS includes a capital gain/loss term, □pI,t which is the rate of increase in the price of a new asset of type i. In paragraph 11 it is argued that this price term is not required if depreciation includes price changes due to obsolescence.

of property income as those earned by corporate enterprises in similar activities. Both assumptions seem equally plausible but the two methods rarely produce a similar allocation of mixed income.

244. An alternative is to estimate r from market interest rates. The logic behind this is that interest rates play a key role in determining rates of return. First, the decision to purchase a capital assets is partially based on a comparison between the rate of return that the asset is expected to earn and the income that could be earned from alternative uses of the funds. These alternative uses include investment in financial assets. Second, investment in capital assets is often financed through borrowing and a producer will usually not borrow to buy an asset unless the expected rate of return exceeds the interest that has to be paid on the loan.

245. The fact that both the interest that could be earned and the interest that would have to be paid seem equally relevant for investment decisions poses a problem. Which should be used for estimating the rate of return? One possibility is to use the average of these two rates as an estimate of the rate of return. This average can be seen as an estimate of the "pure" rate of interest, *i.e.* the compensation that lenders demand for postponing consumption to a future period. The difference between this and the interest actually paid can be regarded as a service charge levied by financial intermediaries for arranging loans to borrowers and managing the accounts of lenders.

246. The BLS has carried out a thorough investigation into the different ways of estimating rates of return and their impact on user cost measures. They compared effects from using market interest rates with those based on the capital income identity and found significant differences in the resulting user costs. Overall, and based on several performance measures, such as the share of negative user costs and the volatility of measures, as well as on theoretical considerations, BLS has adopted the approach based on the income identity. However, no strong conclusion has been reached on the matter and much speaks for solutions that are governed by data availability.

Index calculation

247. Once the users costs have been obtained as described above, the next step is to combine the stocks of each asset type to obtain *indices of the volumes of capital services* for kinds of activities, institutional sectors or for the economy as a whole.

248. Production theory makes it clear that calculation of these indices should be carried out with a **superlative index number**. The rationale for a superlative index number such as the Tornqvist or Fisher index, derives from its property as an approximation to general functional forms of the production function (see OECD *Productivity Manual*).

249. Given estimates of the capital stock for different types of assets in standard efficiency units ($K_{i,t}$), and given a set of user cost weights($f_{i,t}$), a Tornqvist index of total capital services is given by the expression below. This formulation is used in the capital service indices derived by the U.S. Bureau of Labor Statistics and the Australian Bureau of Statistics. With the same type of data, it is also possible to construct a Fisher index of aggregate capital services and experience has shown that results will be very similar.

$$\prod_i \left(\frac{K_{i,t}}{K_{i,t-1}} \right)^{\bar{v}_i} \qquad (5)$$

where $\bar{v}_i = 0.5(v_{i,t} + v_{i,t-1})$ and $v_{i,t} = \dfrac{f_{i,t}K_{i,t}}{\sum_i f_{i,t}K_{i,t}}$.

Development of capital service measures.

250. This Chapter notes that the contribution of capital to the production process should be measured in terms of the services that capital assets provide to their owners rather than in terms of the value of the assets themselves. At present, only three countries - the United States, Canada and Australia - publish capital service measures as part of their official programme of statistics, but measures of the kind described in this Chapter have been calculated by researchers in several other countries. It is also clear that there is growing interest in studying the productive potential of the *new economy* and in calculating the productivity benefits of *globalisation*. It is, therefore, highly probable that several other countries will soon start producing capital service measures on an official basis.

251. The Australian Bureau of Statistics, uses what it describes as an *integrated* approach and derives its volume index of capital services as part of the same process that generates its estimates of gross and net capital stocks and of consumption of fixed capital. This ensures strict consistency in the sense that their stock and depreciation estimates are derived from the same age-efficiency profiles that underlie the volume index of capital services. While there is an inherent appeal for many statisticians in an approach which guarantees a consistent data set, experience in the United States shows that analysts can work with data sets that are not strictly consistent provided that the assumptions on which they are based are transparent. In starting to produce volume indices of capital services, many countries may prefer to develop them independently from their regular stock estimates. The conceptual framework developed in Chapter 1 does, however, suggest that it is important to bear in mind that the assumptions underlying the construction of capital service measures should be broadly consistent with those on which net stocks and depreciation are based.

ANNEX 1.
ESTIMATES OF CAPITAL STOCKS AND FLOWS IN FOUR COUNTRIES

Introduction.

252. This paper summarises the methods used by four countries to estimate capital stocks. All four countries use some version of the Perpetual Inventory Model (PIM). The first country - Singapore - uses a very simple model but one which could be easily applied by many countries that do not at present have any capital stock estimates. France uses what may be regarded as the standard method since most OECD countries estimate capital stocks using methods very similar to those used by France. The United States Bureau of Economic Analysis has developed a version of the PIM which has the merit of simplicity and which exploits empirical data on used asset prices. It has the drawbacks that it does not provide estimates of the gross capital stock prices and that it uses "infinite" geometric depreciation which assumes that assets last for ever. Australia uses an alternative version of the PIM which has the merit of providing measures of "capital services" for use in productivity studies, which are fully consistent with their capital stock and depreciation estimates.

A. Singapore Department of Statistics. (DOS)

253. The Singapore Department of Statistics (DOS) uses the Perpetual Inventory Method (PIM) to estimate Singapore's capital stock of fixed assets at current and constant market prices. The PIM requires assumptions on retirement patterns, depreciation and average service lives. The assumptions used by DOS are:

- simultaneous retirement pattern;
- straight-line depreciation;
- average service lives which are fixed over time.

254. In applying the PIM with the above assumptions, estimates of gross fixed capital formation (GFCF) for the seven broad asset groups shown in Table 1 are obtained from Singapore's national accounts. Table 1 also shows the assumed average service lives for each of these asset groups. These assumed average service lives are arrived at through a consideration of the nature of these asset groups, service lives reported in company accounts, and a careful review of the average service lives used by other (mainly OECD) countries. The average service life for a given class of asset is assumed to be identical for all kinds of economic activities.

Table 1 – Asset Classes and their Average Service Lives

Asset Class	Average Service Life (Years)
Residential Buildings	80
Non-residential Buildings	40
Other Construction and Works	40
Ships and Boats	20
Aircraft	15
Road Vehicles	10
Machinery and Equipment	15

255. The starting point for the computation of the capital stock series is 1946. It is assumed that the value of the capital stock in the economy prior to 1946 is zero. However, as official GFCF data from national accounts are available only from 1960, it is necessary to estimate GFCF for 1946 to 1959. In general, these estimates are arrived at by reference to the best available indicators. For example, estimates from a previous GFCF series together with statistics on retained imports provide some basis to estimate GFCF in buildings, and machinery and transport equipment. Nonetheless, the reliability of Singapore's capital stock estimates is not compromised due to the relatively low values of fixed assets during that time. Moreover, most, if not all of these assets, will have been withdrawn from the capital stock by now.

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Basic assumptions for the PIM

256. The PIM is used with the hypothesis that fixed assets are discarded according to a lognormal mortality function and that depreciation is straight-line.

257. A lognormal mortality function is used since it has the advantage of being a bell-shaped unimodal curve that is easy to use and well adapted to reality. Indeed this law often fits appropriately to empirical distributions. The lognormal mortality function is also a simple way to account for the dispersion of service lives of a heterogeneous group of assets.

258. Assuming straight-line depreciation for each of the "component with constant service life" in the group of heterogeneous assets is also a simple and sensible way to construct net capital stock estimates.

259. The lognormal frequency function is written as:

$$f_l(x) = \frac{1}{\sigma\sqrt{2\pi}}.\frac{1}{x}.\exp\left(-\frac{1}{2}\frac{(\log x - \mu)^2}{\sigma^2}\right)$$

where x is the number of years since the asset was installed,

□ is the lognormal average service life of the asset,