Appendix on Lifetime of New Fixed Assets

If all fixed assets decommissioned in the current year had been bought in the same one earlier year, then the current-year scrap value should equal the (effective) investment value of that particular earlier year. An approximate equivalence can be established through visual inspection or by simulating the economy based on average scrap rates and investment growth rates over several years.

Equivalence between current-period scrap values and earlier periods' effective investment

For the visual inspection, scrap values are obtained by first creating two economy-wide original value of fixed asset series following equation (2'), and then multiplying by scrap rates following equation (3). The first economy-wide series of original values of fixed assets (scenario I) uses investment-based scrap rates in the derivation of the original value of fixed assets series, the second depreciation-based scrap rates (scenario II); both use the depreciation-based scrap rates to derive scrap values. The effective investment series and original value of fixed asset series are first derived for SOUs and non-SOUs separately, and then added up. Only one set of SOU effective investment values is available (method B). Effective investment values of non-SOUs are derived using method C.3 in scenario I, and method C.4 in scenario II. All data are reported in Table 1.

Scrap values are calculated for both series of economy-wide original values of fixed assets by applying the depreciation-based scrap rates. Depreciation-based scrap rates are used in this second step even for the economy-wide series which made use of investment-based scrap rates before, because the investment-based scrap rates correct for underestimated investment. But the application of the investment-based scrap rate in the derivation of the original value of fixed assets (first economy-wide original value of fixed asset series) already achieved the correction. To use it again in the second step would underestimate the scrap value of a presumably correct original value of fixed asset series (that was previously corrected for underestimated effective investment by using investment-based scrap rates).

The resulting scrap values can be compared to the two economy-wide effective investment values of earlier years (with non-SOU values correspondingly obtained following methods C.3 and C.4). The data are reported in Table 1 (with only one decimal to facilitate the comparison). The comparison of scrap values with effective investment in the first instance suggest a 27-year past lifetime for fixed assets decommissioned around 1980-87, a 15-year lifetime for those decommissioned around 1990-93, and a 12-year lifetime for 1995-2003. The comparison in the second instance suggests the following matches: 27 years for 1980-87, 17 years for 1990-95, and 12-13 years for 1996-2003. Other years cannot be matched easily.

Table 2 shows the results of simulations for separate periods of years since 1953, using these periods' average scrap rate and average annual growth rate of economy-wide (nominal) effective investment. First-period effective investment is set equal to 100. The first-period original value of fixed assets is obtained using the perpetual inventory method, as 100 * (1+g) / g, where g is the average annual growth rate of nominal effective investment. A lifetime of k years implies that the scrap value of a particular year (scrap rate times previous-period

original value of fixed assets) equals the value of (nominal) effective investment k years earlier.

Table 2 offers different breakdowns of the period 1953-2003. Going through the 5-year classification, no meaningful comparison is possible for 1953-55 and 1955-60 because of negative average scrap values, nor for 1955-65 because of negative investment growth rates. Based on the first economy-wide effective investment series, the two variable values for 1965-70 suggest a lifetime of approximately 38 years, with subsequent reductions in the following 5-year periods to first 32 years (1970-75), then 26 (1975-80) and 15 years (1980-85). After 1985, lifetime values fluctuate from 17 (1985-90) to 12 years (1990-95) and then 16 years (1995-2000, 2000-03). The patterns obtained from the second economy-wide effective investment series are very similar.

China's average depreciation-based scrap rate was below 1% in 1960-1980, then around 1.5% in 1980-1995, and perhaps just above 2% in 1995-2000 and around 2.5% in 2000-03. Growth rates of effective investment varied but except in the earlier pre-reform years and in the period 1990-95 (when it reached close to 30%, but with investment price inflation of 13%) was around 10-15%. Table 3 reports the lifetime figures using these rounded scrap rate and investment growth values. At 12% investment growth and a 1% scrap rate, the corresponding lifetime is 23 years, at a 2% scrap rate 17 years. A similar exercise can be done by choosing the lifetime and the investment growth rate in order to obtain scrap rates (Table 4).

Equations (7-8) and lifetime of new fixed assets

There are two options as to how to calculate the real original value of fixed assets. One is to is to directly use (subtract) the real effective investment value of the period k years earlier (equation 8). Table 5, for each current year, states which previous year's (or years') effective investment to decommission.

A twelve-year lifetime in recent years (visual inspection) appears far inappropriate for fixed assets such as dams and buildings, and even for the average of all fixed assets; the 16-year lag (in the periodic calculation) or an even longer lag is preferred. One conjecture as to why the visual inspection suggests the shorter period of down to 12 years is that a falling lifetime has a particular effect on the matching procedure (of current-period scrap value with earlier-period effective investment). If the matching procedure were correct, some years' effective investment would later be skipped when it comes to scrapping. For example, in 1970 the effective investment of 38 years earlier (1932) is being scrapped and in 1971 the effective investment of 32 years earlier (1939). The effective investment of 1933-38 then is never scrapped. In other words, if the lifetime changes, the matching procedure becomes problematic: a scrap value in this period that matches the effective investment of 12 years earlier may also match the sum of the effective investment of *two* much earlier years together. Thus, for example, the year 1995 scrap value approximately equals 1983 effective investment as well as the sum of effective investment in 1976-77 (or in 1974-75).

Scrapping may also occur in bouts when government policy, for example, forces the shut-down of inefficient textile mills and small mines, or the policy bankruptcy of state-owned enterprises. The low average lifetimes reported in Table 2 for the periods 1990-95 and 1995-2003 of 12 and 16 years could reflect temporarily high scrap values due to policies.

Table 5 takes into consideration the acceleration in decommissioning and ensures that all previous effective investment is decommissioned at some point. The first positive scrap values combined with positive effective investment growth rates begin in the period 1965-70, but with lifetimes that indicate the decommissioning of fixed assets of the late 1920s. The procedure here is to start the decommissioning process in 1971 with a share of the 1953 real original value of fixed assets; this goes through 1980 and ensures that the transition between 1980 and 1981 is smooth. Beginning in 1981, and corresponding to the 27-year lifetime identified in the visual inspection, the effective investment of 1954 is decommissioned. By the late 1980s the decommissioning process accelerates before slowing down again around 2000.

The second option as to how to calculate the real original value of fixed assets is to use the current-period scrap value divided by a deflator that is dated for a period k years earlier as identified above (equation 7, 7', 7"). The identification in Table 5 of which previous year's (years') effective investment to decommission in a particular year equally applies to the deflator by which to deflate scrap values. Thus, for example, the year 1981 scrap value could be deflated by the year 1954 investment price index (27 years earlier). For the years prior to 1981, the appropriate deflator is that of years prior to 1954, and because those are not available, the appropriate deflator for all years prior to 1954 is taken to be that of 1953. By 2003, the lifetime has shortened to between 12 and 16 years and the corresponding deflator is that of around 1989. When more than one previous year's effective year is decommissioned in a particular year, the corresponding deflator is the mean of the previous years' deflator values (weighted if half-year values etc. of effective investment are involved).

Scrap rates, real scrap rates, and depreciation rates in the literature

The scrap values used above were obtained using scrap rates derived from subsets of the economy. The calculations had to be in terms of original values of fixed assets, i.e., were not possible in real terms. Equations (8) and (9) show why a "real" scrap rate is not feasible. While fixed asset values of period t-1 could be assumed to be base year values at uniform prices, and investment could be deflated using the investment in fixed assets price index, there is no appropriate deflator for *current-period* fixed asset values. This is the case because the current-period scrap values, which affect the current-period original value of fixed assets (equation 2), cover an unknown range of fixed assets purchased at potentially very different periods of time (with different deflators necessary for each period).

All studies in the literature (cited in the paper) that use economy-wide fixed assets construct their capital series by subtracting an assumed amount of depreciation from the previous year's real capital stock and then adding investment to obtain this year's capital stock. The assumed amount of depreciation is a depreciation rate times the previous year's real capital stock.

For the pre-reform period, when the price index for investment in fixed assets was stable in the long run, a such calculated (real) depreciation amount overestimates the actual scrap value. The stable price level implies that the scrap rate derived here, of below 1%, approximately equals the real scrap rate. This contrasts with the usually assumed "depreciation" rate of around 5%.

With the scrap rate derived here applied to the previous-period original value of fixed assets, and the value of effective investment that is accumulated in the original value of fixed assets being priced over many periods at the then relevant price level, this changes in the reform period with the appearance of investment price inflation. In the reform period, the discrepancy between a depreciation (scrap) value calculated as 5% of previous-period *real* capital and a scrap value calculated as scrap rate times previous-period original value of fixed assets is likely to have narrowed because the original value of fixed assets is not a real value but a in part inflated value; the degree to which it is inflated depends on the price level at which effective investment has been added in the years since when the fixed asset that is now decommissioned was previously purchased. (This is apart from the fact that the scrap rate rose during the reform period.)

Sectoral analyses of capital series for China use depreciation values and deflate them using the current-period deflator. For example, Jefferson et al. (1992) compute depreciation as a share of the current-period original value of fixed assets and then deflate it using the current-period deflator value before inserting deflated depreciation in their net fixed asset series. But depreciation is in Chinese practice obtained as fraction of the original value of the fixed asset (purchased at a particular price level in an earlier year); the current period deflator is not necessarily the relevant one.

Jefferson et. al (2000) calculate net investment at current prices following equation (2) to obtain net investment. They then deflate net investment by the current period investment goods price index to obtain deflated net investment, which is accumulated into a real capital series. This again implies the assumption that the proper deflator for depreciation, here embodied in net investment (investment less scrap value), is the current-period one. Jefferson et al. (1996) calculate gross investment as the annual increase in the original value of fixed assets (which, following equation 2, is actually effective investment less scrap value), and then accumulate deflated gross investment, less deflated depreciation, into a capital series. Not only is depreciation deflated by the current-period deflator, but gross investment already constitutes effective investment less scrap value, from which is then further subtracted deflated depreciation (this seems a duplicate subtraction) before the residual is accumulated into a capital series.

Table 1. Economy-wide Scrap Values and Effective Investment (in b yuan RMB)

	Scrap rates		Scenario I (B-C.3)			Scenario II (B-C.4)		
	Depr.-based	Inv.-based	Effective investm.	OFA	Scrap value	Effective investm.	OFA	Scrap value
1953	-0.0259	-0.0227	7.8	41.1		9.7	55.8	
1954	-0.0158	-0.0653	8.8	52.5	-0.6	12.0	68.6	-0.9
1955	0.0020	0.0401	9.6	60.1	0.1	12.9	81.4	0.1
1956	-0.0053	0.0801	13.8	69.1	-0.3	17.6	99.5	-0.4
1957	0.0067	0.0693	16.1	80.4	0.5	17.7	116.5	0.7
1958	0.0016	0.0993	22.6	95.1	0.1	25.8	142.2	0.2
1959	-0.0104	0.0363	28.2	119.8	-1.0	31.6	175.2	-1.5
1960	0.0050	0.0338	31.1	146.9	0.6	33.7	208.1	0.9
1961	-0.0024	-0.0124	13.5	162.2	-0.4	18.2	226.8	-0.5
1962	0.0146	-0.0197	8.7	174.1	2.4	15.1	238.6	3.3
1963	0.0073	0.0160	11.3	182.6	1.3	18.9	255.8	1.7
1964	0.0079	0.0074	15.7	197.0	1.4	25.5	279.3	2.0
1965	0.0160	0.0129	22.6	217.1	3.2	33.4	308.2	4.5
1966	0.0125	0.0116	20.7	235.2	2.7	31.7	336.0	3.9
1967	0.0078	-0.0037	12.3	248.4	1.8	20.9	354.3	2.6
1968	0.0140	-0.0060	9.5	259.4	3.5	19.2	368.6	5.0
1969	0.0103	0.0002	16.3	275.6	2.7	26.5	391.3	3.8
1970	0.0018	-0.0245	28.8	311.2	0.5	39.9	430.4	0.7
1971	-0.0064	-0.1051	29.0	372.8	-2.0	38.6	471.8	-2.8
1972	0.0087	-0.0406	30.3	418.2	3.3	41.0	508.6	4.1
1973	0.0080	-0.0261	38.5	467.7	3.4	50.6	555.1	4.1
1974	0.0073	-0.0222	38.7	516.8	3.4	54.7	605.8	4.1
1975	0.0067	-0.0162	46.6	571.8	3.5	64.8	666.5	4.1
1976	0.0090	-0.0092	44.8	621.8	5.2	60.9	721.3	6.0
1977	0.0084	-0.0144	56.3	687.0	5.2	72.7	787.9	6.0
1978	0.0083	-0.0140	68.7	765.4	5.7	87.5	868.9	6.6
1979	0.0036	0.0043	78.9	841.0	2.8	102.1	967.8	3.2
1980	0.0089	0.0055	82.9	919.2	7.5	111.3	1070.4	8.7
1981	0.0097	0.0028	83.8	1000.5	8.9	109.9	1169.9	10.4
1982	0.0126	0.0016	95.5	1094.4	12.6	123.9	1279.1	14.7
1983	0.0152	0.0055	111.0	1199.4	16.6	145.6	1405.3	19.4
1984	0.0194	0.0168	141.4	1320.6	23.3	176.9	1555.0	27.3
1985	0.0180	-0.0296	196.2	1555.9	23.8	203.9	1730.8	28.1
1986	0.0184	0.0189	263.4	1789.9	28.6	263.4	1962.3	31.9
1987	0.0172	0.0146	310.1	2073.8	30.8	310.1	2238.6	33.8
1988	0.0131	0.0130	380.9	2427.7	27.1	380.9	2590.2	29.3
1989	0.0105	-0.0151	375.8	2840.2	25.5	375.8	2938.8	27.2
1990	0.0171	-0.0008	399.5	3241.9	48.5	399.5	3288.2	50.2
1991	0.0144	-0.0304	465.0	3805.5	46.7	465.0	3705.7	47.4
1992	0.0130	-0.0166	625.4	4494.2	49.4	625.4	4283.1	48.1
1993	0.0147	-0.0122	927.9	5479.8	63.2	927.9	5150.7	60.2
1994	0.0165	-0.0077	1191.2	6720.7	83.1	1191.2	6263.8	78.1
1995	0.0183	-0.0033	1452.2	8208.3	109.2	1452.2	7614.1	101.8
1996	0.0200	0.0012	1848.5	10069.1	142.4	1848.5	9330.6	132.1
1997	0.0218	0.0056	2070.7	12116.7	185.7	2070.7	11229.2	172.1
1998	0.0236	0.0101	2262.9	14306.0	236.7	2262.9	13272.8	219.3
1999	0.0253	0.0145	2463.4	16628.4	295.1	2463.4	15462.4	273.8
2000	0.0271	0.0190	2684.2	19085.7	361.2	2684.2	17810.8	335.8

2001	0.0289	0.0234	2818.5	21571.5	435.4	2818.5	20222.9	406.3
2002	0.0306	0.0279	3230.4	24344.3	515.7	3230.4	22969.9	483.5
2003	0.0324	0.0324	3773.2	27508.9	608.6	3773.2	26168.9	574.2

For scrap rates see the appendix on scrap rates, for effective investment values the appendix on effective investment (or, in both instances, the summary tables in the paper). The original value of fixed assets follows from equation (2'), the scrap value from equation (3). Scenario I uses investment-based scrap rates in the derivation of the original value of fixed assets series, scenario II depreciation-based scrap rates; both scenarios use the depreciation-based scrap rates to derive scrap values. The effective investment series and original value of fixed asset series are first derived for SOUs and non-SOUs separately, and then added up. Only one set of SOU effective investment values is available (method B). Effective investment values of non-SOUs are derived using method C.3 in scenario I, and method C.4 in scenario II.

Table 2. Simulated Lifetime of China's Effective Investment in Fixed Asset (in years)

Average annual scrap rate,[a] in %	Period[b]	Economy-wide effective investment = SOU (B) + non-SOU (C.3) (average annual growth rate of nom. eff. investment, %)	non-SOU (C.4)	Average ann. price change[c]
0.3761	1953-78	37 (9.1162)	37 (9.1762)	0.07
1.6242	1978-03	15 (17.3761)	16 (16.2492)	5.46
-0.5259	1953-60	N/A (21.9581)	N/A (19.4072)	-0.22
0.8976	1960-70	N/A (-0.7852)	56 (1.6829)	-0.29
0.6269	1970-80	28 (11.1554)	28 (10.8124)	1.17
1.5121	1980-90	16 (17.0315)	18 (13.6375)	5.79
1.7053	1990-00	15 (20.9836)	-> identical[d]	7.10
-1.3246	1953-55	N/A (11.4899)	N/A (15.2425)	-2.46
-0.0467	1955-60	N/A (26.4156)	N/A (21.1149)	0.69
0.8669	1960-65	N/A (-6.1910)	N/A (-0.1846)	0.91
0.9282	1965-70	38 (4.9320)	44 (3.5853)	-1.48
0.4874	1970-75	32 (10.1148)	32 (10.2022)	0.76
0.7665	1975-80	26 (12.2060)	22 (11.4261)	1.58
1.4988	1980-85	15 (18.8093)	19 (12.8804)	3.82
1.5255	1985-90	17 (15.2802)	17 (14.3996)	7.79
1.4574	1990-95	12 (29.4473)	-> identical[d]	13.32
1.9533	1995-00	16 (13.0733)	-> identical[d]	1.23
2.3907	2000-03	16 (12.0205)	-> identical[d]	0.93
0.3942	1953-80	36 (9.1677)	36 (9.4383)	0.26
0.6294	1978-80	30 (9.8133)	25 (12.7686)	2.61
1.2504	1978-85	18 (16.1664)	20 (12.8484)	3.47

Simulations are based on the given scrap rate and growth rate of economy-wide effective investment; first-period effective investment is set equal to 100. The first-period original value of fixed assets is obtained using the perpetual inventory method, as 100 * (1+g) / g, where g is the average annual growth rate of nominal effective investment. A lifetime of k years implies that the scrap value of a particular year equals the value of (nominal) effective investment k years earlier.

a Scrap rates are depreciation-based scrap rates.

b Average annual scrap rates of period X-Y refer to years X+1 through Y, except when the starting year is 1953. Average annual growth rates refer to years X through Y.

c The average annual price change is based on the implicit gross fixed capital formation deflator up through 1990 and on the investment in fixed assets price index since 1990.

d After 1985, effective investment values of SOUs and non-SOUs are the actual ones (i.e., the official economy-wide effective investment values are used, and/or C.3 equal C.4 values).

If non-SOU effective investment is calculated using method C.5, the lifetime year values are between those of methods C.3 and C.4.

Sources: for scrap rates, economy-wide effective investment, and the investment price deflator see tables in paper.

Table 3. Simulated Lifetime of Effective Investment in Fixed Asset (in years)

Average annual	Average annual growth rate of effective investment							
scrap rate, in %	5%	8%	10%	12%	15%	20%	25%	30%
0.5	49	37	32	28	25	20	18	16
1.0	36	28	25	23	20	17	15	13
1.5	29	24	21	19	17	15	13	12
2.0	24	20	19	17	15	13	12	11
2.5	20	18	17	15	14	12	11	10
3.0	17	16	15	14	13	11	10	9
3.5	14	14	13	13	12	10	9	9
4.0	11	13	12	12	11	10	9	8

Simulations are based on the given scrap rate and growth rate of economy-wide effective investment; first-period effective investment is set equal to 100. The first-period original value of fixed assets is obtained using the perpetual inventory method, as 100 * (1+g) / g, where g is the average annual growth rate of nominal effective investment. A lifetime of k years implies that the scrap value of a particular year equals the value of effective investment k years earlier.

Table 4. Simulating Scrap Rates (in %) from Investment Growth Rates and Lifetimes

Investment	Lifetime, in years				
growth rate, in %	10	15	17	20	25
5	7.95	4.63	3.87	3.02	2.10
8	6.90	3.68	2.96	2.19	1.37
10	6.27	3.15	2.47	1.75	1.02
12	5.70	2.68	2.05	1.39	0.75
15	4.93	2.10	1.54	0.98	0.47
20	3.85	1.39	0.94	0.54	0.21

Simulations are based on the given lifetime and growth rate of economy-wide effective investment; first-period effective investment is set equal to 100. The first-period original value of fixed assets is obtained using the perpetual inventory method, as 100 * (1+g) / g, where g is the average annual growth rate of nominal effective investment. Scrap rates are scrap rates in period 200 (when they have been stable, at two decimals, for many years.)

Table 5. Year-specific Lifetimes of Fixed Assets

In year	use deflator of year		-> implied		or decommission effective
	Scenario I (B-C.3)	Scenario II (B-C.4)	deflator value		investment of
1953	1953		26.71		--
1954	1953		26.71		--
1955	1953		26.71		--
1956	1953		26.71		--
1957	1953		26.71		--
1958	1953		26.71		--
1959	1953		26.71		--
1960	1953		26.71		--
1961	1953		26.71		--
1962	1953		26.71		--
1963	1953		26.71		--
1964	1953		26.71		--
1965	1953		26.71		--
1966	1953		26.71		--
1967	1953		26.71		--
1968	1953		26.71		--
1969	1953		26.71		--
1970	1953		26.71		--
1971	1953		26.71		1/55 * 1953 ROFA
1972	1953		26.71		2/55 * 1953 ROFA
1973	1953		26.71		3/55 * 1953 ROFA
1974	1953		26.71		4/55 * 1953 ROFA
1975	1953		26.71		5/55 * 1953 ROFA
1976	1953		26.71		6/55 * 1953 ROFA
1977	1953		26.71		7/55 * 1953 ROFA
1978	1953		26.71		8/55 * 1953 ROFA
1979	1953		26.71		9/55 * 1953 ROFA
1980	1953		26.71		10/55 * 1953 ROFA
1981	1954		26.55		see on left
1982	1955		25.41		see on left
1983	1956		25.34		see on left
1984	1957		24.26		see on left
1985	1958		24.35		see on left
1986	1959		26.38		see on left
1987	1960		26.30		see on left
1988	1961 + 1962	1961 + ½ 1962	26.77	26.45	see on left
1989	1963 + 1964	½ 1962 + 1963	28.76	28.61	see on left
1990	1965 + 1966	1964 + 1965	27.25	27.99	see on left
1991	1967, 1968, 1969	1966 + 1967	26.26	27.03	see on left
1992	1970 + 1971	1968 + 1969	25.68	25.85	see on left
1993	1972 + 1973	1970 + 1971	26.16	25.68	see on left
1994	1974 + 1975	1972 + 1973	26.36	26.16	see on left
1995	1976 + 1977	1974 + 1975	26.90	26.36	see on left
1996	1978 + 1979	1976 + 1977	27.54	26.90	see on left
1997	1980 + 1981	1978 + 1979	29.15	27.54	see on left
1998	1982 + 1983	1980 + 1981	30.66	29.15	see on left
1999	1984 + ½ 1985	1982 + 1983	33.06	30.66	see on left
2000	½ 1985 + 1986	1984 + ½ 1985	36.08	33.06	see on left
2001	1987 + 1/3 1988	½ 1985 + 1986	40.06	36.08	see on left

2002	2/3 1988 + ½ 1989	1987 + ½ 1988	44.33	40.50	see on left
2003	½ 1989 + 1990	½ 1988 + 1989	49.47	46.48	see on left

When previous years denote the year of a deflator and more than one previous year is listed as deflator-year for the current year, the deflator is the average (or weighted average) of the previous years' values. When previous years denote effective investment to be decommissioned and more than one previous year is listed as relevant, the effective investment value is the sum of the previous years' values. Scenarios I and II parallel those in Table 1.

The previous effective investment decommissioned in 1971-80 considers the 1953 effective investment value in comparison to the 1954 value (which is decommissioned in 1981) and splits the 1953 real original value of fixed assets (ROFA) such among the ten years 1971-80 that the transition between 1980 and 1981 is smooth.