CHAPTER 4

How to Create IT Capital Stock

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IT economic variables such as IT capital stock and investment play an important role in the new production function. We find, however, very little officially published IT time series data in most countries because many historical input–Output (I-O) tables are needed to create the IT time series data. If ASEAN countries can create uniform IT time series data and share the IT database, it will be very useful for ASEAN to assess the effect of IT on their economies. Since this is one of our purposes, in this chapter we show how to start creating IT capital stock.

1. Methodology of Data Building

1.1. Basic framework of data building

We present the methodology and procedures for accumulating statistics related to IT investment and IT capital stock. An outline of the actual process follows:

[Overall process for obtaining IT investment and capital stock time series data]

(1) Define IT investment and measure benchmarks using the I–O table

(2) Calculate annual time series data

– Nominal time series data using supplemental statistics

– Real-term time series data using price indices

(3) Calculate the IT capital stock

First, the item codes of hardware and software products related to IT are defined and measured based on the input–output table. Unfortunately, although more frequent time series data (e.g. annual datasets) are necessary for relevant empirical studies, the input–output table is published only once every five years in Japan. Secondly, annual time series data between I-O tables are calculated using the growth rate of domestic demand for each product defined above, with such supplemental statistics as industrial production and international trade. This process can be divided into two steps: calculating nominal time series data, and then converting them to real-term data by using the price deflator of each product. Thirdly, IT capital stock data are calculated with real-term annual IT investment data, the depreciation rate of each IT asset, and estimated figures of initial endowments.

Using these steps of data building—definition and benchmark measurement, calculation of flow-based time series data, and creation of capital stock— valuable IT-related macro statistics will become available. We discuss each process more precisely in the following subsections.

2. Benchmarks based on the Input–output Table

2.1. Definition

The first step of data building is to define IT investment. For the definition, product codes or industry codes in the I–O table are useful and relevant. In the case of Japan, a fixed-capital matrix is available in the official input–output table. The fixed capital matrix provides all relevant domestic fixed-capital formation data in the benchmark year, according to the industrial sectors for which capital goods of each type, shown in Figure 4.1.

Figure 4.1. Configuration of Fixed-capital Formation

item codes	capital goods	industry codes / industries	010000 agriculture	- -	160000 automobile industry	- -	260000 communications and broadcasting	- -	private sector total
:	:								
3111011	photocopy								
3111099	other office equipment								
:	:								
3331011	personal computers								
3331021	computers except personal computers								
3331031	computers peripheral equipment								
:	:								
3321011	wired telecommunications equipment								
3321021	cellular phones								
3321031	other wireless telecommunications equipment								
3321099	other telecommunications equipment								
:	:								
4132031	construction of telecommunications facilities								
:	:								
7331011	software								
:	:								
total amount of capital formation									

In light of international comparisons and precedent studies[1], we use the product code in the fixed-capital matrix for definition. We choose the following 11 items as components of IT investment. They are: personal computers (3331011), computers, excluding personal computers (3331021), computer peripheral equipment (3331031), wired telecommunications equipment (3321011), cellular telephones (3321021), wireless telecommunications equipment, excluding cellular telephones (3321031), other telecommunications equipment (3321099), photocopiers (3111011), other office

[1] In the United States, IT investment is defined as "Information processing equipment and software", classified into three categories, "computers and peripheral equipment," "software," and "other." The "other" includes "communications equipment," "photocopy and related equipment," "office and accounting equipment," "medical equipment and instruments," and nonmedical instruments."

equipment (3111099), construction of telecommunication facilities (4132031), and software products (7331011).

As described in the next subsection, we then categorize the 11 products above into five items because of the limited nature of available statistics for creating annual time series data. The five are: (1) computers and peripherals (3331011, 3331021, 3331031), (2) telecommunications equipment and peripherals (3321011, 3321021, 3321031, 3321099), (3) construction of telecommunication facilities (4132031), (4) office equipment and peripherals (3111011, 3111099), and (5) software products (7331011) (Figure 4.2).

Figure 4.2. Categories Classified for IT investment

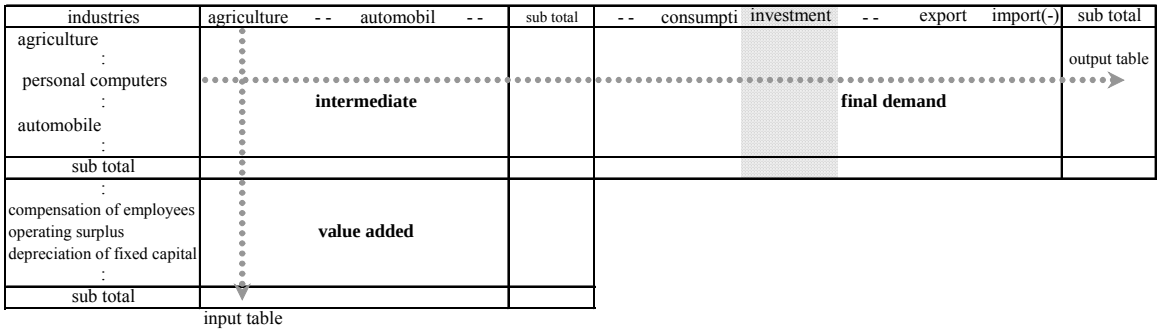
classification of categories			item codes	capital goods	purchaser's price (a)	producer's price (a)	(b)/(a)
hardware	computer related	computers and peripherals	3331011	personal computers	1,354,633	1,036,491	0.7651
			3331021	computers except personal computers	1,079,775	852,830	0.7898
			3331031	computers peripheral equipment	1,388,459	1,126,531	0.8114
	telecom related	telecommunications equipment and peripherals	3321011	wired telecommunications equipment	1,077,001	693,128	0.6436
			3321021	cellular phones	59,334	32,980	0.5558
			3321031	other wireless telecommunications equipment	686,986	575,684	0.8380
			3321099	other telecommunications equipment	314,892	265,255	0.8424
		construction of telecommunication	4132031	construction of telecommunications facilities	311,873	311,873	1.0000
	office related	office equipment and peripherals	3111011	photocopy	434,248	316,358	0.7285
			3111099	other office equipment	836,983	593,846	0.7095
software	software	software	7331011	software	7,277,117	7,267,071	0.9986
total IT investment					14,821,301	13,072,047	0.8820

2.2. Benchmark measurement

Annual figures calculated once every five years are measured as benchmark components of IT investment through evaluation of the amount of defined products in the private sector's fixed-capital matrix. In case a fixed-capital matrix is unavailable, the benchmark can be measured using an "output table" in the I–O table, rather than an "input table." The output table describes where and how each product is demanded and used. Take computer peripheral equipment, for example. Some of this equipment is purchased and used as an intermediate input by a wide range of industries while other equipment is consumed by households or invested by firms as final demand (Figure 4.3). Figures of defined products for investment in the final demand are measured as benchmarks of IT investment. Using these procedures, we can create benchmarks of IT investment for every five years[2].

[2] In case the value of each IT related item is measured in terms of producer's price that excludes delivery cost, broker commissions, and installation cost, it is necessary to convert the value into the purchaser's price that includes those costs to avoid an underestimation of IT investment. See Figure 4.2.

Figure 4.3. Configuration of the Input output Table



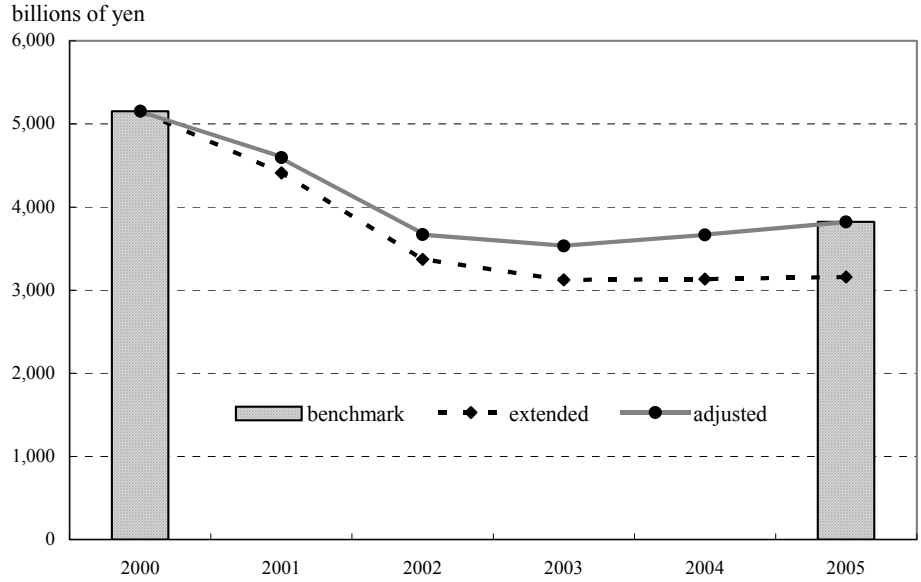
3. Time Series Data of IT Investment

The next step is to annually bridge over the five-year benchmarks. One of the greatest difficulties with this process is a shortage of precise annual data. In other words, missing or imperfect data become apparent, especially tracking back before the 1990s. To address the limitation of available statistics for creating annual time series data, 11 product categories used in the input–output table are integrated into five item components, as described in the previous subsection, which are then calculated annually using supplemental statistics.

The process to bridge over the five-year benchmarks for obtaining annual data is divisible into two steps: (1) calculating nominal time series data and (2) converting them to real-term data. For nominal data, we adopt the annual rate of change of domestic demand for each category. The amount of domestic demand is formulated by subtracting the value of exports from those of domestic production and adding the value of imports using supplemental statistics related to industrial production and international trade.

It is noteworthy that some discrepancy might occur in this process for the benchmark year because the values accumulated for the annual change of domestic demand and the values of benchmarks in the I–O table are not identical. For example, for the process of bridging over benchmarks between 2000 and 2005, the figures simply extended to 2005 by accumulating the annual rate of change of domestic demand from 2000 differ from the figures in the 2005 input–output table (Figure 4.4).

Figure 4.4: Benchmarks, simply extended, and adjusted data.



Source: Ministry of Internal Affairs and Communications, *2005 Input–Output Tables*.

To adjust such discrepancies, we use the "linking coefficient", which smoothly corrects the annual gaps. The formula of the "linking coefficient" is

$$IO05 = IO00 * (1 + DC0005 + ADJ),$$

where *IO*05 represents the benchmark figure from the 2005 input–output table, *IO*00 represents the benchmark figure from the 2000 input–output table, *DC*0005 represents the accumulated rate of change of domestic demand during 2000–2005, and *ADJ* represents the adjustment factor. Then, this formula can be transformed to

$$io0005 = dc0005 + adj ,$$

where *io*0005 represents the annual rate of change of the I–O table benchmark figure during 2000–2005, *dc*0005 represents the annual rate of change of domestic demand, and *adj* represents the annual rate of change of adjustment factor, i.e. the "linking coefficient."

Accordingly, the annual rate of change with no discrepancy is obtained from the annual rate of change of domestic demand and the "linking coefficient (*adj*)." This

procedure is conducted for each item for the years between benchmarks. Linking these rates of change in succession produced the nominal annual IT investment value for each item of the five categories. We can convert these nominal time series data into real-term annual data using price indices as deflators. The steps up to this point tabulate the nominal and real values of IT investment annually (Tables 4.1a and 4.1b).

Table 4.1a Nominal IT investment data

(billions of current yen)

year	(1)	(2)	(3)	(4)	sub total	(5)	total
75	663	292	469	313	1,737	46	1,783
76	715	315	499	343	1,872	51	1,923
77	811	335	531	385	2,062	84	2,146
78	927	349	565	474	2,316	97	2,412
79	1,143	353	602	424	2,521	140	2,661
80	1,264	375	641	423	2,702	167	2,869
81	1,423	477	653	318	2,870	247	3,117
82	1,647	593	665	385	3,289	326	3,615
83	1,736	787	677	644	3,844	395	4,240
84	2,426	1,042	690	739	4,898	556	5,453
85	3,173	1,271	703	888	6,036	714	6,749
86	3,656	1,347	640	1,006	6,650	990	7,640
87	4,056	1,562	583	1,149	7,350	1,198	8,548
88	4,766	1,731	531	1,570	8,598	1,951	10,549
89	5,480	1,822	484	1,728	9,513	2,725	12,238
90	5,452	2,233	440	1,487	9,613	3,751	13,363
91	5,576	2,376	492	1,563	10,008	4,665	14,673
92	4,618	2,119	537	1,423	8,697	4,660	13,356
93	4,040	2,243	604	1,275	8,163	4,136	12,299
94	4,789	2,434	621	1,186	9,030	3,781	12,811
95	5,514	3,169	781	1,156	10,620	4,010	14,630
96	6,345	4,403	1,065	1,159	12,973	4,620	17,593
97	6,146	4,028	1,151	1,262	12,588	5,064	17,652
98	4,988	3,125	1,213	1,150	10,476	5,413	15,889
99	4,847	2,961	1,255	1,214	10,277	5,739	16,016
00	5,154	3,074	1,445	1,402	11,075	6,015	17,090
01	4,594	3,111	795	1,073	9,573	6,755	16,327
02	3,671	2,128	502	1,759	8,060	6,969	15,028
03	3,532	2,387	415	1,298	7,632	6,929	14,562
04	3,665	2,075	340	1,275	7,356	7,208	14,563
05	3,823	2,138	312	1,271	7,544	7,277	14,821
06	3,792	2,258	323	1,168	7,540	7,464	15,004
07	3,284	2,298	307	1,099	6,988	7,817	14,805
08	3,212	2,119	318	781	6,430	7,887	14,317
09	2,441	1,682	304	553	4,979	7,366	12,345

(1) computers and peripherals
(2) telecommunications equipment and peripherals
(3) construction of telecommunications facilities
(4) office equipment and peripherals
(5) software

Table 4.1b Real IT investment data

(billions of 2005 constant yen)

year	(1)	(2)	(3)	⑷	sub total	(5)	total
75	70	123	807	63	1,062	73	1,135
76	76	134	802	89	1,101	74	1,176
77	90	141	797	111	1,138	114	1,252
78	112	147	792	151	1,202	125	1,327
79	145	149	787	141	1,222	175	1,397
80	161	156	782	149	1,248	194	1,443
81	190	196	793	121	1,301	274	1,575
82	236	243	805	164	1,449	351	1,801
83	267	324	816	301	1,709	417	2,126
84	395	427	828	371	2,021	571	2,592
85	581	531	840	468	2,420	720	3,140
86	820	631	746	579	2,776	999	3,776
87	1,086	801	662	748	3,297	1,212	4,509
88	1,344	936	588	1,124	3,991	1,955	5,946
89	1,542	990	522	1,252	4,306	2,603	6,909
90	1,576	1,235	463	1,081	4,354	3,442	7,796
91	1,683	1,350	503	1,165	4,701	4,130	8,831
92	1,455	1,212	540	1,084	4,291	4,100	8,391
93	1,322	1,290	605	999	4,216	3,708	7,924
94	1,679	1,423	622	953	4,676	3,561	8,237
95	2,115	1,895	781	955	5,746	3,906	9,652
96	2,582	2,705	1,072	964	7,322	4,511	11,833
97	2,548	2,500	1,148	1,061	7,256	4,782	12,038
98	2,157	1,990	1,241	994	6,382	4,986	11,368
99	2,158	2,054	1,304	1,113	6,630	5,251	11,880
00	2,481	2,262	1,494	1,307	7,545	5,490	13,034
01	2,487	2,430	837	1,011	6,765	6,298	13,063
02	2,397	1,801	535	1,660	6,393	6,621	13,014
03	2,769	2,178	439	1,252	6,638	6,854	13,492
04	3,250	2,002	352	1,243	6,846	7,161	14,008
05	3,823	2,138	312	1,271	7,544	7,277	14,821
06	3,989	2,346	299	1,226	7,861	7,369	15,230
07	3,785	2,631	278	1,181	7,875	7,642	15,517
08	4,072	2,545	292	845	7,753	7,611	15,364
09	3,514	2,097	288	628	6,526	7,323	13,850

(1) computers and peripherals
(2) telecommunications equipment and peripherals
(3) construction of telecommunications facilities
(4) office equipment and peripherals
(5) software

Indeed, Japan's real IT investment enjoyed an increasing trend until 2007, as seen in figure 4.5. But if we compare Real IT investment – Real Total investment ratio between Japan and the U.S.A., then the ratio has been almost flat in Japan since 1995 while the ratio has been accelerating in the United States since 1995 (figure 4.6). These differences imply the different IT effects on their economies.

Figure 4.5: Japan's Real IT Investment (Billions of 2005 constant yen)

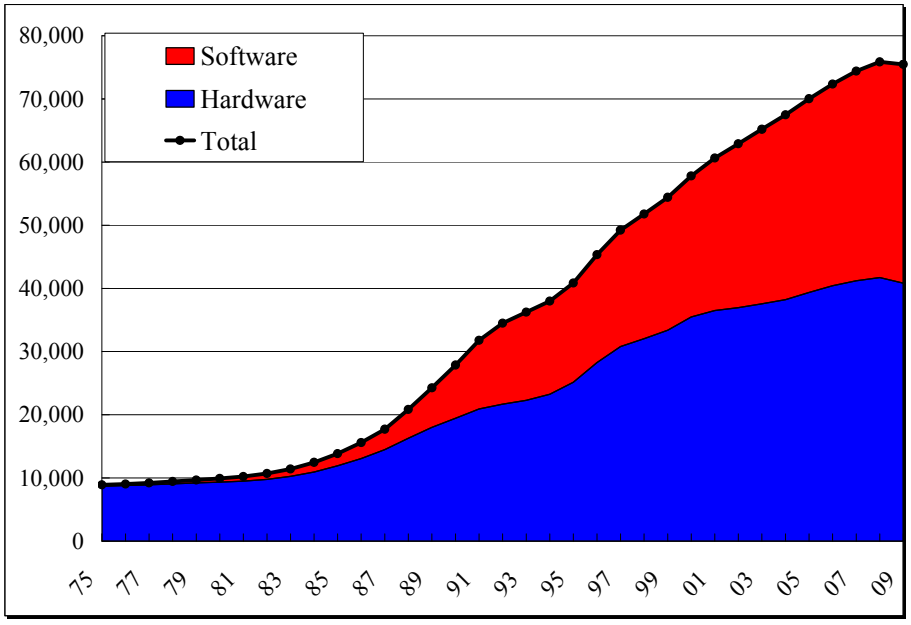
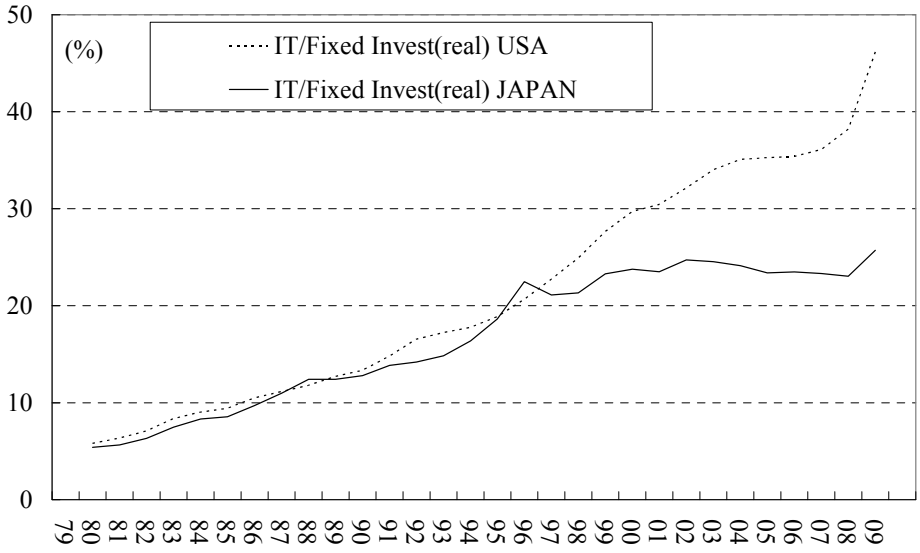


Figure 4.6: Real IT investment – Real Non-residential fixed investment Ratio between Japan and the United States (%)



4. Time Series Data of IT Capital Stock

The time series of capital stock data is what we need for empirical studies to analyze the impact of IT on economic growth and development. Using investment flow data, depreciation rate, and initial endowment of assets, we can create the time series data of IT capital stock according to the following formula:

$$K_t = I_t + (1-\delta) * K_{t-1} \quad \text{..... eq. 4.1}$$

In eq. 4.1, K stands for capital stock, I represents the investment flow, δ denotes the depreciation rate, and t signifies the year or time series. Given that the annual growth rate of investment (g) and depreciation rate (δ) are constant for the years before t, the following formula is obtained[3]:

$$K_{t-1} = I_t / (g + \delta) \quad \text{..... eq. 4.2}$$

Therefore, on the assumption that the first several years' growth rate and depreciation rate are maintained until the initial benchmark year, the initial IT capital stock endowment can be calculated. Here, the missing figure for calculating the time series IT capital stock is the depreciation rate, which is obtainable from Fraumeni (1997) for hardware. Although the figures presented by Fraumeni (1997) are derived from IT investment in the United States, it is reasonable to assume that the depreciation rates of IT-related products are almost identical around the world because of the nature of the technology: it diffuses rapidly and globally. As for the depreciation rate of software, we assume 20%, or 5 years' duration, in light of precedent studies.

Figure 4.6: Depreciation rate

	Hardware			Software
	Computer related	Telecom related	Office related	
Depreciation Rate	0.31190	0.11000	0.18000	0.20000
Duration (year)	3.2	9.1	5.6	5.0

Source: Fraumei(1997), Japan Center for Economic Research(2000)

[3] This formula is commonly adopted for creating capital stock from investment flows.

Finally, we have the time series data of real net IT capital stock (table 4.2). We have demonstrated the importance of IT capital stock data in revealing the influence of technology on macroeconomies from the Industrial Age to the Information Age. World-wide collaboration for data building and collection is necessary because IT investment and capital stock data enable economists to conduct international comparisons related to the economic impact of IT based on relevant macroeconomic statistics.

Table 4.2: Real Net IT Capital Stock

billions of 2005 constant yen

year	total (a)=(b)+(c)	Net IT capital stock				
		hardware capital stock（ b)	of which computer related	of which telecom related	of which office related	software capital stock（ c)
75	8,911	8,698	168	8,328	202	214
76	9,039	8,794	192	8,348	255	245
77	9,219	8,909	222	8,367	320	310
78	9,436	9,063	265	8,386	413	373
79	9,680	9,206	328	8,399	479	473
80	9,915	9,342	386	8,414	542	573
81	10,232	9,500	456	8,478	566	732
82	10,709	9,772	550	8,594	628	937
83	11,418	10,251	646	8,788	817	1,167
84	12,462	10,957	840	9,077	1,041	1,505
85	13,853	11,929	1,158	9,449	1,322	1,924
86	15,606	13,067	1,618	9,786	1,663	2,539
87	17,727	14,483	2,200	10,172	2,112	3,243
88	20,839	16,290	2,857	10,576	2,856	4,549
89	24,269	18,027	3,509	10,925	3,594	6,242
90	27,874	19,438	3,990	11,420	4,028	8,436
91	31,793	20,914	4,429	12,018	4,467	10,879
92	34,500	21,698	4,502	12,448	4,747	12,803
93	36,236	22,286	4,420	12,974	4,891	13,950
94	37,997	23,275	4,720	13,592	4,963	14,721
95	40,844	25,160	5,363	14,772	5,025	15,683
96	45,338	28,280	6,273	16,923	5,085	17,058
97	49,232	30,803	6,864	18,710	5,230	18,428
98	51,774	32,045	6,880	19,883	5,282	19,729
99	54,425	33,391	6,892	21,055	5,444	21,034
00	57,807	35,490	7,224	22,495	5,772	22,317
01	60,640	36,488	7,457	23,287	5,744	24,152
02	62,902	36,960	7,528	23,062	6,370	25,942
03	65,174	37,567	7,949	23,142	6,475	27,607
04	67,470	38,223	8,720	22,950	6,553	29,247
05	70,018	39,343	9,823	22,876	6,644	30,675
06	72,337	40,428	10,748	23,005	6,675	31,909
07	74,388	41,219	11,181	23,383	6,655	33,169
08	75,861	41,715	11,765	23,648	6,302	34,146
09	75,476	40,836	11,610	23,431	5,795	34,640

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