# Capitalizing Own Account Software in Japan

Koji Nomura *

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**Keywords**

own-account software, prepackaged software, custom software, capitalization, original and reproduction, software investment and stock, depreciation, cost index and harmonized index

**Abstract**

In this paper, we measure own-account software investment in Japan as the applications of the OECD Task Force recommendation at the aggregate level and the BEA's methodology at the industry level. We can conclude that the scale of own-account software investment in Japan is 0.60 percent of GDP in 2000. This share is 0.13 percent point lower than that in the U.S. The share of total software investment to GDP is 2.03 percent, which is the almost same as that in the U.S. (2.07 percent), reflecting the larger share of custom software in Japan relative to other countries.

By type of software, in 1970, own-account software has the largest share in software investment and prepackaged software is minor in the U.S. and Japan. The composition is very similar between the two countries. In the U.S., the diminution of the share of own-account software is reflected by the rapid expansion of prepackaged software in the 1970s and the 1980s. On the other hand, in Japan, the diminution is mainly reflected by the expansion by custom software.

To measure software capital stock, we consider four scenarios. First, for depreciation, the 33 percent and 55 percent geometric depreciation rates are assumed. Second, there are two options for prices, a cost index for all types of software and harmonized indexes for each type of software. When we use 33 percent depreciation rates and the cost index, Japan's own-account software stock is 7.6 trillion yen (evaluated by the 1995 constant prices) estimated using the cost index and 8.1 trillion yen using the harmonized prices in 2000, which amounts to about 0.4 percent of fixed capital stock and about 0.2 percent of total capital stock including land and inventories. Total software stock in Japan is 25.2 trillion yen estimated using the cost index and 27.5 trillion yen using the harmonized indexes in 2000.

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* Koji Nomura <nomura@sanken.keio.ac.jp>: Associate Professor, Keio Economic Observatory (Institute for Economic and Industry Studies), Keio University, Japan, and CBG Fellow, Kennedy School of Government, Harvard University, U.S. I thank Ms.Kimiko Hanabusa, Research Center on Global Warming, Development Bank of Japan, for her help estimating Japanese labor data. Also, I thank Professor Dale W. Jorgenson and Jon D. Samuels, Harvard University, for their helpful supports. This measurement contributes the extension of our productivity database for the Japanese economy, KEO Database (KDB), and the joint research about international comparison of IT impacts on economic growth in the industry and aggregate levels between the U.S. and Japan with Professor Dale W. Jorgenson. This paper is preliminary. Comments welcome.

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# 1 Introduction

On understanding recent economic growth, the role of software as a capital is becoming more significant. In the U.S. economy, Jorgenson-Ho-Stiroh[forthcoming] shows that the growth of software capital input explains 6.5 percent of the economic growth during 1989-2002. The contribution of software capital input is almost half of that of computer (12.5 percent) and higher than that of communications equipment (4.7 percent). Also, as impacts of software capital to the total capital input, the contribution share is 12.1 percent for the same periods, which increased from the 4.6 percent contribution during 1973-89.

The role of software in national accounts is redefined by the UN's recommendation on the System of National Accounts in 1993 (SNA 1993) that purchases of software, including software produced in-house, should be capitalized. After the recommendation of SNA 1993, statistical divisions in almost all OECD countries published the trial calculation and strive to improve it. For the international comparison of economic growth, it should be an important issue to harmonize the methodology to measure the capitalization of software. The non-comparable exception country is Japan, which may have the second largest scale of software investment in the world.

In Japan, the present official national accounts treat expenditures for custom software, mineral exploration, and plant engineering as gross fixed capital formation (GFCF) of intangible assets. So far, own-account software and pre-packaged software still have not been capitalized in the Japanese national accounts. The reason why the Japanese government avoided them to be capitalized is not evident[*1]. However, it is quite evident that Japanese government does not have particular substantial difficulties preventing from capitalizing, based on similar data and methodology used in other countries. In this paper, we estimate own-account software investment by industry during 1955-2000 in Japan.

Our basic methodological concepts to measure own-account software investment in this paper is based on comprehensive research by the OECD Task Force on software measurement in the national accounts (Lequiller-Ahmad-Varjonen-Cave-Ahn[2003])[*2], whose concept is totally consistent with the SNA 1993. Additionally, we apply the U.S. methodology for estimating own-account software by industry, which is reported by Grimm-Moulton-Wasshausen[2003] of the Bureau of Economic Analysis (BEA), to the Japanese economy.

In section 2, we look through the concept of software and the basic methodology to measure own-account software. In section 3, we measure own-account software investment in Japan as suggested by the OECD Task Force methodology at the aggregate level. Also, we apply BEA's methodology at the industry level and discuss our estimates in comparison with the other Japanese estimates at the aggregate level, Motohashi[2002] and Miyagawa[2003], and with official software investment in the

[*1] One of the direct reasons might be that benchmark 1995 input-output (IO) table, which is one of basic statistics for estimating national accounts, did treat only custom software as a software investment. In the summer of 2004, benchmark 2000 IO table was published and begun to treat pre-packaged software as GFCF, additionally. However, capitalization of own-account software was postponed even in the benchmark 2000 IO table.

[*2] The OECD Task Force had the first meeting in October 2001. The chairperson of the Task Force is Carol Moylan, Division Chief of National Income and Wealth, BEA, the U.S., and the secretariat are Francois Lequiller and Nadim Ahmad, OECD.

U.S. and other OECD countries in section 4. Based on the estimates of software investment, we compute software stock with some scenarios about depreciation rates and prices by type of software in section 5. We conclude in section 6.

# 2 Concept and Methodology

## 2.1 What Should be Capitalized?

In order to clarify the object to be capitalized, we start with the definition of software as an intangible asset, as recommended by the SNA 1993 and the OECD Task Force on software measurement in the national accounts. Paragraphs 10.92 and 10.93 of the SNA 1993 define software as,

> Computer software that an enterprise expects to use in production for more than one year is treated as an intangible fixed asset. Such software may be purchased on the market or produced for own use. Acquisitions of such software are therefore treated as gross fixed capital formation. Software purchased on the market is valued at purchasers' prices, while software developed in-house is valued at its estimated basic price, or at its costs of production if it not possible to estimate the basic price. Gross fixed capital formation in software also includes the purchase or development of large databases that the enterprise expects to use in production over a period of time of more than one year. These databases are valued in the same way as software, described above.

By this definition, it is comprehensible why acquisitions of software should be treated as gross fixed capital formation (GFCF) in the national accounts. However, for the sake of the measurement, it is not clear enough to apply. Lequiller-Ahmad-Varjonen-Cave-Ahn[2003] reports the OECD Task Force on software measurement in the national accounts to describe a more detailed descriptive definition of software. The OECD Task Force recognizes that software as a distinct entity has two sub-categories: *originals* and *reproduction of originals* (recommendation 1(1)). This conceptual distinction of two sub-categories is consistent with the SNA recommendation. They define *originals* as,

> Original software are machines used in the process of production of other products, and as such are considered as investment. Originals can be produced on own-account (they are then called "own account original software") or can be bought ("purchased original software"). This includes games' originals. Originals cover two types:
>
> - *Originals for reproduction*: original software whose purpose is to be reproduced. They are generally the result of the production of software editing companies.
> - *Other originals*: software that can be used in the process of production of other products.

Also, the OECD Task Force defines *reproduction of originals* as,

> Reproductions of software are copies of original software. They include software giving users the rights, or license, to use, and software that gives the rights, or licenses, to reproduce:
>
> - *Licenses to use*: They are mostly marketed, and thus called "packaged software" or "off-the-shelf software". In general they legally provide a license to use the software. This category

includes reproduced software for final use and reproduced software for bundling in hardware, other equipment or other software. This category also covers "multiple copy" licenses to use and software "rented" for use, for which payments often take the form of "royalties". It excludes licenses that permit copies to be made for sale.

- *Licenses to reproduce*: Licenses to reproduce permit companies to make further software reproductions (licenses-to-use) for subsequent sale. These reproductions can be sold via licenses-to-use or as part of a bundle, whether the bundled software is included separately or embedded directly onto hardware. Often, licenses to reproduce are paid for using royalties.

In order to consider the capitalization of software, it is significant to identify originals and reproduction of originals, even if the physical formats of both are exactly the same. Reproduced games are not treated as GFCF, since they are not used in the production process. However, the games' originals should be treated as GFCF, since they are used for producing the reproductions of the games. Prepackaged software used in production process for more than one accounting period is treated as GFCF by the purchasers. Also, the originals should be treated as GFCF by the producers to reproduce the copies. This is not double-counting, but the proper treatment for the description of two different production processes. The U.S. initial measurement of own-account software investment was under this misconception. Expenditures for software originals, whose purpose is to be reproduced, were excluded from own-account software investment. In the benchmark 1997 input-output table, the BEA revised it to the proper treatment that originals and reproduction of originals should be recorded as investment in the two different production processes (Grimm-Moulton-Wasshausen[2003]).[*3]

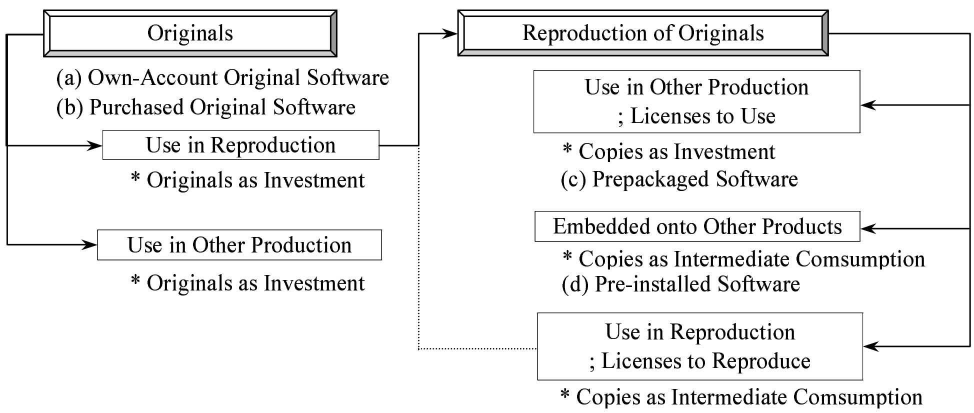


Figure. 1 Production Process and Use of Software

Figure 1 briefly summarize software production flow and investment activity. Originals consist of (a)own-account originals and (b)purchased originals. (a) is called simply as *own-account software* and

[*3] Like software to be reproduced, some thought software to be embedded onto other products should be excluded. However, the software originals, whose copies will be embedded onto other products, also should be recorded as own-account software. This kind of misconception is found in U.S. Congressional Budget Office[1998], Motohashi[2002,], and so on.

most of (b) is so-called *custom software*. (a) and (b) are used in reproduction and other production process. The values of (a) and (b) should be defined as investment, including *work-in-progress* (WiP), destined for investment (Recommendation 1(2))[*4]. As for the reproduction of originals, (c)prepackaged software should be treated as GFCF, if it is durable and used in the production process. Some reproduction of software will be embedded onto products; equipment, machinery, and other software. This pre-installed software should be recorded as intermediate consumption and the final products can be treated as GFCF. The SNA and the OECD Task Force recommend that payments for licenses to reproduce should be treated as intermediate consumption.

The OECD Task Force defines own-account software as a *production process* that leads to the creation of a software original. For originals to be reproduced, in equilibrium, the total present value of profits from the sales of reproductions is equal to the value of originals. For originals to be used in other production, the present value of net capital flow is also equal to the value of originals. From the point of view of measurement, the value of own-account software is practically determined by a production cost (imputation) approach since it is difficult to directly observe the market value[*5]. Ahmad[2003] indicates that every OECD country estimates own-account software using the production cost approach. Therefore, the imputation strongly depends on the definition of costs included in the valuation. The OECD Task Force describes the eight stages of the production process of own-account software; (1)Feasibility analysis, (2)Functional analysis, (3)Detailed analysis, (4)Programming, (5)Test, (6)Documentation, (7)Training, (8)Maintenance. They recommend that own-account software should include compensation of all staff and all internal overheads cost incurred in own-account production on stages (2)-(6) above (Recommendation 1(3)).

## 2.2 Methodology to Measure

Practically, there are two main difficulties in measuring own-account software investment. The first difficulty is to extract the production process only for own-account software. The second difficulty is to identify the cost for each stage of the production process for software. Companies may not capitalize own-account software, unless the expenditure is substantial. Also, the production cost for own-account software is not recorded separately in their business accounts. Because of the difficulties in measuring own-account software, we have to start with the measurement of the number of workers engaged in software production.

Here, we examine methodologies of the OECD Task Force and the BEA (Grimm-Moulton-Wasshausen[2003]). The standard measurement process of own-account software investment

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[*4] In general, the expenditure for non-completed assets is reported as WiP. When the asset is completed, at which point the cumulative value of WiP is transferred to investment. Although this rule should be followed for software if possible, very few companies capitalize originals for software at all. OECD Task Force concluded that, in practice, most own-account software WiP would ultimately be recorded as investment and, so, where it was not possible to identify WiP, own-account production should be recorded directly as investment (Lequiller-Ahmad-Varjonen-Cave-Ahn[2003]).

[*5] The production process of own-account software can also include unsuccessful software development. In the SNA, some unsuccessful development is recorded as WiP while development is on-going, and the written-off when the project is abandoned. The OECD Task Force looked to the analogy of mineral exploration, where unsuccessful projects are, in practice, capitalized.

comprises several steps like below,

(1) Estimate number of workers of software professionals.
  (1)-1 Exclude workers linked to custom software and reproduction software to be sold.
  (1)-2 Exclude working time linked to other activities.
(2) Estimate wages for software professionals and compute labor cost.
(3) Estimate non-labor costs for own-account software.

Step-(1) is to estimate number of workers of software professionals. Since it is difficult to directly observe the number of software professionals, employment data by occupation can be used. On the International Standard Classification of Occupation in 1988 (ISCO 88), occupations related to software professionals are 213.Computing professionals and 312.Computer associate professionals. ISCO-213 consists of 2131.Computer systems designers, analysts and programmers and 2139.Computing professionals not elsewhere classified. ISCO-312 consists of 3121.Computer assistants, 3122.Computer equipment operators, and 3123.Industrial robot controllers. The OECD Task Force recommends the coverage of employees should be limited to the number of computing professionals (ISCO-213) for international comparability (recommendation 5(8)).

In Japan, occupation classification in the Population Census is based on the Japan Standard Classification of Occupation (JSCO). Table 1 shows the rough occupational concordance between ISCO and JSCO. As we compare the shares of ISCO-213 and JSCO-06 in section 3, they are almost consistent.

In the U.S., the Bureau of Labor Statistics (BLS) uses Standard Occupational Classification (SOC). The group of the three occupational categories, SOC-15-1020.Computer programmers, SOC-15-1030.Computer software engineers, and SOC-15-1050.Computer System Analysts, are almost consistent with ISCO-213. In this paper, we label the occupation of the workers engaged in own-account software production simply as "software professionals" or ISCO-213.

Table. 1 Concordance between ISCO and JSCO on Software Professionals

| ISCO 1988 | JSCO 1997 |
|---|---|
| 213.Computing professionals | 06.Computing professionals |
| 2131.Computer systems designers, analysts and programmers | 061.system engineers |
| 2139.Computing professionals not elsewhere classified | 062.programmers |
| 312.Computer associate professionals | 31.Office machinery operators |
| 3121.Computer assistants | 311.stenographers, typists, and word processor operators |
| 3122.Computer equipment operators | 312.Key punchers |
| 3123.Industrial robot controllers | 313.Computer operators |
| | 319.Other office machinery operators |

ISCO: International Standard Classification of Occupation

JSCO: Japan Standard Classification of Occupation

At step-(1), we need two adjustment processes. At first as (1)-1, we have to exclude workers linked to custom software and reproduction software to be sold. Software professionals we observe work in production processes of originals and reproduction of originals. The BEA limits the maximum shares of employment in three digit-SIC-level industries to a maximum of 0.2 percent of total employment in each industry (Grimm-Moulton-Wasshausen[2003]). Numbers in excess of these limits are assumed to be engaged in the production of custom software and reproduction software to be sold.

The second adjustment at step-(1) is a limitation of working time. The BEA assumes that 50 percent of working time of software professionals is spent doing tasks associated with new investment rather than such activities as minor revisions and upgrades and maintenance (Paker-Grimm[2000] and Grimm-Moulton-Wasshausen[2003]). This 50 percent deduction rule originates from a study on the share of software development and maintenance costs in 487 business organizations reported by Barry Boehm[1981][*6]. The OECD Task Force recommends the 50 percent deduction rule can be applied as an upper limit (recommendation 5(11)).

Step-(2) is the estimation of wages for software professionals and labor costs of own-account software production. The OECD Task Force recommends that labor costs should be based on compensation, including net salaries and wages, but also social contributions (employer and employee, including imputed contributions).

At last, step-(3) is to estimate non-labor costs. Non-labor costs comprises intermediate consumption, consumption of capital, operating surplus, etc. The OECD Task Force recommends the use of the relationship between labor cost and non-labor costs derived from computer industries (if possible, custom software developments would be preferable) (recommendation 5(12)).

# 3 Measurement of Own-Account Software Investment

## 3.1 Number of Software Professionals

In order to estimate own-account software investment in Japan in terms of the methodology in section 2.2, we start with the estimation for the number of software professionals (ISCO-213).

Table 2 represents the share of software professionals, which is defined by JSCO-06, to total workers in Japan. The right three columns on the table are limited to employee and the left three columns are based on employment, which is defined by the total of employee, self-employed, and unpaid family workers. The data for Japan is based on the Population Census in each benchmark year. Although the Population Census has been conducted almost every five years since 1920, the occupation classification for the JSCO-06 has been separated only since the 1970 survey. Here, we examine the data in 1970, 75, 80, 85, 90, 95, and 2000.

In 1970, the share of employees engaged as software professionals to total employees is 0.13 percent; 0.18 percent for male and 0.04 percent for female[*7]. The share gradually increases and reaches to 1.13 percent in 1990. In the 1990s, the Japanese economy was in a long depression, which was the so-called

[*6] Although the best point estimate of the share of time spent on investment is 62 percent in Boehm's report, the BEA uses a 50 percent share to emphasize the approximate nature of the estimate (Parker-Grimm[2000]). Lequiller-Ahmad-Varjonen-Cave-Ahn[2003] reports Canada, France, and Italy also use this 50 percent deduction rule.

[*7] In the 1970 Population Census, the data in Okinawa prefecture, which was restored to Japan in 1972, is excluded.

Table. 2 Share of Software Professionals to Total Workers in Japan

| | Employment | | | Employee | | |
|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female |
| 1970 | 0.09 | 0.13 | 0.02 | 0.13 | 0.18 | 0.04 |
| 1975 | 0.15 | 0.22 | 0.04 | 0.22 | 0.29 | 0.06 |
| 1980 | 0.23 | 0.34 | 0.05 | 0.32 | 0.44 | 0.08 |
| 1985 | 0.55 | 0.77 | 0.20 | 0.72 | 0.96 | 0.29 |
| 1990 | 0.91 | 1.26 | 0.37 | 1.13 | 1.52 | 0.48 |
| 1995 | 0.94 | 1.35 | 0.32 | 1.13 | 1.59 | 0.40 |
| 2000 | 1.23 | 1.80 | 0.41 | 1.43 | 2.07 | 0.49 |

unit: percent. Software Professionals is defined by the JSCO-06 in Table 1.

"lost decade". Since households have confronted the decreases of household income during the lost decade, many females, who had not worked or worked as unpaid-family workers, were compelled to enter labor markets to compensate for the decrease of total household income. During 1990-95, the growth rate of total female employees is 2.0 percent, which is twice as fast as the growth rate of male employees. In the same period, female software professionals decreases annually by 1.8 percent, although males increase by 2.0 percent. So the share of software professionals increases for males and decreases for females. This contrastive movement may be related to the difference of labor quality between males and females. In 1995, the wage rate for female system engineers is 20.0 percent lower than that for males, based on the Basic Survey on Wage Structure published by MHLW (Ministry of Health, Labour and Welfare, Japan) as described in section 3.3.3. In this paper, we apply different wages for males and females to measure own-account software in section 3.3.

During 1995-2000, the expansion of software professionals is outstanding. The growth rates of employees of software professionals are 4.8 percent for males and 4.6 percent for females. In the same period, total male employees decrease by 0.4 percent and females increase by 0.8 percent, annually. The share of software professionals increases to 1.43 percent in 2000.

The international comparison of shares of software professionals to total employees is in Table 3. Here, the U.S. share is computed by the Occupational Employment and Wages (BLS), 2000. The data in the other OECD countries but the U.S. and Japan is excerpted from Ahmad[2003].

From the view of point of international comparison of software professionals, we should note the differences in the definition of occupational classification among countries. Ahmad[2003] points out that the employees in ISCO-213 in the United Kingdom is overestimated because no employees are recorded within ISCO-312. As described in section 2.2, the Population Census in Japan uses JSCO. Here, we substitute JSCO-06 for software professionals (ISCO-213) and JSCO-31 for software associated professionals (ISCO-312). In Japan, the share of ISCO-213 to the total of ISCO-213 and ISCO-312 is 67.4 percent. This value is less than that in Sweden-1999 and almost similar to the share in France-1998. We can conclude there is no significant difference between the occupational definition for software professionals in Japan and that in other OECD counties.

Keeping the inconsistency on the U.K. in mind, the share of software professionals in Japan is the

Table. 3 International Comparison of Software Professionals

| | Year | a.Share | b.ISCO-213 | c.ISCO-312 | d.b/(b+c) |
|---|---|---|---|---|---|
| Italy | 1998 | 0.0 | 13196 | 13868 | 48.8 |
| Greece | 1998 | 0.2 | 7444 | 7196 | 50.8 |
| Spain | 1996 | 0.3 | 44026 | 34107 | 56.3 |
| Denmark | 1997 | 0.4 | | | |
| France | 1998 | 0.4 | 196705 | 99011 | 66.5 |
| Australia | 1998/99 | 0.7 | | | |
| Finland | 1995 | 0.8 | 18967 | | |
| Netherlands | 1998 | 0.9 | 100765 | 82144 | 55.1 |
| Canada | 1998 | 1.0 | | | |
| United States | 2000 | 1.3 | 1633280 | | |
| Sweden | 1999 | 1.3 | 75881 | 24474 | 75.6 |
| Japan | 2000 | 1.4 | 753493 | 363753 | 67.4 |
| (United Kingdom)*) | 1999 | 1.8 | 473915 | 0 | 100.0 |

a.Share is ISCO-213 to total employees (unit:percent). Countries sorted by the share.

b. and c. is number of employees. d. is share of ISCO-213 (unit:percent).

U.S. is by Occupational Employment and Wages (BLS), 2000. (SOC-26-1020,30,50 for ISIC-213)

Japan is by Population Census (MIC), 2000. (JSIC-06 for ISIC-213)

Countries but the U.S. and Japan are from Ahmad[2003].

*)UK's number probably includes the number of workers on ISCO-312.

highest level in the world, reflecting the difference of industrial structures among countries. The number of employees as software professionals is 753 thousand in Japan, which is the second biggest in scale.

Figure 2 represents The Japanese industrial distribution of employee and employment of software professionals in 2000.*8 In the Population Census, the industry classification is defined based on the establishment, to which workers belong. So, industry categories might give some information to identify the sorts of produced software, in which software professionals are engaged.

In 2000, 60.3 percent of software professionals work in software industry. Also, 6.9 percent belong to the information service industry. In the above two industries, the software professionals (67.2 percent) are engaged in the production of software originals and reproduction of the originals. Software professionals in industries except information services and software (32.8 percent) are unlikely to be engaged in custom software production. Software professionals in government can be interpreted to be engaged only in own-account software, by definition.

The share of software professionals in software and information service industries has a clear upward trend. In comparison with 67.2 percent in 2000, in 1995 software professionals in the two industries

*8 Here, we aggregate the original 217 industries in Population Census to 46 Industries and not elsewhere classified. The total number of employee by industry is the same as the number in Table 3. We can neglect the consistency problem between own-account and mineral exploration, which is capitalized as one of intangible assets in the Japanese official national accounts based on SNA93 recommendation, since software professionals in mining industry are very small in Japan.

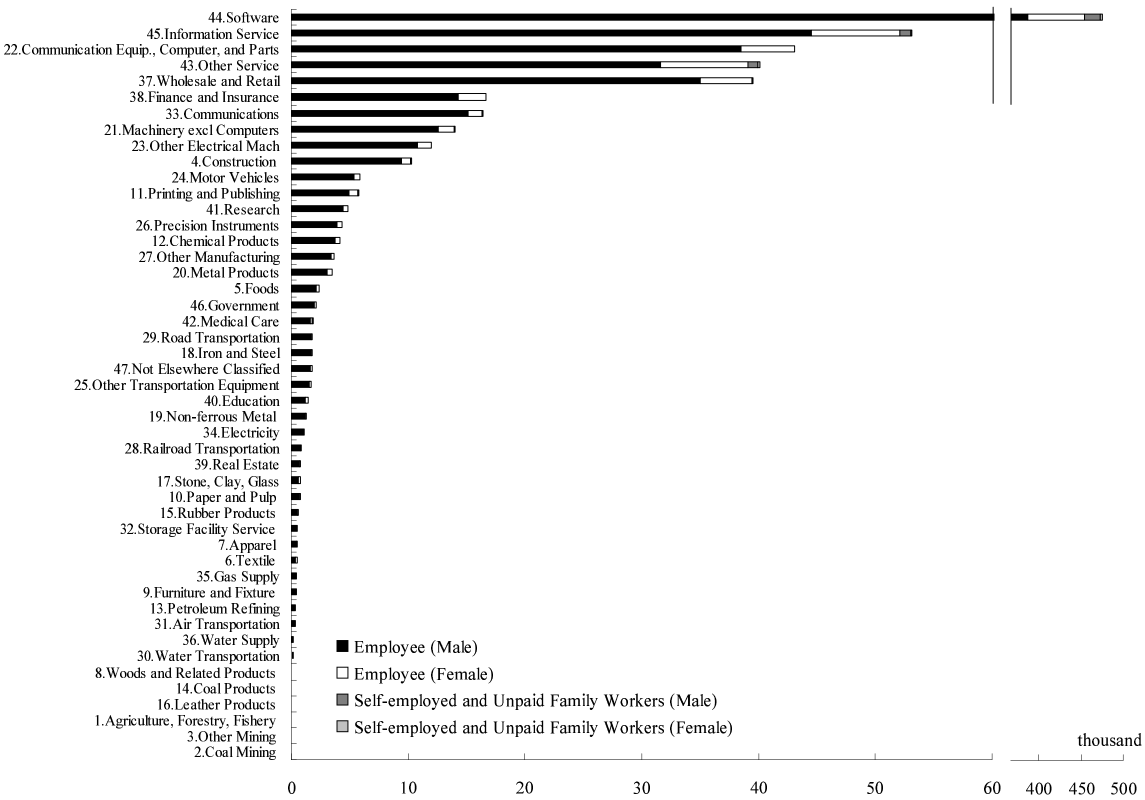



Figure. 2 Software Professionals by Industry in 2000

make up 62.0 percent in 1995, 58.9 percent in 1990, 35.6 percent in 1980, and less than 20 percent in 1970.*9 This trend should be taken into consideration in estimating the number of software professionals.

## 3.2 Aggregate Estimates Based on the OECD Task Force Methodology

As the first approach in this paper, we estimate own-account software investment using the internationally harmonized methodology proposed by the OECD Task Force at the aggregated level. Ahmad[2003] derives the harmonized estimates of own-account software investment for several OECD countries except Japan.

Ahmad's harmonized estimation at the aggregate level is based on two basic assumptions. The first assumption is that 50 percent of the labor cost for software professionals is spent doing tasks associated with new investment of own-account software. In other words, the 50 percent deduction rule has two roles: to exclude workers linked to custom software and reproduction software to be sold and to exclude working time linked to other activities. The second assumption is that the ratio of non-labor costs over

*9 In the Japanese Population Census, the exact comparison for software and information service industries is difficult, since the industry classifications are not fully disaggregated before 1990. Here, the shares for the benchmark years (except 1995 and 2000) are the maximum estimates. We can extract the clear upward trend, nevertheless.

labor cost is fixed at 1.017, which is the ratio in 1992 in the U.S.

Table. 4 Own-Account Software Investment by Harmonized Methodology of the OECD Task Force

| | | | | | Own-Account Software Investment | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | ISCO-213 | Wage | LC | Harmonized Estimates | | | Official | |
| Australia | 1998/99 | 76976 | 34273 | 1319 | 2661 | (4200) | [0.7] | (2831) | [0.5] |
| Canada | 1998 | 201700 | 29876 | 3013 | 6077 | (8937) | [1.0] | (3372) | [0.4] |
| Sweden | 1999 | 75881 | 40631 | 1542 | 3109 | (25472) | [1.3] | (10449) | [0.5] |
| U.S. | 1992 | 1175000 | 48000 | 27962 | 56400 | (56400) | [0.9] | (34600) | [0.6] |
| | 2000 | 1633280 | 64785 | 52906 | 106712 | (106712) | [1.09] | (72100) | [0.73] |
| Japan | 1980 | 128967 | 16862 | 1087 | 2193 | (497) | [0.21] | n.a. | |
| | 1985 | 317423 | 18052 | 2865 | 5779 | (1378) | [0.42] | n.a. | |
| | 1990 | 551650 | 32680 | 9013 | 18180 | (2633) | [0.59] | n.a. | |
| | 1995 | 593019 | 56952 | 16887 | 34061 | (3204) | [0.64] | n.a. | |
| | 2000 | 753493 | 55194 | 20794 | 33008 | (4520) | [0.87] | n.a. | |

ISCO-213 shows the number of total software professionals. Wage shows average annual wage evaluated in the U.S. dollor. LC (Laor Cost) and harmonized estimates are defined by million dollar and estimates evaluated by national currency are in ( ). The percentage of estimates over nominal GDP in [ ]. Official shows the values in the published national accounts by national currency in ( ).
Australia, Canada, Sweden, and the U.S.(1992) are the harmonized estimates by Ahmad[2003].

Based on the two basic assumptions, we estimate own-account software in 2000 in the U.S., and in benchmark years in Japan. Table 4 shows the harmonized estimates if the OECD Task Force recommendations are applied. The Japanese own-account software is 4.52 trillion yen in 2000. This value is 39.3 percent of that in the U.S. In the total number of software professionals, the number in Japan is 46.1 percent of that in the U.S. Because of the wage gap between the U.S. and Japan, however, the gap of own-account software investment expands in nominal value.

The share of own-account software over official GDP in 2000 in Japan is 0.87 percent.[*10] In table 4, we excerpt the harmonized estimates for Australia(1998/99), Canada(1998), Sweden (1999), and the U.S.(1992) from Ahmad[2003]. In comparison with other countries, the share of own-account software investment in Japan is a little smaller than that in Canada.

Ahmad[2003] discusses that the harmonized estimates are significantly higher than the official value of own-account software in each country. In Canada (1998) and Sweden (1999), the official investment in their national accounts is less than half of the harmonized estimates. In the U.S., the official investment of own-account software investment is 38.7 percent lower than the OECD-harmonized estimates in 1992. Also in 2000, the BEA's estimate is 32.4 percent lower than the harmonized estimate. This may be why the harmonized methodology abandons the industry category in order to reconcile differences of data availability among countries.

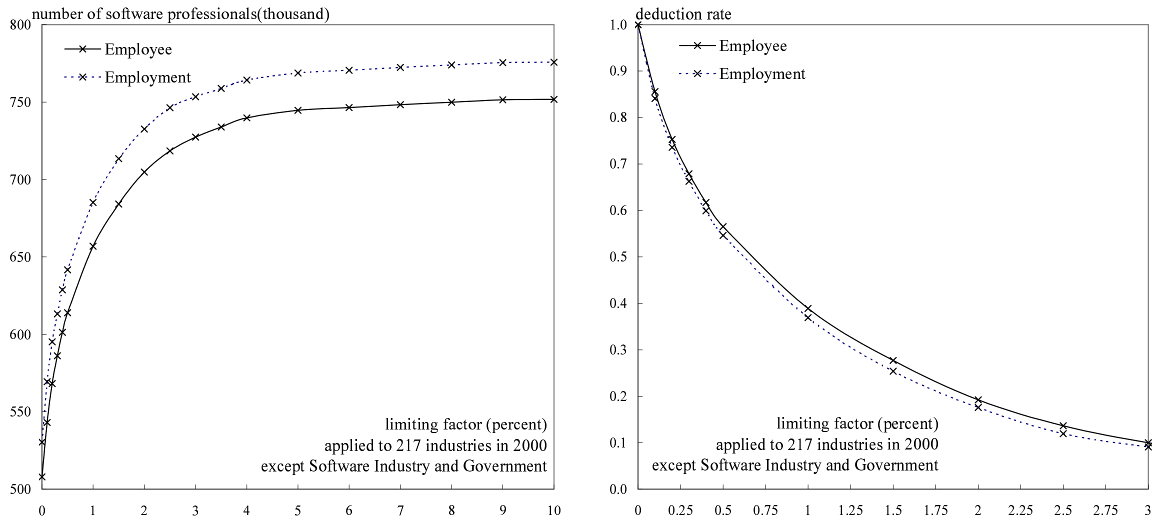
[*10] Here, we define GDP as official GDP + own-account software investment (our estimates) + prepackaged software investment (our estimates), since Japanese official GDP excludes these categories.

## 3.3 Measurement by Industry

### 3.3.1 Software Professionals in Non-Software Industries

The harmonized methodology in the previous section does not use the information of industrial distribution of software professionals. Next, as the second approach in this paper, we examine the application of the BEA's methodology.

The workers defined as software professionals in Table 3 are engaged in the production not only of own-account software, but also of custom and reproduction software to be sold. As described in section 2.2, we should exclude workers linked to custom and reproduction software to be sold. Here, we split this adjustment process into two procedures. The first procedure is the adjustment for non-software industries and the second is the adjustment for software industry.




(a) Number of Software Professionals

(b) Deduction Rate

Figure. 3 Limiting Factor for Non-Software Industry and Number of Software Professionals

Figure 3 shows the impact on the adjusted number of own-account software professionals and the deduction rate, applying limiting factors to every non-software industry. The BEA sets 0.2 percent of total employment as a maximum share of employment of software professionals in each three digit-SIC-level industry (Grimm-Moulton-Wasshausen[2003]). Here, we examine limiting factors to 217 industries in 2000 in Japan. The exceptional industries are the software industry, for which the 0.2 percent limiting factor is too restrictive, and government, which has no employment of software professionals engaged in the production of custom and reproduction software to be sold, by definition[*11]. The scale of the horizontal axis of Figure 3(a) indicates limiting factors defined by percentages. The vertical axis indicates

[*11] Here, the software industry is defined as "computer programming and other software services" and "data processing and research information services". In the Population Census 2000, the share of software professionals to total employees

the total number of software professionals adjusted by limiting factors in each industry. If the limiting factor is zero, software professionals in all non-software industries are assumed to be engaged only in the production of own-account software. The intercept on the vertical axis means the number of software professionals in software industry and government.

If we apply the BEA's 0.2 percent rule for each non-software industry, 183.5 thousand software professionals should be deducted in total. The total deduction rate is 75.4 percent in non-software industries, as shown in Figure 3(b). Table 5 represents the adjusted numbers and the deduction rates of software professionals by industry in 2000, when the limiting factors are 0.1 percent, 0.2 percent, 1.0 percent, and 2.0 percent. In the case of applying the 0.2 percent limiting factor, 96.1 percent of software professionals in the communication industry are deducted. Also, for manufacture of communication equipment, computer, and peripheral equipment, 93.6 percent are deducted. The deduction rates for the two industries, which represent IT users and IT producers, respectively, seems too large.

In all of the non-software industries, the share of software professionals to total employee is 0.5 percent (0.7 percent for males and 0.1 percent for females) in 2000. The 0.2 percent rule used by the BEA seems too restrictive to apply to the Japanese occupational structure by industry. In the case of the 2.0 percent limiting factor, 46.9 thousand employees are deducted and the deduction rate is 19.3 percent in total. The deduction rate in communication industry is 68.4 percent and that in manufacture of communication equipment, computer, and peripheral equipment is 48.3 percent, as described in Table 5. Even in this case, the impact to some IT-related industries may be too large.

Examining the make-table, which describes product-mix by industry, non-software industries produce only 2.5 percent of the total output of software and information services in 2000.[*12] Software professionals in non-software industries are unlikely to be engaged in custom software production. Prepackaged software produced by non-software industries may be included in this 2.5 percent at the make-table. Although software professionals for the reproduction of prepackaged software must be excluded here, the production cost of originals for prepackaged software should be capitalized as own-account software. Here, we assume that the cost for reproductions is negligible and that all software professionals linked to prepackaged software are engaged in the production of the originals to be reproduced. In this paper, we account all software professionals in non-software industries to be engaged in the production of own-account software, as originals to be reproduced or to be used in other production.

### 3.3.2 Software Professionals in Software Industry

The second procedure is the adjustment of the number of workers in the software industry. Software professionals in the software industry are engaged in the production of own-account software, custom software, and prepackaged software. For the adjustment of reproduction of prepackaged software, we assume all software professionals linked to prepackaged software are engaged in the production of the

is 68.4 percent in computer programming and other software services and 26.2 percent in data processing and research information services. Although we examine employee and employment in Figure 3, software professionals as self-employed and unpaid-family workers are excluded from our measurement because of difficulties in applying the 50 percent deduction rule for adjusting working time.

[*12] The make matrix is one of supplementary tables of benchmark input-output table published by Ministry of Internal Affairs and Communications (MIC), Japan.

Table. 5 Software Professionals in Non-Software Industry and Limiting Factors

| | Original | 2.0% | | 1.0% | | 0.2% | | 0.1% | |
|---|---|---|---|---|---|---|---|---|---|
| 1.Agriculture, Forestry, Fishery | 31 | 31 | (0.0) | 31 | (0.0) | 31 | (0.0) | 31 | (0.0) |
| 2.Coal Mining | 3 | 3 | (0.0) | 3 | (0.0) | 3 | (0.0) | 3 | (8.6) |
| 3.Other Mining | 10 | 10 | (0.0) | 8 | (15.4) | 2 | (83.1) | 1 | (91.5) |
| 4.Construction | 10170 | 10170 | (0.0) | 10170 | (0.0) | 9560 | (6.0) | 5133 | (49.5) |
| 5.Foods | 2409 | 2409 | (0.0) | 2409 | (0.0) | 1427 | (40.8) | 837 | (65.2) |
| 6.Textile | 468 | 468 | (0.0) | 468 | (0.0) | 311 | (33.5) | 193 | (58.8) |
| 7.Apparel | 526 | 526 | (0.0) | 526 | (0.0) | 298 | (43.3) | 176 | (66.5) |
| 8.Woods and Related Products | 119 | 119 | (0.0) | 119 | (0.0) | 116 | (2.1) | 84 | (29.2) |
| 9.Furniture and Fixture | 422 | 422 | (0.0) | 422 | (0.0) | 247 | (41.5) | 135 | (68.0) |
| 10.Paper and Pulp | 745 | 745 | (0.0) | 745 | (0.0) | 413 | (44.5) | 244 | (67.3) |
| 11.Printing and Publishing | 5735 | 5661 | (1.3) | 4607 | (19.7) | 1359 | (76.3) | 685 | (88.0) |
| 12.Chemical Products | 4147 | 4147 | (0.0) | 3822 | (7.8) | 1048 | (74.7) | 536 | (87.1) |
| 13.Petroleum Refining | 332 | 332 | (0.0) | 211 | (36.6) | 42 | (87.2) | 21 | (93.6) |
| 14.Coal Products | 72 | 72 | (0.0) | 72 | (0.0) | 19 | (73.4) | 10 | (86.7) |
| 15.Rubber Products | 595 | 595 | (0.0) | 595 | (0.0) | 302 | (49.2) | 153 | (74.3) |
| 16.Leather Products | 36 | 36 | (0.0) | 36 | (0.0) | 36 | (0.0) | 29 | (20.3) |
| 17.Stone, Clay, Glass | 768 | 768 | (0.0) | 768 | (0.0) | 493 | (35.8) | 345 | (55.0) |
| 18.Iron and Steel | 1767 | 1767 | (0.0) | 1767 | (0.0) | 536 | (69.7) | 268 | (84.8) |
| 19.Non-ferrous Metal | 1273 | 1273 | (0.0) | 1273 | (0.0) | 326 | (74.4) | 176 | (86.2) |
| 20.Metal Products | 3468 | 3468 | (0.0) | 3468 | (0.0) | 1864 | (46.3) | 957 | (72.4) |
| 21.Machinery excl Computers | 13962 | 13952 | (0.1) | 10000 | (28.4) | 2200 | (84.2) | 1100 | (92.1) |
| 22.Comm. Eq., Computer, and Parts | 43067 | 22270 | (48.3) | 13414 | (68.9) | 2766 | (93.6) | 1383 | (96.8) |
| 23.Other Electrical Mach | 11962 | 8619 | (27.9) | 5171 | (56.8) | 1273 | (89.4) | 637 | (94.7) |
| 24.Motor Vehicles | 5868 | 5868 | (0.0) | 5868 | (0.0) | 1677 | (71.4) | 839 | (85.7) |
| 25.Other Transportation Equipment | 1667 | 1578 | (5.3) | 1205 | (27.7) | 331 | (80.2) | 165 | (90.1) |
| 26.Precision Instruments | 4335 | 3908 | (9.8) | 2149 | (50.4) | 548 | (87.4) | 274 | (93.7) |
| 27.Other Manufacturing | 3666 | 3521 | (4.0) | 3285 | (10.4) | 1219 | (66.7) | 682 | (81.4) |
| 28.Railroad Transportation | 818 | 818 | (0.0) | 818 | (0.0) | 531 | (35.1) | 265 | (67.5) |
| 29.Road Transportation | 1811 | 1811 | (0.0) | 1811 | (0.0) | 1811 | (0.0) | 1571 | (13.3) |
| 30.Water Transportation | 134 | 134 | (0.0) | 134 | (0.0) | 134 | (0.0) | 80 | (40.0) |
| 31.Air Transportation | 309 | 309 | (0.0) | 309 | (0.0) | 65 | (79.1) | 32 | (89.5) |
| 32.Storage Facility Service | 540 | 540 | (0.0) | 540 | (0.0) | 230 | (57.3) | 128 | (76.3) |
| 33.Communications | 16300 | 5158 | (68.4) | 2915 | (82.1) | 640 | (96.1) | 324 | (98.0) |
| 34.Electricity | 1144 | 1144 | (0.0) | 1144 | (0.0) | 308 | (73.1) | 154 | (86.5) |
| 35.Gas Supply | 441 | 441 | (0.0) | 416 | (5.6) | 102 | (76.9) | 51 | (88.4) |
| 36.Water Supply | 200 | 200 | (0.0) | 200 | (0.0) | 200 | (0.0) | 129 | (35.3) |
| 37.Wholesale and Retail | 39404 | 33222 | (15.7) | 24877 | (36.9) | 10661 | (72.9) | 6675 | (83.1) |
| 38.Finance and Insurance | 16650 | 16649 | (0.0) | 10355 | (37.8) | 3154 | (81.1) | 1681 | (89.9) |
| 39.Real Estate | 800 | 800 | (0.0) | 800 | (0.0) | 797 | (0.4) | 462 | (42.2) |
| 40.Education | 1451 | 1451 | (0.0) | 1451 | (0.0) | 1451 | (0.0) | 1320 | (9.0) |
| 41.Research | 4835 | 4089 | (15.4) | 2266 | (53.1) | 501 | (89.6) | 251 | (94.8) |
| 42.Medical Care | 1797 | 1797 | (0.0) | 1797 | (0.0) | 1226 | (31.8) | 776 | (56.8) |
| 43.Other Service | 39256 | 35332 | (10.0) | 26225 | (33.2) | 9728 | (75.2) | 5840 | (85.1) |
| Total | 243513 | 196634 | (19.3) | 148670 | (38.9) | 59986 | (75.4) | 34835 | (85.7) |

Unit: number of software professionals in non-software industries in 2000 (only employee). Deduction rates by limiting factors are in ( ).
Software industry, government, and not elsewhere classified (nec) are excluded in this table.
Industry classification is aggregated from 217 industries, to which limiting factors are applied.

originals to be reproduced, as described in section 3.3.1. By this assumption, all software professionals in software industry are engaged in the production of originals to be reproduced, to be sold, or to be used in other production. We have to exclude the number of software professionals engaged in the production of originals to be sold, since it is already capitalized as custom software of the purchasers.

As described in the first footnote in section 1, the Japanese benchmark 2000 input-output table does not capitalize own-account software. The costs for producing own-account software are internally described as intermediate consumption, labor costs, operating surplus, and so on, in each industry. In the software industry, output is defined by prepackaged software and custom software, although the inputs may include the costs for developing own-account software. In the benchmark 2000 input-output table, the output share of custom software is 67.4 percent.[*13] Here, we consider the 67.4 percent of the number of software professionals to be engaged in the production of custom software in 2000.

In order to estimate software professionals engaged in the production of originals to be own-used in software industry, we apply 0.7 percent for males and 0.1 percent for females, as shares to total employees in 2000. These rates are the shares of software professionals over total employees in total non-software industries.[*14] Although the number to be added is small by this adjustment, almost two thirds (66.4 percent) of software professionals in software industry are deducted in 2000.

As a result, the total estimated number of software professionals for own-account software at the aggregate level is 416 thousand (362 thousand males and 53 thousand females) in 2000. It means the net deduction rate of total software professionals is 44.8 percent. As mentioned in section 3, the share of software professionals in the software industry has a clear upward trend. Because of this upward trend and the changes of the above deduction rates, the net deduction rates in total software professionals are 42.8 percent in 1990, 24.2 percent in 1980, 11.1 percent in 1970, respectively. The difference between the adjusted total number of software professionals estimated using the modified BEA's methodology in this section and the harmonized estimates by the OECD Task Force in section 3.2 tends to expand.

#### 3.3.3 Labor and Non-Labor Costs

In order to exclude working time spent on minor revisions and maintenance of own-account software, we use BEA's 50 percent deduction rule, which is also recommended by the OECD Task Force as an upper limit. Based on the average wage of programmers and system engineers by the Basic Survey on Wage Structure (MHLW, Japan), we estimate labor costs for the production of own-account software by industry. Average wages are defined as annual wages per worker for males and females, respectively.[*15]

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[*13] In the Survey of Selected Service Industries (SSSI) for information service industry by METI (Ministry of Economy, Trade and Industry, Japan), the production share of custom software in the software industry is 85.2 percent in 2000. The production of prepackaged software for business use and games in SSSI are almost same as the benchmark 2000 IO. The gap was mainly from the production of other software, which should be interpreted as the difference of coverage of both statistics.

[*14] In 1995, 0.62 percent for males and 0.14 percent for females. This shares increase from 0.15 percent for males and 0.03 percent for females in 1970.

[*15] We use the same average wages by sex for each industry. The average wage for females is 11.6 percent lower than the wage for males as programmers and also 20.0 percent lower as system engineers in 2000. For males, wages for system engineers are 39.2 percent higher than the wage for programmers and 25.9 percent higher for females in 2000, as well. Here, we compute average wages in two occupations by sex, using the number of the workers as weights in the benchmark year and

To add social contributions and some allowances, which companies do not directly pay to employees but bears, we compute the expansion rates for wages in information service industry based on benchmark input-output tables. The expansion rates increase from 7.5 percent in the 1960s to 14.6 percent in 2000.

The ratios of non-labor cost over labor cost are computed from the benchmark input-output tables. The ratio in 2000 is 1.508 and the ratios are almost stable within a range of 1.4-1.6 during 1960-2000. Lequiller-Ahmad-Varjonen-Cave-Ahn[2003] reports the ratios are 0.460 in Canada (1995), 1.498 in Denmark (1997), 0.885 in Finland(1995), 0.604 in Italy (1998), 0.995 in Sweden (1999), and 1.017 in the U.S. (1992). In comparison with other OECD counties, the ratio in Japan is at the highest level. At the nominal value, the higher non-labor cost in Japan should be reasonable, reflecting the differences of relative prices among countries. Nomura-Samuels[2003] describes the relative price for labor per worker is 1.120 and the relative price for GDP is 1.443 between the U.S. and Japan in 2000.[*16] The GDP price relative to labor costs per worker is 32.3 percentage point higher in Japan in comparison with the U.S.[*17]

# 4 Impacts of Own-Account Software Investment

## 4.1 Comparison with Other Estimates in Japan

In the previous section, we estimate own-account software investment by industry in Japan. Figure 4 shows the estimated total investment for own-account software based on the modified BEA's methodology and the comparison with the harmonized estimates by the OECD Task Force methodology in section 3.2.[*18]

In 2000, the estimated results here is 3107 billion yen, which is 31.3 percent lower than the harmonized estimate. Although we modified the BEA's methodology, the gap of the two estimates is very close to that in the U.S. As shown in Table 4, the BEA's official estimate is 32.4 percent lower than the harmonized estimate in 2000.[*19]

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the growth rate of the Theil–Törnqvist wage index.

[*16] Relative prices are defined by the purchasing power parities (PPPs) over the exchange rate. If the PPP for a particular input is smaller than exchange rate, the relative price is less than one. In Nomura-Samuels[2003], the PPP for labor input is computed from the cross-classified data, which has 1260 categories, by sex, age, education, class of worker, and industry between the U.S. and Japan.

[*17] Our estimates by industry have to be consistently described in our time-series input-output table. The description of the IO table for capitalization of own-account software is discussed in Appendix.

[*18] Before 1970, we estimate benchmark values by sex every five years during 1955-1970 based on the number of professional and technical employees, because the number of workers classified into JSCO-06 is not separated in the Population Census. In interval periods between benchmark years, we interpolate the total number of software professionals by sex using the number of workers for programmers and system analysts from the Basic Survey on Wage Structure (MHLW, Japan) at the aggregate level. The interpolated number of software professionals by sex is distributed to industries based on the tentative industry share, which is interpolated values using the benchmark value in each benchmark year and the growth rates of employees by sex by industry in the interval periods.

[*19] Here, the ratios of non-labor cost over labor-cost in Japan are higher than that used for the harmonized estimates. As described in section 3.3.2, the total deduction rate in total software professionals has upward trend, from 11.1 percent in 1970 to 44.8 percent in 2000. In 1980, the estimates based on the two methodology are very close, as shown in Figure 4.

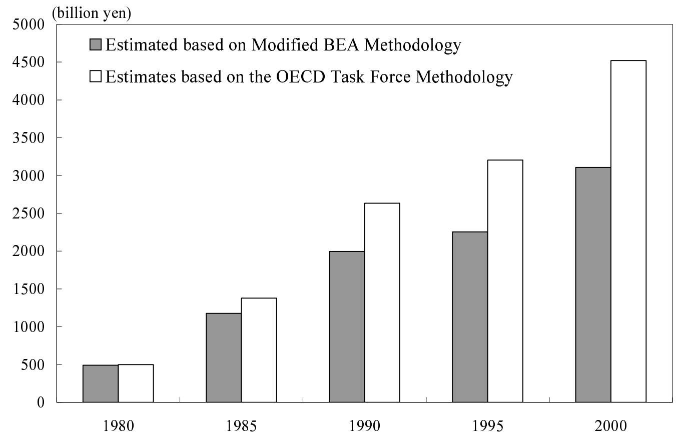



Figure. 4 Own-Account Software Investment in Japan: Comparison of Two Estimates

Table 6 and Figure 5 show our estimated results by type of software, compared to the other Japanese estimates, Miyagawa[2003] and Motohashi[2002], which estimate own-account software investment at the aggregate level.*20 For own-account software shown in the center figure in Figure 5, although our estimate is close to Motohashi's estimate in 1990, his estimate has a different trend in the early 1990s. In 2000, Motohashi's estimate is 13.5 percent lower than our estimate, which is close to Miyagawa's.

From the view of the point of methodology, own-account software estimates in Miyagawa and Motohashi exclude all software professionals in software industry, in order to avoid double-counting of investment in own-account software and prepackaged software. However, as clarified in section 2.1, software originals and reproduction must be conceptually distinguished. Software originals to be reproduced should be recorded as investment by the producers of the copies.

The estimates of custom software investment are very similar after the 1990s in particular, because we can make use of official estimates in the Japanese national accounts after 1980 and the 1985-90-95 linked input-output table. In 1980, the two estimates are about 40 percent lower than that in official national accounts. We set it to the same as the official estimates. For prepackaged software, we have to exclude the embedded software onto other products as GFCF. The trends of prepackaged software investment among three estimates look similar, although the levels in 2000 are different. Probably, Motohashi's estimate does not exclude the embedded software.

As total investment of software shown in Table 6, all of the three estimates in 2000 are almost 10 trillion yen, which is almost 2.0 percent of GDP in Japan. In the U.S., the average annual growth rates of total software investment in current values are 38.7 percent for 1959-79, 15.7 percent for 1979-92, and 12.3 percent for 1992-98 (Parker-Grimm[2000]). Growth rates in our estimates are respectively 29.8 percent,

*20 Our estimates of software investment during 1955-2000, except own-account software estimated in this paper, are described in Nomura[2004] (Chapter-A). Our estimates of custom software investment is set equal to the value in the Japanese official national accounts after 1980, until which the ESRI (Economic and Social Research Institute, Cabinet Office of Japan) estimates it backwardly. Also, prepackaged software investment in our estimates in 2000 is set to the same as that in benchmark 2000 IO table.

Table. 6 Software Investment in Japan: Comparison with Other Estimates

| | 1960 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|
| Custom Software | | | | | | | | |
| Miyagawa | – | 9692 | 44665 | 246392 | 1368067 | 2751524 | 3575611 | 6150076* |
| Motohashi | – | – | 54959 | 269102 | 1623896 | 3266059 | 3575611 | 6497791 |
| Nomura | 1075 | 26725 | 114245 | 430500 | 1292300 | 3390200 | 3561600 | 6698300 |
| Own-Account Software | | | | | | | | |
| Miyagawa | – | 35690 | 148268 | 323207 | 975185 | 2071658 | 2328775 | 3245550* |
| Motohashi | – | – | 188929 | 359649 | 1211011 | 1885213 | 1856936 | 2685696 |
| Nomura | 1600 | 62580 | 219646 | 481559 | 1156191 | 1877514 | 2267517 | 3106820 |
| Prepackaged Software | | | | | | | | |
| Miyagawa | – | 2793 | 10552 | 40890 | 172924 | 357371 | 272734 | 415195* |
| Motohashi | – | – | 12158 | 59432 | 376050 | 876394 | 702039 | 1303861 |
| Nomura | 134 | 3342 | 13883 | 48292 | 183251 | 449847 | 424381 | 649757 |
| Total Software | | | | | | | | |
| Miyagawa | – | 48175 | 203485 | 610489 | 2516176 | 5180553 | 6177120 | 9810821* |
| | | | (28.8) | (22.0) | (28.3) | (14.4) | (3.5) | (9.3) |
| Motohashi | – | – | 256046 | 688183 | 3210957 | 6027666 | 6134586 | 10487348 |
| | | | (–) | (19.8) | (30.8) | (12.6) | (0.4) | (10.7) |
| Nomura | 2809 | 92648 | 347774 | 960352 | 2631742 | 5717562 | 6253498 | 10454877 |
| | | (35.0) | (26.5) | (20.3) | (20.2) | (15.5) | (1.8) | (10.3) |

unit: million yen (nominal). Miyagwa[2003](* 1999 value is written in 2000, in this table.), Motohashi[2002].

Nomura's estimates in custom software is set equal to the official national accounts after 1980.

Nomura's estimates in prepackaged software is set equal to benchmark input-output table in 2000.

Average annual growth rates of nominal values during five years are written in ( ).

16.5 percent, 4.2 percent for the same periods. The growth rates and the diminishing trends are similar between the U.S. and Japan.

## 4.2 International Comparison

International comparison of shares of own-account software investment to official GDP is in Figure 6(a) and for total software investment to GDP is in Figure 6(b).*21 In Japan, the share of own-account software to the GDP, which is adjusted to include all software investment, is 0.60 percent in 2000. It is higher than that in the EU countries but Denmark. The U.S. has the highest share of own-account software (0.73 percent) among the countries. As for total software investment in Figure 6(b), Japan has 2.03 percent GDP attributed to software investment. It is slightly lower than that in the U.S. (2.07 percent). Although Sweden has the highest share in total software, we may take the difference of

*21 In Figure 6, each share in each country is computed, based on the official national accounts, although Japan is the exception. The share in the U.S.(2000) is from the BEA's National Income and Product Accounts (NIPA). The others are from Hermans[2002] for Belgium and from Ahmad[2003] for the other countries.

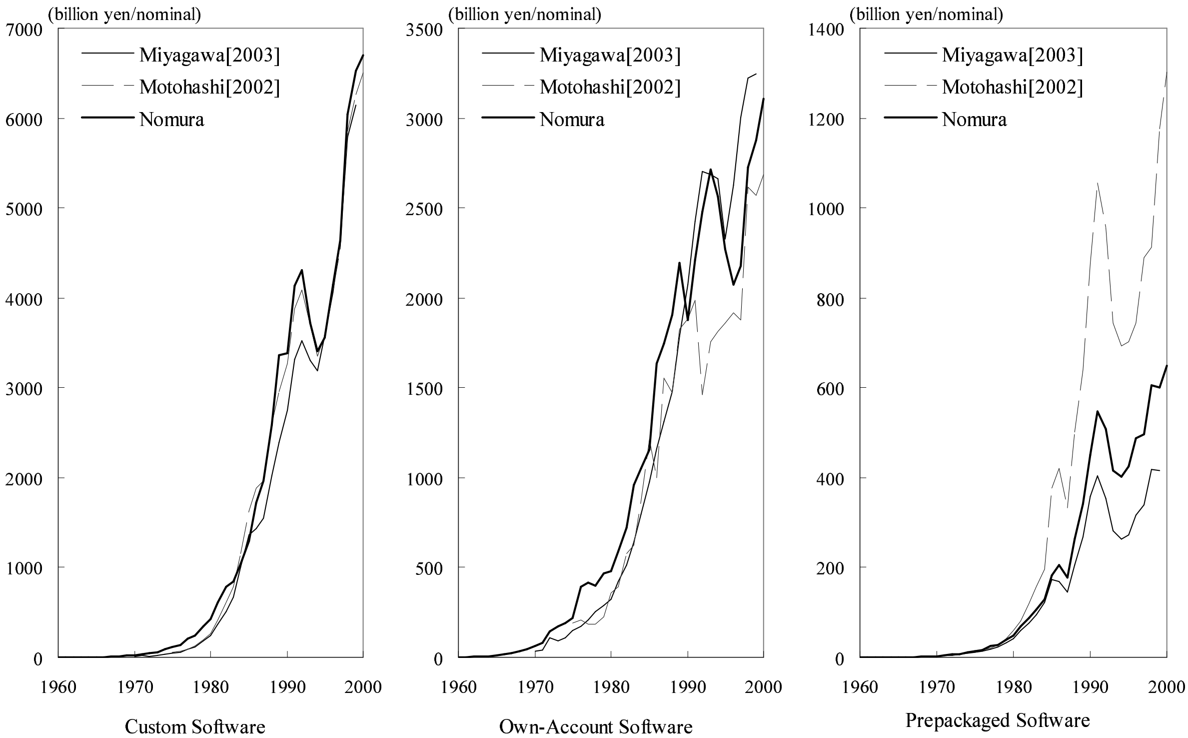


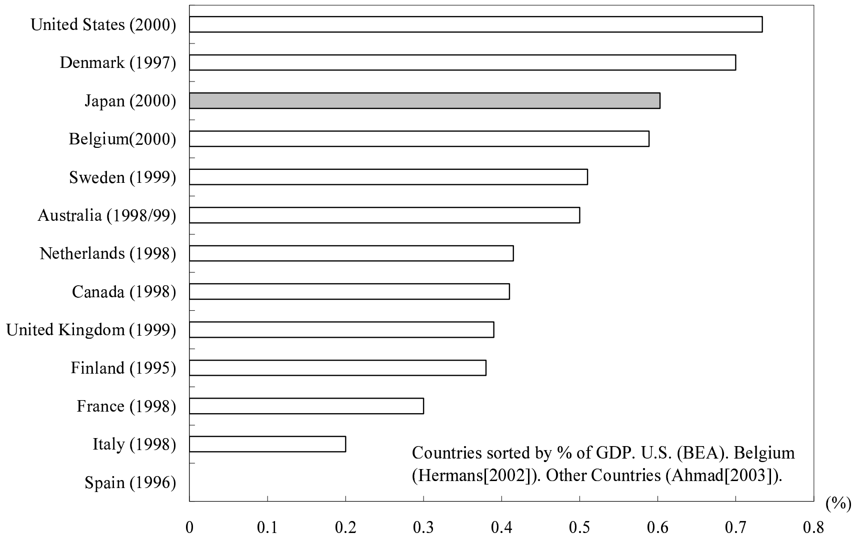

Figure. 5 Software Investment in Japan: Comparison with Other Estimates

economic scales into consideration. The relative scale of software investment between the U.S. and Japan may be appropriate.

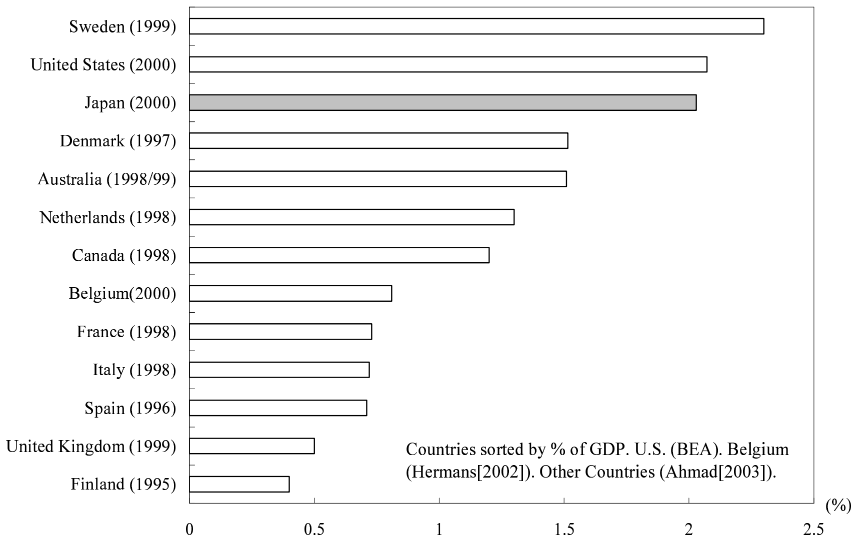
Figure 7 shows the long-term comparison on shares of software investment in GFCF between the U.S. and Japan.*22 In 2000, the share of own-account software investment in GFCF is 3.53 percent in the U.S. and 2.19 percent in Japan. As shown in Figure 7(a), although Japan's share is close to that in the U.S. in the middle of the 1980s, the gap of the shares expands in the 1990s. Also, Japan's share of total software investment to GFCF is 7.37 percent, which is smaller than that in the U.S. (9.97 percent). From the point of the view of GFCF, the gap between the two countries expands in comparison with the relative scale to GDP, reflecting the larger share of tangible assets investment in Japan.

Although the GDP-share of software investment is very close between the U.S. and Japan, the composition by type of software is significantly different. Figure 8 shows the changes of composition of software investment every five years from 1970 to 2000 in the U.S. and Japan. In 1970, own-account software has the largest share in software investment and prepackaged software is minor. We can indicate that the composition in both countries is very similar between the two countries in 1970.

*22 Software investment by type of software in the U.S. is based on Prices and Output for Information and Communication Technologies, which is one of the BEA's supplemental estimates, after 1997. Although this data is revised from the estimates by Parker-Grimm[2000], we extrapolate the values by type of software before 1996, using the growth rate of the estimates by Parker-Grimm. Japan's long-term GFCF is based on Nomura[2004]. In Figure 7, the GFCF is defined by all investments by private business and government in both countries.

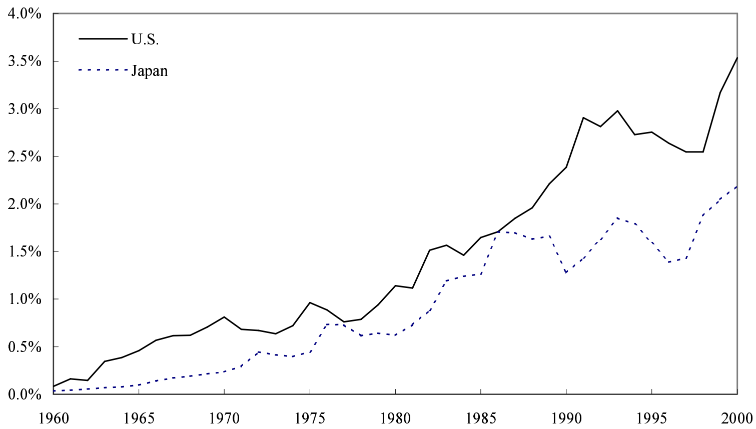



(a) Own-Account Software Investment

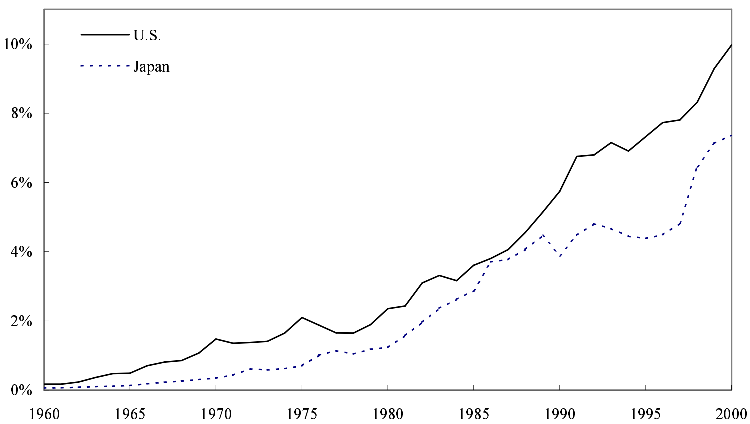



(b) Total Software Investment

Figure. 6 Share of Software Investment in GDP: International Comparison




(a) Own-Account Software Investment




(b) Total Software Investment

Figure. 7 Share of Software Investment in GFCF: the U.S. and Japan

The share of own-account software decreases in both countries through the 1970s and the 1980s. In the U.S., the diminution of the share of own-account software is reflected by the rapid expansion of prepackaged software. On the other hand, in Japan, the diminution is mainly reflected by the expansion of custom software. In 2000, custom software occupies the largest portion, the share of which is almost two thirds of the total software investment in Japan. The difference in the direction of outsourcing of software production in the U.S. and Japan may be partly interpreted as the difference of business custom, like the difference of the share of embedded software. Partly, the difference of the software market conditions in both countries may explain some of the difference, because some software in Japanese market is required to be compatible with the use of Japanese language.

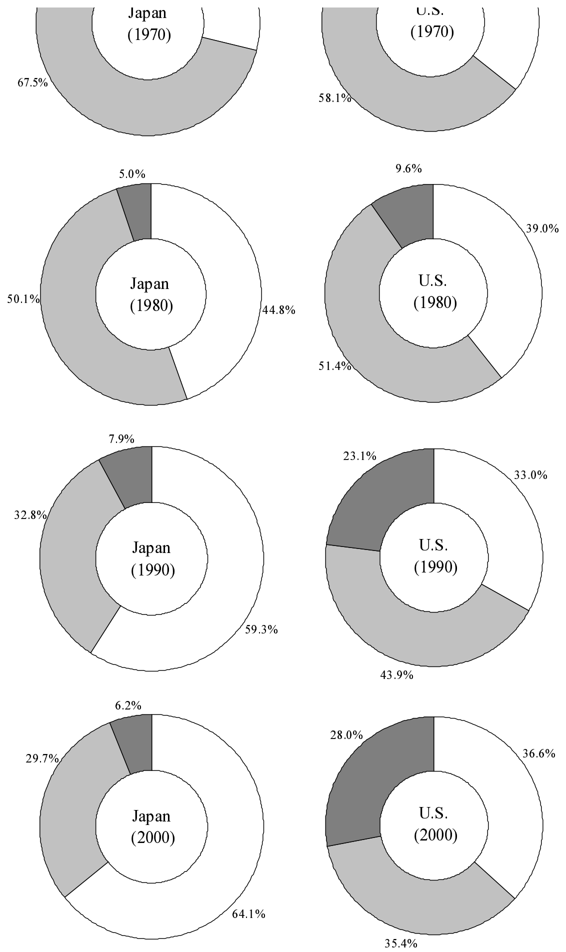



Figure. 8 Composition of Software Investment: Comparison between the U.S. and Japan

## 4.3 Software Investment by Industry

Figure 9 represents the long-term industry composition of own-account software investment for manufacture and electrical machinery industry, which has the biggest share within manufacture. Manufacture occupies 42.8 percent of own-account software investment on average in the 1960s. The share gradually decreases to 39.3 percent in 1970s, 34.9 percent in 1980s, and 30.7 percent in 1990s. In 2000, 74.0 percent of own-account software investment is by service sectors. The exception industry within manufacture is electric machinery, which holds 13-20 percent shares in these periods. Figure 10 shows the details of own-software investment by industry in 2000.[*23] Software industry has the largest investment in own-account software, as shown in Figure10. It produces 1.1 trillion yen in 2000, which is 36.4 percent of the total.

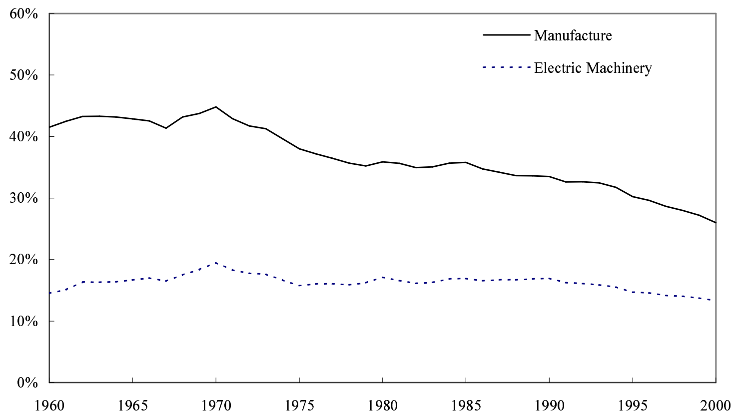



Figure. 9 Industry Share of Own-Account Software Investment in Japan

Figure 11-13 represent the shares of own-account software and software investment in GFCF by industry in 1970, 1990, and 2000 in Japan. In each figure, industries are sorted by the order of the own-account investment share. By capitalizing own-account software, there are large impacts on investments in IT producers, like communications equipment, computers, and electronic components, relatively. In 1970, the share of own-account software investment in GFCF by industry in Figure 11(a) is similar to the share of total software investment in Figure 11(b), since custom software and prepackaged software have a minor portion in 1970, as shown in Figure 8 at the aggregate level.

In 1990, we find a clear difference between Figure 12(a) and Figure 12(b) for finance and insurance. Although this industry is in the fourth highest position in terms of own-account software share in 1970, it descends to the seventh position in 1990, and twelfth position in 2000. Clearly, the finance and insurance industry moves from own-account software to custom-software, while it expands overall software investment during these periods.

[*23] In Figure 10, we define GFCF by industry excluding household residence and almost all of infrastructure, which are included as aggregate GFCF in Figure 7.

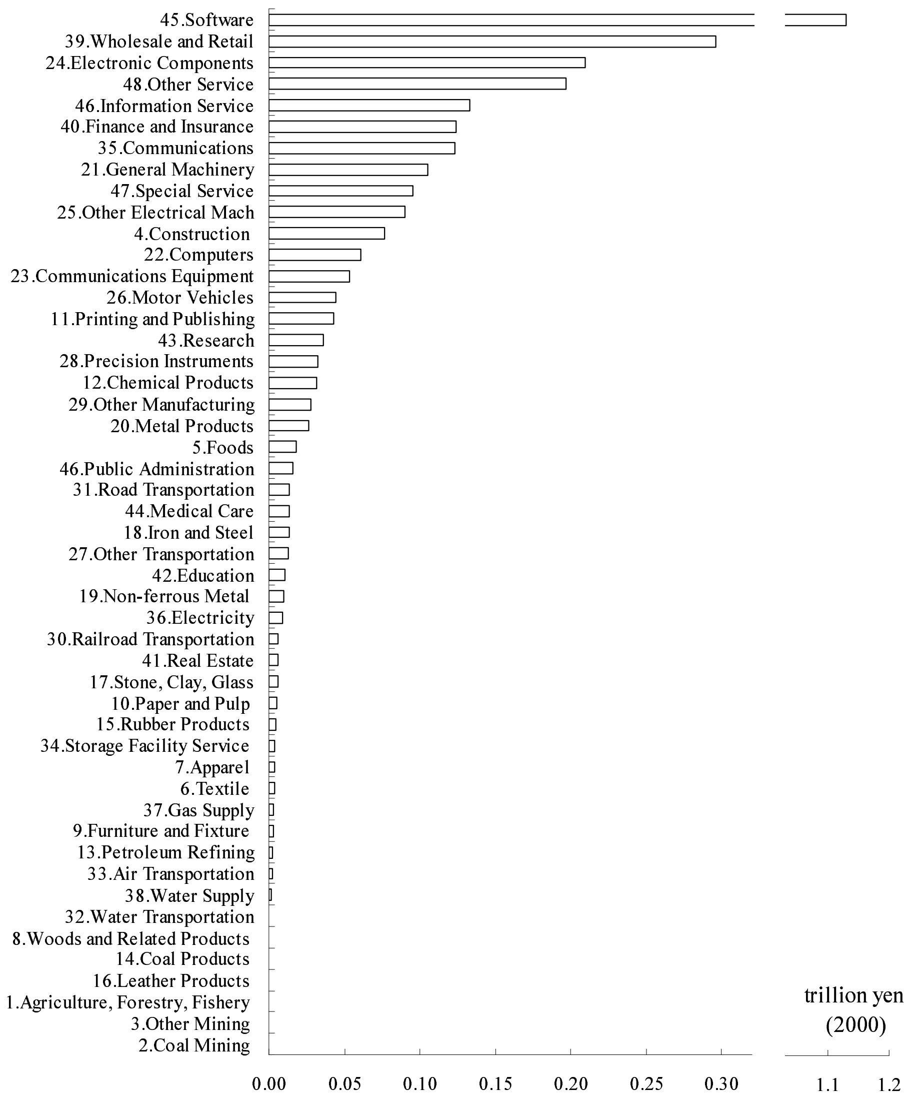
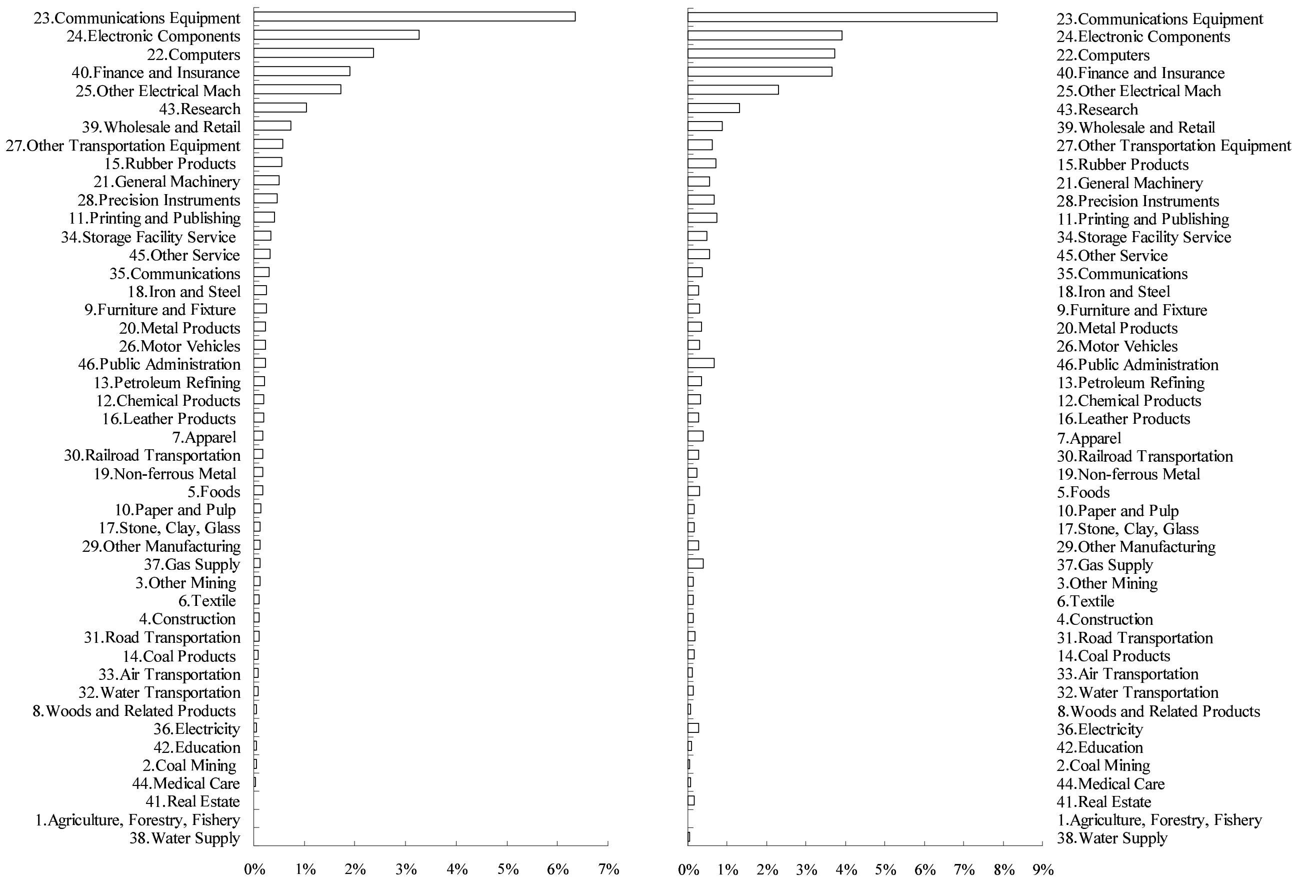


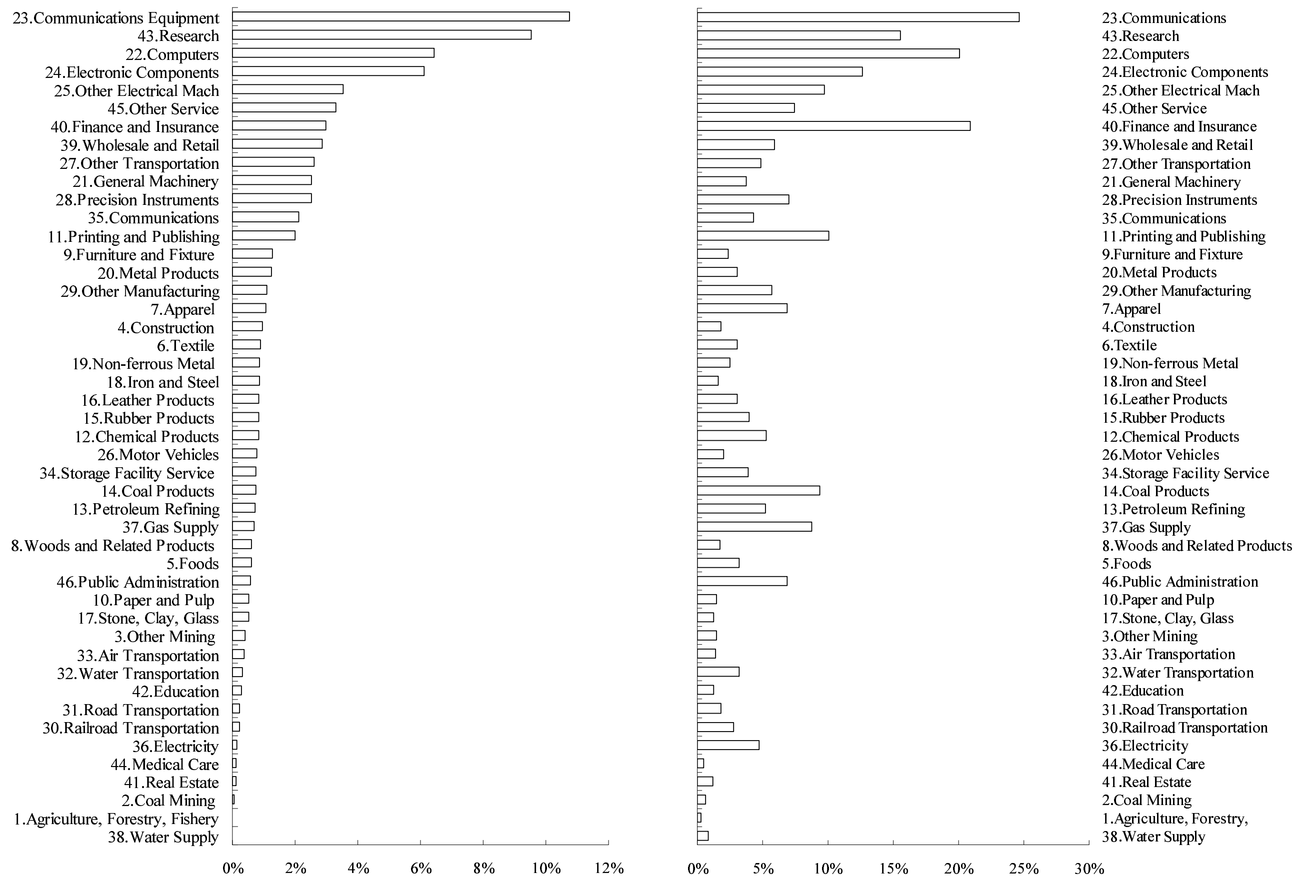

Figure. 10 Own-Software Investment by Industry in 2000, Japan




(a) Own-Account Software Investment

(b) Total Software Investment

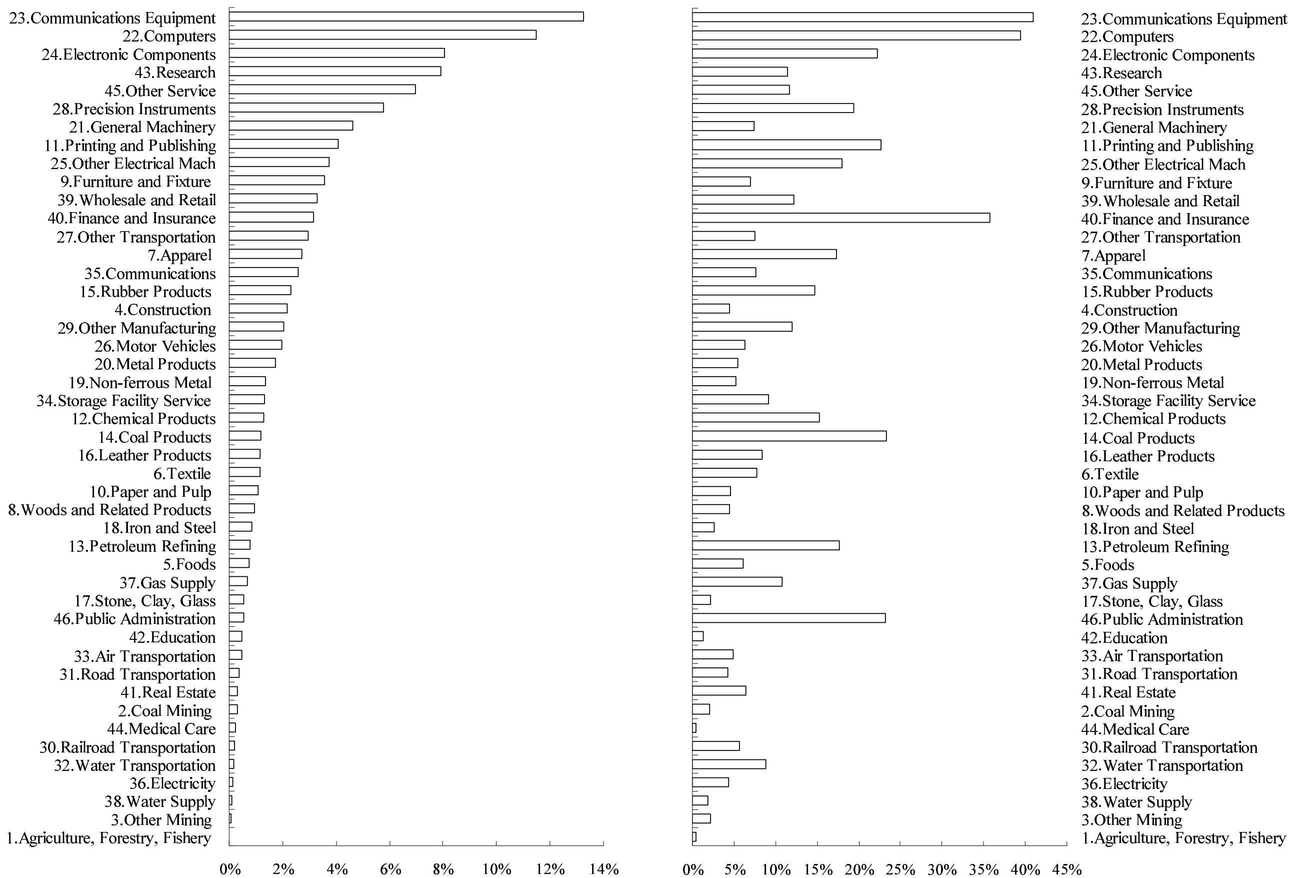
Figure. 11 Share of Software Investment in GFCF by Industry in 1970, Japan




(a) Own-Account Software Investment

(b) Total Software Investment

Figure. 12 Share of Software Investment in GFCF by Industry in 1990, Japan




(a) Own-Account Software Investment

(b) Total Software Investment

Figure. 13 Share of Software Investment in GFCF by Industry in 2000, Japan

As shown in Figure 7(a), although the impact of capitalizing own-account software is 2.19 percent of share of GFCF at the aggregate level in 2000, the impacts for communications equipment and computers exceed 10 percent. In comparison with the aggregate impact (7.37 percent) of total software in GFCF as shown in Figure 7(b), the three industries, communications equipment, computers, and finance and insurance, have the impacts of more than 30 percent of GFCF. Seven industries have more than 20 percent shares of software; electronic components, printing and publishing, coal products, and public administration, in addition to the others. Impacts of software investment for the above industries are very significant for their technological changes as capital inputs.

# 5 Software Stock

## 5.1 Price and Depreciation Rate

Next, we estimate capital stock by type of software, based on our estimates of software investment in this paper. To measure capital stock by the perpetual inventory method, we examine depreciation rates and prices for software. In current Japanese tax law, the service life of software is set to 5 years, except software to be reproduced and software to be used in research and development activity, which has 3 years service lie.[*24] Under the 1.65 declining-balance depreciation rate, the corresponding geometric depreciation rate for a 5-year service life is 33.0 percent.

The BEA uses a 3-year service life for prepackaged software and a 5-year service lie for custom software and own-account software and the 3-year service life is the same as that used in the U.S. tax law (Parker-Grimm[2000]). Lequiller-Ahmad-Varjonen-Cave-Ahn[2003] reports the survey for asset service lives for software in national accounts of some OECD countries. Czech Republic, Finland, France, Italy, and United Kingdom use a 5-year service life. Spain uses a 4-year service life and Netherlands uses the shortest service life; a 3-year life for all types of software. The service life in Canada is the same as that in the U.S. Adding to Canada and the U.S., Australia, Denmark, and Sweden assume the 30-40 percent lower service life for prepackaged software than that for custom software and own-account software.[*25] The range for the software service life among countries is 3-6 years, with a median of 5. In this paper, we use a 33.0 percent geometric depreciation rate, which corresponds to a 5-year service life. The sensitivities of different rates of depreciation will be examined in section 5.2.

Prices of software also should be noted. As Jorgenson-Ho-Stiroh[forthcoming] discusses the possibility that the price indexes used to deflate software investment fail to hold quality constant, the BEA's estimates in the U.S. also are in the process to accurately capture quality change in software. In the 2003 comprehensive revision by the BEA, the price indexes for custom software and own-account software are identical, and are defined by a weighted average of the input cost index with the NIPA prepackaged

[*24] Software began to be treated as depreciable intangible fixed assets in the 2000 revision of Japanese tax law. Before 2000, own-account software had not been defined as fixed assets from the point of the view of tax law, although some own-account software had been capitalized in business accounts.

[*25] Assumed depreciation distributions are geometric in Sweden and the U.S., hyperbolic in Australia, and straight line in other countries.

software price index.*26

Ahmad[2003] indicates a big diversity in software price estimates in some OECD countries. In Sweden, the software price increases by about 6 percent annually during 1995-2000. On the other hand, the software price in Australia decreases by annually 6 percent in the same period and the BEA's revised price for total software (0.8 percent annual decline) is between the two estimates.

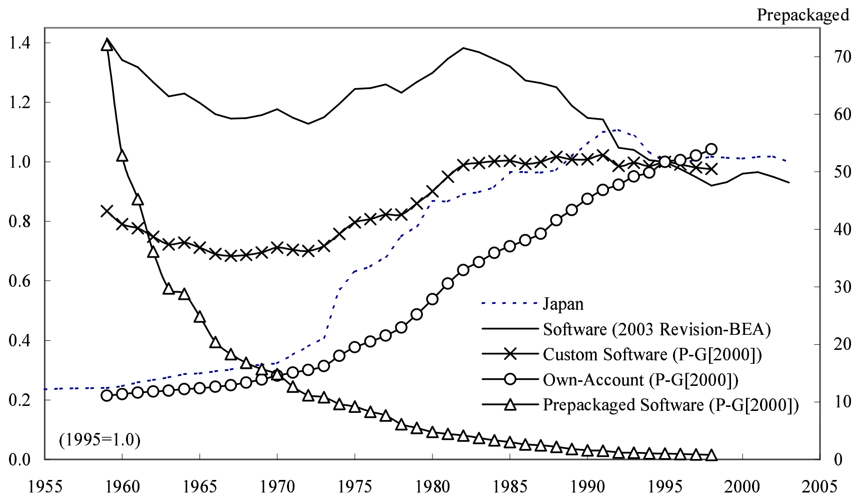



Figure. 14 Software Investment Price: Comparison between the U.S. and Japan

Figure 14 shows prices for total software in the U.S. revised in 2003, for three types of software reported by Parker-Grimm[2000] in the U.S., and for custom software in Japan. Japan's price for custom software is estimated by the Corporate Service Price Index (CSPI, Bank of Japan) after 1995, which is measured by the labor cost. Japanese official national accounts also uses this price index and estimates it backwardly until 1980. In Figure 14, we estimate it until 1955 using the cost index of computer services. Here, we consider it to be a cost index for software production in Japan. Prices by type of software reported by Parker-Grimm[2000] are estimates before the 2003 comprehensive revision by the BEA. We can consider the price for own-account software by Parker-Grimm to be a cost index for software production in the U.S., which is defined as a simple average of programmer labor cost and non-labor inputs. The price for custom software is defined by a weighted average of the price indexes for own-account software and prepackaged software.

If we use the cost index as total software price in Japan, the trends in the 1970s and the 1980s differ between the U.S. and Japan. In comparison with cost indexes in both countries, the movements of both indexes are similar. The gap in the total software price is generated from the very rapid decline of

*26 See the postscript added in June 2004, in Grimm-Moulton-Wasshausen[2003]. Until this revision, the price index for own-account software was defined by the BEA's input cost index consisting of compensation cost indexes and an intermediate inputs cost index. For custom software, the price index was defined as a weighted average of the price indexes for own-account software and prepackaged software, where the weights are arbitrarily selected as 75 percent for own-account software and 25 percent for prepackaged software (Parker-Grimm[2000]).

prepackaged software prices in the U.S., which is shown in Figure14 (right axis), which holds quality constant. The annual average rate of decline in prepackaged software price is 11.0 percent in the 1980s and 8.7 percent during 1990-98 in the U.S.

So far, in Japan, we don't have a good estimate for prepackaged software that holds quality constant. In this paper, we use the cost index, which is used for custom software in the Japanes national accounts, for all types of software. In order to examine the sensitivity of the results to the change of deflators, we also compute harmonized indexes, as a tentative approximation. Based on the relationship between cost indexes, $p^U_{c.i.}$ in the U.S. and $p^J_{c.i.}$ in Japan, we compute the harmonized index for prepackaged software $p^J_{pre}$ for Japan, the growth of which is defined by the $\Delta \ln p^J_{pre} = \Delta \ln p^U_{pre} + (\Delta \ln p^J_{c.i.} - \Delta \ln p^U_{c.i.})$, where $p^U_{pre}$ is the price of prepackaged software in the U.S. Like the BEA's revised methodology, we also define the harmonized prices for custom software and own-account software in Japan as a weighted average of the harmonized index for prepackaged software and the cost index. Figure 15 shows the comparison between the revised total software price in the U.S. and the harmonized price for total software in Japan, which is defined as a Theil–Törnqvist index of types of software with their nominal investment values as weights. We examine the sensitivity of the results to the harmonized prices in section 5.2.

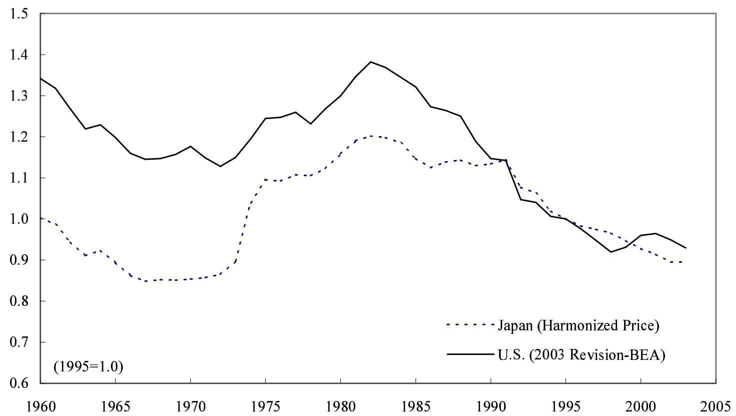



Figure. 15 Harmonized Software Investment Price in Japan

## 5.2 Measurement Results of Software Stock

To measure software capital stock, we examine four scenarios. First, for depreciation, the 33 percent and 55 percent geometric depreciation rates are assumed. Second, there are two options for prices, the cost index for all types of software and the harmonized indexes for each type of software. Table 7 and Figure 16 represent the estimated results of software stock corresponding to the four scenarios. Shares to fixed capital stock are in ( ) and shares to total capital stock, including land and inventory, are in [ ] in Table 7.[*27]

[*27] Here, capital stock is composed of one hundred two assets; ninety tangible fixed assets, five intangible assets including three types of software, four types of land, and three types of inventories. Measurement of capital stock, except software, is based

Table. 7 Software Stock and the Share to Total Capital Stock

| | Own-Account Software | | | | Total Software | | | |
|---|---|---|---|---|---|---|---|---|
| | 33% $\delta$ | | 55% $\delta$ | | 33% $\delta$ | | 55% $\delta$ | |
| | C.I. | H.I. | C.I. | H.I. | C.I. | H.I. | C.I. | H.I. |
| 1960 | 14.5 | 3.7 | 10.8 | 2.6 | 27.3 | 7.0 | 19.7 | 4.5 |
| | (0.01) | (0.00) | (0.01) | (0.00) | (0.02) | (0.00) | (0.01) | (0.00) |
| | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] |
| 1965 | 71.9 | 21.4 | 54.2 | 16.5 | 103.1 | 29.7 | 76.0 | 22.3 |
| 1970 | 405.1 | 143.6 | 308.3 | 110.4 | 574.7 | 197.5 | 441.7 | 153.2 |
| | (0.10) | (0.04) | (0.08) | (0.03) | (0.15) | (0.05) | (0.11) | (0.04) |
| | [0.02] | [0.01] | [0.02] | [0.01] | [0.04] | [0.01] | [0.03] | [0.01] |
| 1975 | 1146.3 | 529.3 | 759.9 | 368.3 | 1700.2 | 764.6 | 1149.6 | 541.7 |
| 1980 | 1941.1 | 1167.6 | 1237.4 | 776.3 | 3347.8 | 1965.7 | 2241.4 | 1365.2 |
| | (0.23) | (0.14) | (0.15) | (0.09) | (0.40) | (0.24) | (0.27) | (0.16) |
| | [0.08] | [0.05] | [0.05] | [0.03] | [0.14] | [0.08] | [0.09] | [0.06] |
| 1985 | 3320.7 | 2371.3 | 2253.7 | 1644.3 | 6978.0 | 4815.0 | 4834.0 | 3397.1 |
| 1990 | 5761.7 | 4882.4 | 3682.4 | 3236.2 | 14656.2 | 12282.8 | 9848.1 | 8555.3 |
| | (0.44) | (0.37) | (0.28) | (0.25) | (1.11) | (0.93) | (0.75) | (0.65) |
| | [0.18] | [0.16] | [0.12] | [0.10] | [0.47] | [0.39] | [0.32] | [0.27] |
| 1995 | 6902.7 | 6830.6 | 4313.1 | 4343.9 | 18363.2 | 18174.4 | 11323.7 | 11416.0 |
| 2000 | 7628.4 | 8181.9 | 4829.4 | 5289.0 | 25168.1 | 27507.5 | 16432.2 | 18362.2 |
| | (0.41) | (0.44) | (0.26) | (0.28) | (1.35) | (1.47) | (0.88) | (0.99) |
| | [0.20] | [0.21] | [0.13] | [0.14] | [0.65] | [0.71] | [0.43] | [0.48] |

unit: billion yen (1995 constant price). $\delta$ means a geometric depreciation rate. Stock is defined as an average of values in the beginning and ending periods.

C.I. is deflator defined by cost index.

H.I. is harmonized price index, computed basing relative cost indexes between the U.S. and Japan.

Shares to fixed capital stock is in ( ) in every ten years.

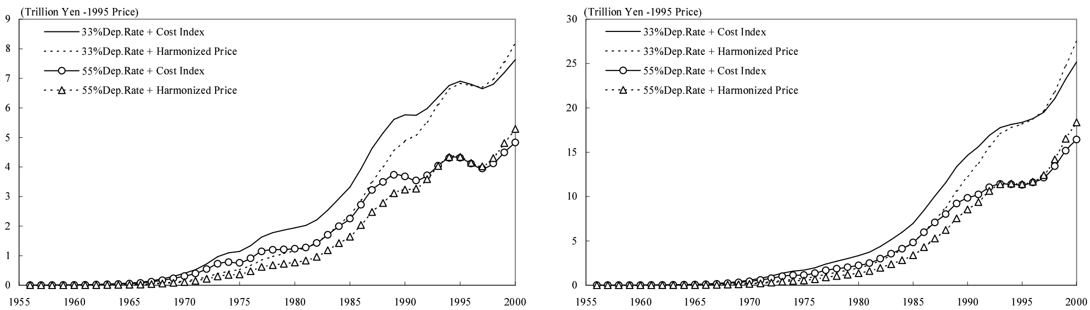
Shares to total capital stock, including land inventory, is in [ ] in every ten years.

In case of 33 percent geometric depreciation rate ($\delta$), own-account software stock are 7.6 trillion yen estimated using the cost index and 8.1 trillion yen using the harmonized prices in 2000, which amounts to about 0.4 percent of fixed capital stock and about 0.2 percent of total capital stock. As our estimated stock is evaluated 1995 constant price, the estimated values by both price indexes are similar around 1995 in cases with same $\delta$. In 1970, the own-account software stocks estimated using the harmonized prices is 65 percent lower than that using the cost index. For total software stock, 25.2 trillion yen estimated using the cost index and 27.5 trillion yen using the harmonized indexes in 2000.

on the revised estimates of Nomura[2004]. The initial year for perpetual inventory method is 1955, when the large-scale survey for national wealth took place in Japan. We estimate initial stock for tangible assets based on the 1955 National Wealth Survey. For software, we estimate the initial stock by type of software, based on assumptions of constant growth rate for each type of software by industry and constant depreciation rate before 1955; as the ratio is the real investment value in 1995 over a sum of average growth rate of real investment during 1955-60 and a depreciation rate.

As shown in Table 8, the growth rate of own-account software stock estimated by the cost index is lower than that using the harmonized indexes. From 1995 to 2000, although the growth rate of stock using the cost index for own-account software is 2.0 percent, the stock using the harmonized prices increases annually by 3.6 percent. For total software, the annual growth rates are 6.3 percent using the cost index and 8.3 percent using the harmonized index. Since Japan has much smaller share of prepackaged software relative to the U.S., as shown in Figure 8, the impacts through the revaluation of prepackaged software is relatively small. Impacts depend on how prices for custom software and own-account software are defined to consider the quality changes in these software.

In the case of the 55-percent-$\delta$, own-account software stock is about 36 percent lower in 2000 than that with the 33-percent-$\delta$. Also in 1970, the stock levels with 55-percent-$\delta$ is about 24 percent lower. The changes in $\delta$ shift the levels of the estimated software stocks, but have a relatively small impact on the growth rates, as shown in Table 8.




(a) Own-Account Software Investment

(b) Total Software Investment

Figure. 16 Software Stock: Four Scenarios

Table. 8 Growth Rates of Software Stock

| | Own-Account Software | | | | Total Software | | | |
|---|---|---|---|---|---|---|---|---|
| | 33% $\delta$ | | 55% $\delta$ | | 33% $\delta$ | | 55% $\delta$ | |
| | C.I. | H.I. | C.I. | H.I. | C.I. | H.I. | C.I. | H.I. |
| 1960-65 | 32.0 | 35.1 | 32.2 | 37.2 | 26.6 | 28.8 | 27.0 | 32.0 |
| 1965-70 | 34.6 | 38.0 | 34.8 | 38.1 | 34.4 | 37.9 | 35.2 | 38.5 |
| 1970-75 | 20.8 | 26.1 | 18.0 | 24.1 | 21.7 | 27.1 | 19.1 | 25.3 |
| 1975-80 | 10.5 | 15.8 | 9.8 | 14.9 | 13.6 | 18.9 | 13.4 | 18.5 |
| 1980-85 | 10.7 | 14.2 | 12.0 | 15.0 | 14.7 | 17.9 | 15.4 | 18.2 |
| 1985-90 | 11.0 | 14.4 | 9.8 | 13.5 | 14.8 | 18.7 | 14.2 | 18.5 |
| 1990-95 | 3.6 | 6.7 | 3.2 | 5.9 | 4.5 | 7.8 | 2.8 | 5.8 |
| 95-2000 | 2.0 | 3.6 | 2.3 | 3.9 | 6.3 | 8.3 | 7.4 | 9.5 |

unit: annual average growth rate(percentage).

C.I. is the cost index. H.I. is the harmonized price index.

As mentioned in section 5.1, we use a 33-percent-$\delta$ and a cost index for all types of software. It should be of note that the estimated growth rate of own-account software stock may be underestimated if we consider the quality adjustment of Japan's software prices in the future.

# 6 Conclusion

In this paper, we measure own-account software investment in Japan as suggested by the OECD Task Force methodology at the aggregate level and the BEA's methodology at the industry level. We conclude that the scale of own-account software investment is 0.60 percent of GDP in 2000 in Japan. This share is 0.13 percentage points lower than that in the U.S. The share of total software investment to GDP is 2.03 percent, which is almost the same as that in the U.S. (2.07 percent), reflecting the larger share of custom software relative to other countries.

We find a significant difference of the composition by type of software between the U.S. and Japan in this paper. In 2000, the investment share of prepackaged software is 28.0 percent of total software in the U.S., in comparison with 6.2 percent in Japan. Also, the difference in the composition may be also important for the consideration of the constant-quality price for software investment. So far, the BEA computes software prices by type of software and carefully examines the prepackaged software price to hold quality constant. There is a big difference of price trends among type of software in the U.S. Although, it is hard to justify that software quality change depends on the type of software. Reconciliation of quality changes among the types of software should be taken into consideration.

Additionally, it may be important to consider the consistency between prices for non-embedded prepackaged software, which is defined as investment of prepackaged software, and embedded prepackaged software, which is defined as investment in other tangible assets. With further conceptual sophistication of software investment, including the relationship between own-account software and other activities still not capitalized, like R&D, OJT, advertisement, and so on, we continue to accumulate empirical results to improve the measurement of the price, effective service life, and depreciation distribution of software.

# A Capitalizing on Input-Output Table and Consistency with Other Data

Let us think of the input-output table, which comprises the use-table (commodity*industry), make-table (industry*commodity), and x-table (commodity*commodity). In the use-table without capitalization of own-account software, the costs for producing own-account software are internally described as intermediate consumption, compensation of employees (L), consumption of fixed capital (D), operating surplus (O), and so on, in each industry. To capitalize own-account software, we should modify this description of the input-output table.

The description depends on the definition of output. Industry classification is defined by the establishments, of which the company consists. Based on a main product of establishment, each of the different establishments within one company is classified into different industries, individually. All outputs, which can include different products, produced by one establishment is defined as the output of the same industry, to which the establishment belongs. The make-table describes the product-mix by industry.

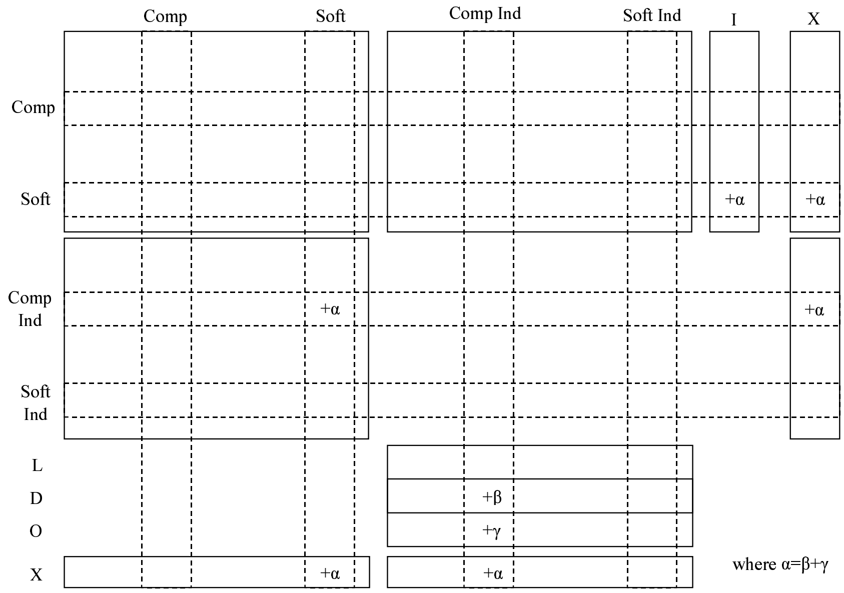



Figure. 17 Capitalization of Own-Account Software: Approach-1

For example, if the computer manufacturing industry develops software originals not to be sold, we have two options to define the output of the computer industry: the industry outputs including the production of own-account software or excluding it. Figure 17 shows the rebalanced IO table after capitalization of own-account software, if we define the output in computer industry as the product-mix of computer and own-account software. The original output in computer industry should be increased by the produced value ($\alpha$) of own-account software. The input balance of computer industry in the use-table is retained by the increase ($\beta$) of the consumption of fixed capital for own-account software and the increase ($\gamma$) of the operating surplus, which is defined by $\gamma = \alpha - \beta$. At the make-table, the value

($\alpha$) produced by computer industry is described as the increase of the production of software. Finally, the increase of software production is capitalized as additional investment of the computer industry. The increase of value added ($\beta + \gamma$) is the same as the increase of final demand ($\alpha$) in a total economy, in which the GDP also increases by $\alpha$.

The second approach to describe capitalization of own-account software is shown in Figure 18. In this case, the original output value of the computer industry remains unchanged since the output is defined excluding the production of own-account software in computer industry. Here, in order to produce own-account software, the labor cost is $y_2$, consumption of fixed assets is $y_3$, operating surplus is $y_4$, and the other intermediate consumptions are $y_1$. The production value is defined as the total cost, $\alpha = y_1 + y_2 + y_3 + y_4$. In computer industry, these costs are reduced by the cost for producing computer. Instead, capital service cost for using own-account software should be described. In terms of the first approach in Figure 17, that is $\beta$ and $\gamma$. The value ($\alpha$) of own-account software is counted to be produced by the software industry. The increased value ($\alpha$) is described at the diagonal in the make-table and capitalized in investment from software production. The increase of value added, which is equalized with the increase of final demand ($\alpha$), are $y_1$ in the computer industry and $y_2 + y_3 + y_4$ in the software industry.[*28]

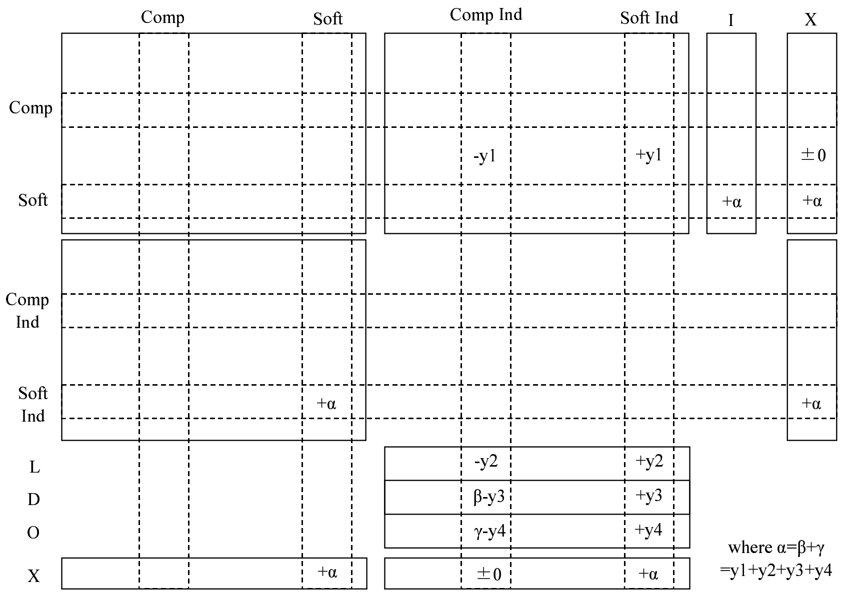



Figure. 18 Capitalization of Own-Account Software: Approach-2

Probably, the first approach is easier for rebalancing IO. On the other hand, we have to redefine industry output prices even in non-software industries, which should be defined as the aggregate prices

*28 In our example, for simplicity, we neglect own-account software produced by government sector. If it is included, gross output of the government sector decreases by the value of own-account software and increases by the value of consumption of own-account software. Redefinition of government output leads to an adjustment of government consumption in final demand. In the economic system, increase of the GDP is (increase of investment for own-account software;$\alpha$) - (own-account software produced by government) + (consumption of own-account software of government).

of commodities between the original outputs and the own-account software produced by the industry, based on the product mixes in the make-matrix. Also, the measured productivities in non-software industries are sensitive to the change of the price for own-account software, which may be frequently revised.

In order to avoid the product-mix problem in non-software industries, the second approach may be preferable. In this case, there is no need to redefine industry output prices in non-software industries. However, it makes it difficult to keep the consistency with detailed labor inputs. Labor inputs are cross-classified by sex, age, education, class of worker, and industry, like Jorgenson-Ho-Stiroh[forthcoming] for the U.S. productivity accounts and Nomura[2004] for Japan. If we don't have a category of occupation for labor inputs or we don't reconcile software professionals for producing own-account software to the categories in labor inputs, the generated bias may be not negligible, especially, for some IT related industries like computer manufacturing and communication.

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