This paper is very preliminary. Comments welcome.

Can We Go Back to Data? Reconsideration of U.S.-Harmonized Computer Prices in Japan

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Keywords

Computer Prices, Internationally Harmonized Prices, Index Number, Aggregation, Output Price (BEA), PPI (BLS), WPI/CGPI (BOJ), Electronic Components, Communications Equipment, Investment Price

Abstract

We analyze the widely used methodology of international price harmonization by comparing the sources of IT price gaps between the U.S. and Japan at the SIC 3-, 4-, 5-digit level. By careful examination of the most detailed published data and methodology used in both countries, we can conclude; (i) At the SIC 5- and 4-digit level, we find almost no differences in computer output prices during 1995-2003. (ii)At the SIC 3-digit level, Computer & Peripheral Equipment prices fall almost twice as fast in the U.S. as in Japan during 1995-2001. Over the long-term, the price gap is similar. This gap mainly results from the higher production weight of the peripherals, which have relatively moderate price declines in Japan. (iii)Moving to the other IT goods, Electronic Component prices fall more rapidly in Japan before 1990, but faster in the U.S. after 1990. Communication Equipment prices fall faster in Japan. Price gaps for IT goods are unique and should be considered separately from the Computers & Peripherals price gap.

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1 Introduction

In recent studies of the role of Information Technology (IT) in economic growth, rapidly declining computer prices translate to faster real GDP growth and significant contributions of IT-Capital and IT-TFP to economic growth. In studies of the U.S. economy, researchers have used a quality-adjusted computer price constructed by the Bureau of Economic Analysis (BEA), which captures the rapid technological improvements in the computer industry. In studies covering multiple countries, researchers have employed internationally harmonized prices, that translate U.S. prices to comparison country prices in order to control for the quality improvements in the comparison country.[*1]

For countries with statistical agencies which do not adjust for quality change in IT-goods, the use of harmonized prices for international comparisons is one possible approximation for proper quality adjusted prices. However in a country like Japan, where price statistics have already been quality-adjusted, the use of harmonized prices needs further justification.

In this paper, we revisit the use of harmonized prices in international comparisons of economic growth. Mainly, we focus on computer prices in the U.S.–Japan case, where recent studies, Jorgenson–Motohashi[2003] and Jorgenson[2004], have used internationally harmonized prices to analyze the role of computers in economic growth.

For aggregated commodities or industries, for example SIC 3-digit or 4-digit, there are basically three sources of price-gaps between countries. The first is the price gap at the most detailed level, a so-called "commodity", in the case of computers this is 5-digit SIC. Differences in commodity prices at the 5-digit level represent either true price differences or differences in estimation procedure.[*2] After considering estimation procedures, the second possible explanation for price gaps is the index number formula used in aggregation from the detailed 5-digit level to higher level aggregates. Finally, definition of the weights used

[*1] Price harmonization is an attempt to control for these price differences, under the assumption that the comparison country's price data fails to capture quality improvements. Various studies have used different methods to construct harmonized prices, but the basic idea is the same. The relative price of IT to non-IT in the comparison country is set equal to the IT to non-IT price relative in the U.S. Colecchia–Schreyer[2002] use some econometric technique, Van Aark, et al[2002], Jorgenson–Motohashi[2003] and Jorgenson[2004] use price relatives. In Colecchia–Schreyer[2002], the harmonized price is formulated such that: $\Delta \ln p_{it}^{X} = \Delta \ln p_{nit}^{X} + (\Delta \ln p_{it}^{US} - \Delta \ln p_{nit}^{US})$, where X is the reference country, *it* is the IT product price, and *nit* is the non-IT price. In practice, the non-IT price in country X is formulated as the residual of the total price and IT product price, ie $\Delta \ln p_{nit}^{X} = (\Delta \ln p_{total}^{X} - \omega_{it}^{X} \Delta \ln p_{it}^{X})/\omega_{nit}^{X}$, where ω is the value share of the IT and Non-IT component.

[*2] Although the hedonic technique has been shown to be an effective technique for capturing quality change, it is not necessarily the case that the traditional approach is inferior. See Aizcorbe–Corrado–Doms[2000] and Landefeld–Grimm[2000]. If quality adjustments are done in both countries, in this paper we consider the price differences at the most detailed level as a true price differences, without examining the methodology and raw data used for adjustments.

in aggregation can lead to price differences. Given these three possibilities, when there are significant differences in methodology and the estimated results *at the detailed level*, it may be valuable to consider the use of internationally harmonized prices to capture true price changes. The other two causes of international price differences can be addressed using existing data by changing aggregation procedures, if so desired.

To address the issue of price harmonization, first we examine the differences in computer price statistics in the U.S. and Japan at the 3- and 4-digit SIC level in section 2. We look at BEA's Output prices and the Producer Price Index (PPI) produced by Bureau of Labor Statistics (BLS) in the U.S. and the Wholesale Price Index(WPI), which has been revised and renamed to the Corporate Goods Price Index (CGPI) by the Bank of Japan (BOJ). A review of this data leads to the main two questions addressed in this paper. First, *what accounts for the difference between the BEA and BLS prices in the U.S.?* Second, *can index number methodology and aggregation weights explain the price gap between the BEA and WPI/CGPI prices, in other words what is the true U.S.-Japan price gap?*

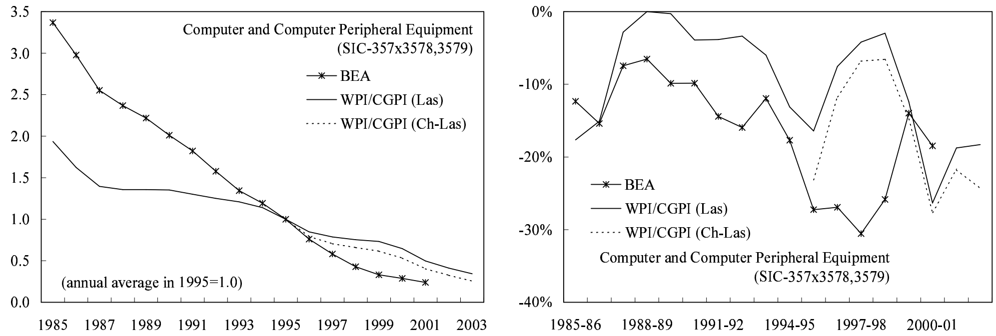
In order to answer these two questions, in section 3 and section 4 we review and compare the methodology used in the U.S. and Japan to construct quality-adjusted computer prices. After understanding the methodological differences, we are able to analyze the sources of the price gap at 5-digit, 4-digit and 3-digit level in section 5.

In section 6, we recalculate and examine the long-term trend of prices of Electronic Computer and Peripheral Equipment, Communications Equipment, and Electronic Components in the U.S. and Japan. Using these recalculated IT output prices, we complete the IT price story by computing the prices of IT goods as investment goods by taking into account import prices, wholesale and transport prices, and margin rates. We conclude the preliminary analysis presented in this paper in section 7.

2 How fast are computer prices falling in the U.S. and Japan?

To examine the price-gap between the U.S. and Japan, we compare price gaps at the 3- and 4-digit SIC level. In doing an international comparison of price indexes, it is important to consider the long term trend of the data, which dampens the impact of short term fluctuations in economic conditions, and changes of exchange rate. In this section, we compare prices evaluated in local currencies to mitigate the effects of volatile movements in the exchange rate and introduce the impact of the exchange rate in a later section. Here, we focus on prices during 1993–2003 due to data constraints, but refer to longer time series whenever possible.[*3]

[*3] The BOJ completed a major revision of its WPI to CGPI in 2000, as described in section 4, the effect of which is shown on the Computer price in Figure 9. Here, we use WPI until 2000 and CGPI after, and call the linked series "WPI/CGPI".



(a) Price Index (b) Growth Rate

Fig. 1 Prices of Computer and Peripheral Equipment 357x: BEA vs WPI/CGPI

Since most industry analysis is done at the 3-digit level, we start here, comparing BEA's Output price and BOJ's WPI/CGPI prices for Computer and Peripheral Equipment (SIC-357x3578,3579).[*4] Figure 1(a) clearly shows that output prices fall more rapidly in the U.S. than in Japan. In both countries, prices have declined every year since 1985, except 1988–89 in Japan when prices were flat, as shown in Figure 1(b). Overall, during 1985–2001, prices in the U.S. decline 16.5 percent annually, almost twice as fast as the 8.5 percent annual rate in Japan. From 1995 to 2001 the average price decline in the U.S. is 23.8 percent per year, compared to 11.6 percent in Japan. Given the widespread improvements in computer production technology, the obvious question becomes: *Why are computer prices falling so much faster in the U.S.?*

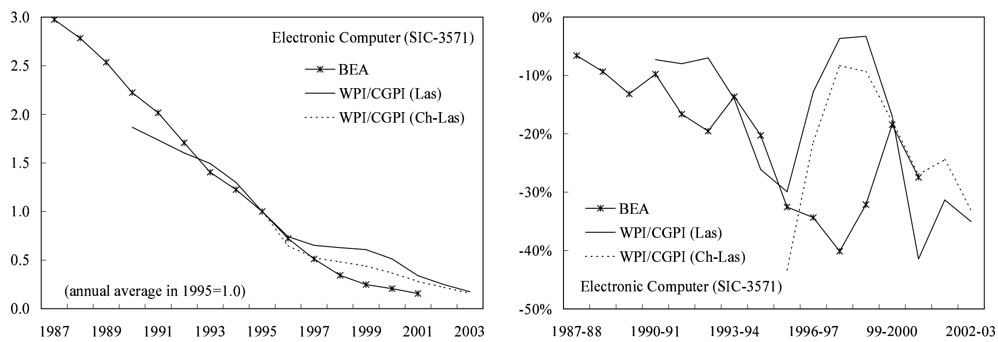
Price movements, in general, depend on market structure and the availability of substitutable products for similar use, in addition to the technology used in production. If we focus only on Personal Computers(PCs), the computer price movements are not surprising, at least until 1991. In 1980s, the Japanese PC market was dominated by the monopolistic power of NEC, which had a 60-70 percent share of domestic demand. On the other hand, the international PC market was very competitive, with many manufacturers of IBM-compatible computers coming online to combat the dominance of IBM in the early 1980's. Until 1991, the Japanese PC market was separated from the international market due to hardware and software differences and incompatibility issues, but the dawn of DOS/V as a new Operating

[*4] "x" indicates excluding SIC code. SIC-357 consists of not only computer and computer peripheral equipment (3571, 3572, 3575, and 3576), but also office machinery (3578 and 3579). The price decline of SIC-3578 and 3579 is relatively small. Here, we analyze SIC-357 excluding 3578 and 3579, and simply call it "SIC-357x", to clarify the difference between statistics in the U.S. and Japan. The aggregate BEA output price SIC-357x is calculated using a Chained Fisher index.

System(OS) in 1991 changed that.

DOS/V is a version of MS-DOS that provides both English and Japanese language command interfaces and can be used for applications designed for either or both English and Japanese. DOS/V includes all the English-based commands and specific Japanese DOS/V commands.*5 Because DOS/V works on all IBM-compatible computers, foreign manufacturers were able to enter to the Japanese PC market. Competition brought prices down for computers, peripherals, and software. However, since computer users in Japan were subject to the lock-in effect while transitioning to new platforms, it took some time for prices to adjust.

After 1991, markets in the U.S. and Japan gradually integrated, so the question remains: how do we explain the significant difference in computers prices in the U.S. and Japan? Some researchers have posited that Japan statistical agencies have not properly captured quality improvements, but the main producer of Japanese data on computer prices, the BOJ, does, in fact, quality adjust computer prices using a similar hedonic approach to the BLS.*6 On the other hand, some researchers suspect that price declines in the U.S. are being overstated by the use of the hedonic approach. However, Aizcorbe–Corrado–Doms[2000] and Landefeld–Grimm[2000] show that the hedonic and matched-model approach yield similar results.



(a) Price Index (b) Growth Rate

Fig. 2 Prices of Electronic Computers 3571: BEA vs WPI/CGPI

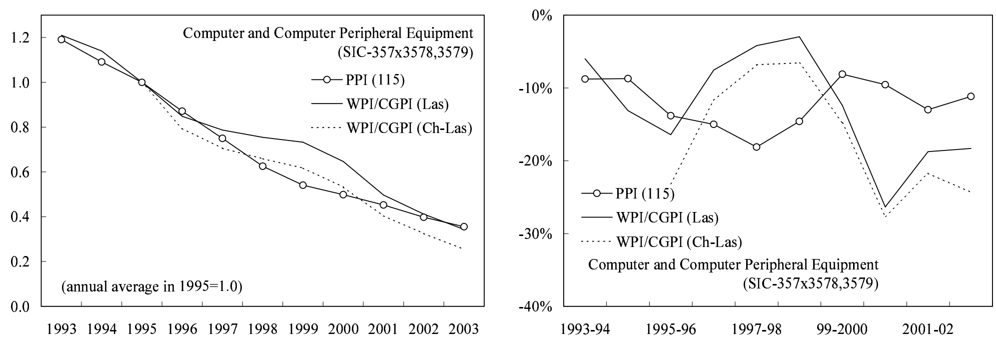
The quality adjusted time series of the BEA and WPI/CGPI prices at the 4-digit level are presented in Figure 2. At this level of detail, we isolate Electronic Computers, which exclude the peripheral and other equipment that are part of SIC-357x. As a result, we expect faster price declines, and that, indeed is what we find. The annual average rate of price decline

*5 DOS/V gets its name because it requires a Video Graphics Array (VGA) display. In 1991, the Open Access Development Group (OADG), a consortium organized by IBM, developed DOS/V.

*6 As described in section 4, WPI/CGPI uses hedonic methods for personal computers (1990–), mainframes (1990–2000), and servers (2000–).

during 1990–2001 in the U.S. is 24.1 percent compared to a 16.5 percent price decline of SIC-357x. In Japan, prices of Electronic Computers fall 15.5 percent per year, compared to 9.1 percent. From 1995 to 2001, the BEA price declines 30.8 percent per year, in comparison to price declines of 23.8 percent in SIC-357x and in Japan the WPI/CGPI price falls 18.0 percent per year, 6.4 percent faster than the 3-digit price index. However, when comparing the declines in the U.S. to those in Japan, prices in the U.S. fall 5.6 percent per year faster in the U.S. than in Japan during 1990–2001, and 12.8 percent faster during 1995-2001. This price gap may have been big enough to convince some researchers to use a U.S.-harmonized computer price in Japan.

Previously, we have compared the BEA output price to the WPI/CGPI. Here, we compare the WPI/CGPI to the BLS price indexes. Figure 3(a) shows the comparison at the 3-digit level. The annual average rate of price decline of PPI-115, which corresponds to SIC-357x is 12.1 percent during 1993–2003, only slightly smaller than 12.6 percent decline in WPI/CGPI. In fact, when comparing the Chained Laspeyres version of the WPI/CGPI price index, prices of Computers and Peripheral Equipment actually fall faster in Japan.[*7] Where has the gap gone?



(a) Price Index

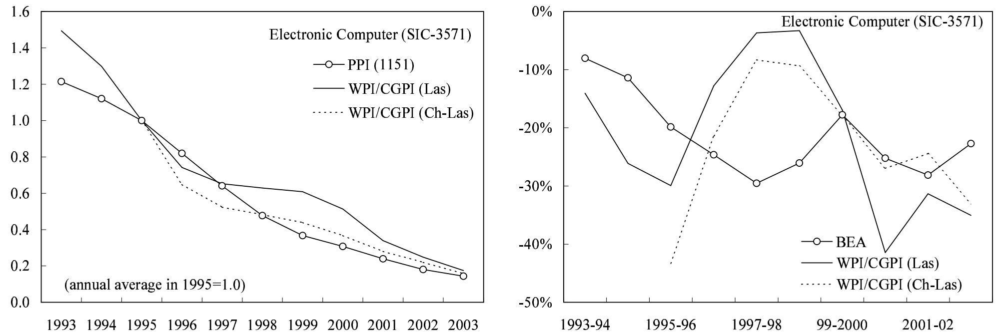
(b) Growth Rate

Fig. 3 Prices of Computer and Peripheral Equipment 357x: PPI vs WPI/CGPI

On the 4-digit level, the price comparison between the PPI and WPI/CGPI is in Figure 4. The annual average rate of price decline of PPI-1151 Electronic Computers, which corresponds to SIC-3571, is 21.3 percent and that of WPI/CGPI is 21.5 percent during 1993–2003. Hence, at the 4-digit level, the average price declines in the PPI and WPI/CGPI are very similar. Comparing the PPI and WPI/CGPI, there is no reason to believe Japanese statistics are underestimating computer price declines.[*8]

[*7] The role of index number methodology is discussed starting in section 3

[*8] On 5-digit level, BOJ[2001b] compares the prices for WPI/CGPI and PPI Personal Computers prices. They find



(a) Price Index　　(b) Growth Rate

Fig. 4 Prices of Electronic Computers 3571: PPI vs WPI/CGPI

Table. 1 Price Declines of Computers

		1993–2003			1995–2003		
		BEA	PPI	WPI/CGPI	BEA	PPI	WPI/CGPI
3-digit	357x	-21.6[1)]	-12.1	-12.6	-23.8[1)]	-12.9	-13.4
4-digit	3571	-26.8[2)]	-21.3	-21.5	-29.3[2)]	-24.2	-21.8

unit: average annual growth rate (%). WPI/CGPI is evaluated by Yen.
3-digit: 357x.Computer and Peripheral Equipment
4-digit: 3571: Electronic Computer, [1)] until 2001
[2)] extended during 2001–03 using PPI and 2001 fixed weight

The basic relationship between the three computer price statistics is price declines reported by BEA> PPI ≈ WPI/CGPI during 1993–2003, as shown in Table 1.[*9] At the 3-digit level, during 1993–2003 the PPI declines 12.1 percent per year, almost the same as the 12.6 percent decline in the WPI/CGPI. In contrast, the BEA price falls 21.6 percent per year. At the four digit level, the PPI decreases 21.3 percent per year, almost equivalent to the 21.5 percent decrease in the Japan price compare to the 26.8 percent average annual drop in the BEA price. Given the similarity of the WPI/CGPI to the PPI, which is the underlying source of the BEA data, we have two questions. First, *what accounts for the difference between the BEA and BLS*

there is only a small difference during 1995-99(WPI) and January2000–October2001(CGPI) when prices are expressed in local currencies or in U.S. Dollars. In general, when comparing the prices between the U.S. and Japan, statisticians compare BLS's PPI and BOJ's WPI/CGPI at the most detailed commodity and researchers compare BEA's Output Price and BOJ's WPI/CGPI at the aggregated level. These comparisons sometimes lead to contradictions and misunderstandings. We examine 5-digit level comparison in section 5.1.

[*9] BEA's Output price is available until 2001. Here, we extended it to 2003 using fixed weights based on BEA's methodology described in section 3.

prices in the U.S.? Second, *can index number methodology and aggregation weights explain the price gap between the BEA and WPI/CGPI prices?* In the first part of this paper, we examine these two questions.

3 Price Statistics in the U.S.

In the U.S., computer prices at the commodity level are estimated by the Bureau of Labor Statistics (BLS) as a part of their Producer Price Index (PPI) program. These prices are estimated hedonically, that is adjusted for quality and performance improvements in computers.[*10]

These detailed prices are used by the Bureau of Economic Analysis (BEA) to construct output prices for the computer industry, and investment prices for business and government purchases of computer capital goods, all of primary importance in analyzing the role of computers in economic growth.[*11] Additionally, the BLS and BEA aggregate the detailed commodity prices to create higher level price aggregates, for example the price index for Electronic Computers discussed in section 2.

A diagram of the role of BLS and BEA in the production of U.S. computer price statistics is presented in Figure 5. In recent years, BLS produces detailed PPI data, the first step in the production of U.S. prices. This BLS data is used by the BEA to produce computer investment prices, and 3- and 4-digit output prices. Similarly, the BLS aggregates their detailed PPI data to calculate 3- and 4-digit industry and commodity prices. The figure portrays what can be described as a circle of data in the U.S. statistical agencies, as in the end the BLS Office of Employment Projections uses the BEA 3-digit output price to deflate their concept of output in industry SIC-357.[*12]

3.1 Quality Adjustment

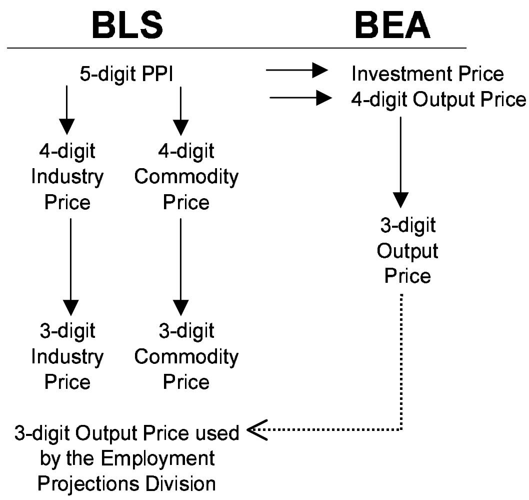
As discussed in the previous section, the BLS starts the estimation process by producing hedonically adjusted computer prices. These estimates adjust unit prices for improvements in computer technology over time. Put simply, the computer of today is significantly more advanced than a computer from ten years ago, and a hedonic adjustment is one possible way

[*10] The importance of quality adjusted prices for IT goods is discussed in Jorgenson[2001]. The impact of hedonic computer prices on GDP is discussed in Landefeld–Grimm[2000].

[*11] The price index for personal (household) purchases of computers is based on the Consumer Price Index (CPI) produced by BLS.

[*12] BLS's decision to use the BEA deflator relates to our discussion of aggregation methods described below, which is of central importance in analyzing the price difference in the U.S. and Japan. Furthermore, the use of the BEA price index for SIC-357 is an exception; the Office of Employment Projections uses BLS estimates to deflate the vast majority of their industry output.

Fig. 5 U.S. Computer Price Statistics: BLS and BEA



to capture this improvement in quality. In the U.S. National Accounts, hedonically adjusted computer prices were introduced in December 1985 representing five types of computer equipment: processors, disk drives, printers, displays, and tape drives covering 1972-1984 (Wasshausen[2002]). In 1987, a hedonic price was introduced for personal computers, beginning in 1983.

Adopting BEA's research, the BLS, who has the responsibility for producing price statistics in the U.S., incorporated hedonic prices for computers into their PPI program in the early 1990s. Since then, BEA has used BLS computer prices to update their estimates, extrapolated their series back to 1958 using other studies, and changed their aggregation methodology to Chained Fisher aggregation. Overall, researchers agree that the U.S. system has been the most successful in capturing quality adjusted computer price declines.

In addition to spending on computers, 2.95 percent of GDP in 2000, BEA employs hedonic prices for components of software(1.04 percent of GDP), structures(5.45 percent), telecommunications(0.36 percent), photocopiers(0.04 percent), audio and video equipment(0.50 percent), apparel(2.44 percent), household appliances(0.31 percent), rent(9.57 percent), and educational writing equipment(0.03 percent). In total, BEA deflates 22.7 percent of the components of GDP with hedonically quality adjusted price indexes (13.1 percent if we exclude rent).[*13]

3.2 Computer Price Statistics in the U.S.

We described in the previous section the BLS produces the most detailed computer price statistics. The BLS classifies these prices according to the North American Industrial Classifi-

[*13] BEA's hedonic inventory can be found at http://www.bea.gov/bea/dn/info_comm_tech.htm.

cation System (NAICS).[*14] However, because the most recent BEA output price data is on an Standard Industrial Classification (SIC) basis, it is constructive to review the computer price classification under the NAICS, SIC, and PPI classification systems.

[*14] Details on BLS conversion from SIC to NAICS is available at http://www.bls.gov/ppi/ppinaics.htm.

Table. 2 SIC, NAICS, and PPI Classification for Electronic Computers (SIC-3571)

	SIC		↔	NAICS		PPI(Commodity)		Weight
	3571	Electronic Computers	1.00	334111	Electronic Computer Manufacturing	1151	Electronic Computers	1.000
1	35713	General Purpose Large Scale Processing Equipment	0.71	3341111	Host Computers, Multiusers (Mainframes, Super Computers, Medium Scale Systems, UNIX Servers, PC Servers)	11510111	Large-Scale General Purpose Computers	0.181
2	35714	General Purpose Medium and Small Scale Processing Equipment	0.29			11510112	Mid-range General Purpose Computers	0.240
3	35715	General Purpose Personal Computers and Workstations	0.86	3341117	Single User Computers, Microprocessor Based, Capable of Supporting Attached Peripherals(Personal Computers, Workstations, Portable Computers)	11510114	Personal Computers and Workstations	0.450
4	35716	General Purpose Portable Computers	0.14			11510115	Portable Computers	0.070
5	35717	Other General Purpose Digital Processing Units	0.35	334111D	Other Computers (Array, Analog, Hybrid, or Special Use Computers)	11510121	Other Computers	0.058
6	35718	Special Purpose Hybrid, or Analog Computers, Including Array, Database, Image Processors, etc.	0.65					
7	35710	Electronic Computers, nsk	1.00	334111W	Electronic computers, nsk, total			

↔ indicates 1996 SIC Share of NAICS Category.
Weight: computed weight from the relative importance on 1997 benchmark PPI.

Table. 3 SIC, NAICS, and PPI Classification for Electronic Computer, Peripheral Equipment and Office Equipment(SIC-357)

	SIC		NAICS		PPI (Industry)	
1	3571	Electronic Computers	334111	Electronic Computer Manufacturing	334111334111	Electronic Computer Manufacturing
2	3572	Computer Storage Devices	334112	Computer Storage Device Manufacturing	334112334112	Computer Storage Device Manufacturing
3	3575	Computer Terminals	334113	Computer Terminal Manufacturing	334113334113	Computer Terminal Manufacturing
4	3577	Computer Peripheral Equipment, Not Elsewhere Classified	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing (pt)	334418334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing (pt)
			334613	Magnetic and Optical Recording Media Manufacturing (pt)	334613334613	Magnetic and Optical Recording Media Manufacturing
			334119	Other Computer Peripheral Equipment Manufacturing (pt)	334119334119	Other Computer Peripheral Equipment Manufacturing
5	3578@	Calculating and Accounting Machines, Except Electronic Computers	334119	Other Computer Peripheral Equipment Manufacturing (pt)	334119334119	Other Computer Peripheral Equipment Manufacturing
			333311*	Automatic Vending Machine Manufacturing (pt)	333311333311	Automatic Vending Machine Manufacturing
			333313*	Office Machinery Manufacturing (pt)	333313333313	Office Machinery Manufacturing
6	3579@	Office Machines, Not Elsewhere Classified	339942*	Lead Pencil and Art Good Manufacturing (pt)	339942339942	Lead Pencil and Art Good Manufacturing
			334518	Watch, Clock, and Part Manufacturing (pt)	334518334518	Watch, Clock, and Part Manufacturing
			333313*	Office Machinery Manufacturing (pt)		

3 digit SIC-357 (Computer and Office Equipment) does not directly correspond to 3 digit NAICS 334 (Computer and Electronic Product Manufacturing). NAICS industries marked with an * are allocated differently at the 3 digit level. Ie, Automatic Vending Machines are allocated to 333 (Machinery Manufacturing) and Lead Pencil and Art Good Manufacturing is part of 339 (Miscellaneous Manufacturing) on a NAICS basis, but included (partly) in SIC-357.

(pt) indicates that only part of the NAICS industry is included in the comparable SIC industry.

@ in the SIC code column indicates that the SIC industry cannot reasonably be approximated from NAICS based data. The U.S. Census Bureau estimates that there will be a time series difference of at least 3 percent when comparing total shipments, or sales of the NAICS based counterparts to the 1987 SIC industries.

Table 2 shows the most detailed classification on an SIC, NAICS, and PPI basis. The SIC and NAICS classifications are for the most detailed industry level, while the PPI is for the most detailed commodity level. Since the 5-digit level data is the most detailed available, there is no distinction between industry and commodity prices. On an SIC basis, Electronic Computers are divided into seven categories, while under NAICS, Electronic Computer Manufacturing is divided into four categories. The BLS classifies their detailed data in a hybrid SIC-NAICS system with five categories; basically the NAICS classification with Single User Computers (NAICS-3341117) divided into Personal Computers and Portable Computers.

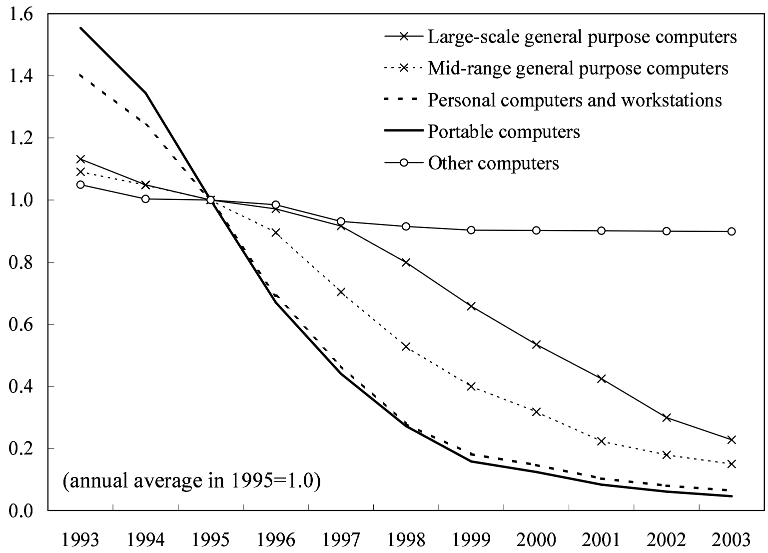


Fig. 6 BLS PPI Data: 5-digit Prices

Also, Table 2 shows the concordance between the 1987 SIC and 1997 NAICS classification system.[*15] Shipments data available in the Annual Survey of Manufacturers show that in 1996, 86 percent of shipments of Single User Computers were General Purpose Personal Computers and Workstations (desktops), while 14 percent of shipments were Portable Computers (laptops).[*16] Share data for the other categories is presented in the Table. In SIC terminology, we call the most detailed commodity/industry classification 5-digit, the price aggregates, like Electronic Computers(SIC3571), 4-digit, and the more higher level prices like Computer and Office Equipment (SIC357), 3-digit. We compare the classification presented in table 2 to that of Japan in a later section.

[*15] Details provided in the 1997 Economic Census, Manufacturing Subject series, Appendix G which provides a detailed mapping between 1987 SIC codes and 1997 NAICS, http://www.census.gov/prod/ec97/97m31s-ps.pdf.

[*16] The Annual Survey of Manufactures is a survey conducted by the Census Bureau for years between the Economic Census, which is conducted at five year intervals http://www.census.gov/econ/overview/ma0300.html.

In order to consider higher level aggregates, we present the 3-digit concordance between SIC, NAICS, and PPI in Table 3. Again, this concordance is important to reconcile the statistics produced by the BLS and BEA. At the 3-digit level, SIC-357, Electronic Computer, Peripheral Equipment and Office Equipment, is made up of six 4-digit SIC industries: Electronic Computers (SIC-3571), Computer Storage Devices(SIC-3572), Computer Terminals (SIC-3575), Computer Peripheral Equipment NEC (SIC-3577), Calculating and Accounting Machines (SIC-3578) and Office Machines NEC (3579). Under the NAICS classification, SIC-3571, SIC-3572, and SIC-3575 have direct counterparts, however, the concordance between the remaining industries indicates that some NAICS industries must be only partially allocated (pt) to the corresponding SIC industry. For example, part of NAICS industry 334119, Other Computer Peripheral Equipment Manufacturing gets allocated to SIC-3578 and part gets allocated to SIC-3579, although this distinction does not play a meaningful role in our analysis, since we exclude SIC-3578 and SIC-3579. It is also important to note that under the NAICS system, some of the components get allocated to different industries at the 3-digit level. In the case of SIC-357, part of Automatic Vending Machines is included, but under NAICS, this industry is included in Machinery Manufacturing, NAICS industry 333.

The tables mentioned above present the detailed and higher level industry classifications that we use to examine prices on the 5-,4-, and 3-digit, respectively. In this paper, we start at the most detailed level, and build to more aggregated results. The 5-digit computer prices constructed by the BLS are presented in Figure 6.[*17] The figure shows that Portable Computers are the most rapidly falling component of Electronic Computers, 35.2 percent per year since 1993. Personal Computers and Workstations declined almost as rapidly, 30.8 percent per year. Large and Midscale General Purpose Computer prices fell at 16.0 and 19.8 percent per year, respectively. Other computers declined a modest 1.5 percent per year.[*18]

3.3 Aggregation: BLS and BEA

The concordance table and shipments data presented above is important because both the BLS and BEA use this data as weights to construct higher level price aggregates.

The BLS constructs a *commodity* price index for Electronic Computers, an aggregate of the five PPI product categories in Table 2. Additionally, BLS constructs an *industry* price based on the same detailed product categories, but using different weights. Another set of weights is used by the BEA to construct an aggregate industry output price.

[*17] Note that at the 5-digit level, BLS industry and commodity prices are equivalent.

[*18] 2002 and 2003 data for Other Computers is extrapolated based on most recent available data.

3.3.1 BLS: Weighting and Index Numbers

Conceptually, the different weighting schemes are employed to construct meaningfully different price aggregates. The BLS industry price uses *Net Output* shares derived from the 1997 Economic Census and BEA Input-Output tables as base year weights. The difference between *net* and *gross* output is that *net* output subtracts intra-industry shipments, thus eliminating the double-counting of computers and computer components manufactured by establishments in the Electronic Computers industry and shipped to other establishments in the same industry.[*19] In the Electronic Computers industry, Net and Gross Output are equivalent to Net and Gross Shipments.

BLS constructs a *commodity* price index that is meant to capture price movements of computers produced and shipped across all industries and all establishments.[*20] Here, the BLS uses Gross Revenues of each product as base year weights in value form.[*21]

We write base year in year t as $\alpha(t)$. Given the base year weights described above, $\omega_{\alpha(t),i}$, the BLS aggregate price indexes, I_t, are defined as:

$$I_t = I_{t-1}\frac{\sum_i \omega_{t,i}}{\sum_i \omega_{t-1,i}} \tag{1}$$

where

$$\omega_{t,i} = \omega_{\alpha(t),i}\frac{p_{t,i}}{p_{\alpha(t),i}} \tag{2}$$

The BLS aggregation is described as a modified Laspeyres formula.[*22] BLS uses this formula to construct their *commodity* and *industry* price aggregates.

We highlight the difference between the BLS industry and commodity price in Figure 7. In this figure, the industry and commodity price are based on the same underlying 5-digit prices, namely those shown in figure 6. From 1993, the industry price fell an average of 16.1 percent per year, while the commodity price fell 21.3 percent per year. Given that the aggregation procedure for both series is the modified Laspeyres, and underlying 5-digit price data are the same, the difference in the industry and commodity price can be attributed to the difference between Net Output and Gross Revenue weights used in aggregation.

[*19] Using the concept of Net Output, BLS attempts to construct price indexes that represent prices of goods sold to establishments outside of the industry.

[*20] The commodity and establishment distinction is trivial for NAICS Computer products 334111, 334112, 334113, and 334119 since all products are classified by commodity. That is, all shipments of desktop computers are allocated to Single User Computers (NAICS 3341117) regardless of the classification of the shipping establishment.

[*21] The Gross Revenue of a product is equal to the total revenue from product shipments across all industries and establishments. Includes items such as maintenance costs and repair services.

[*22] BLS methodology can be found at http://www.bls.gov/opub/hom/homch14_e.htm. BLS benchmarks their weights to the Economic Census every five years.

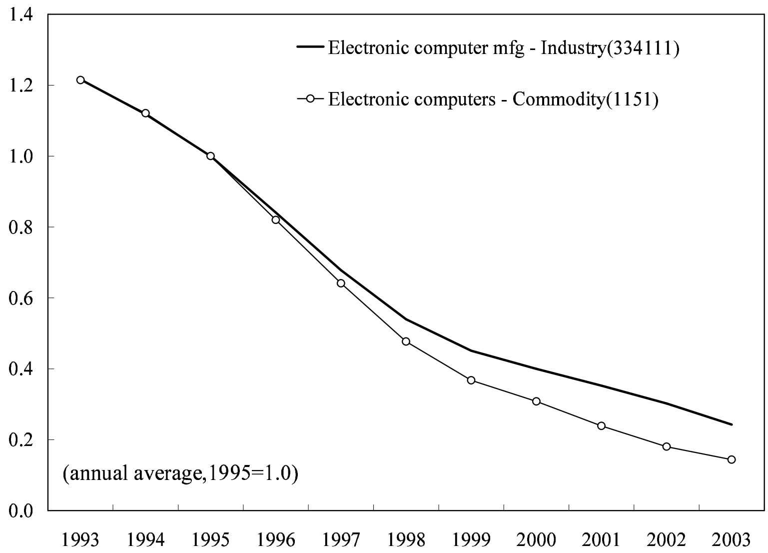


Fig. 7 BLS PPI Data: 4-digit Prices

3.3.2 BEA: Weighting and Index Numbers

Similar to the BLS, the BEA's Industry Division publishes industry shipment prices at the four digit SIC level, 3571 in Table 2, for the manufacturing sector. The seven components of the BEA shipments price are also presented in Table 2. While the underlying prices are the same as those used by BLS, the weights and aggregation method differ.

BEA uses *Gross Output* weights and Chained Fisher Aggregation to construct aggregate prices. Gross Output weights are taken from the Census Annual Survey of Manufacturers.[*23]

Given the annual weights, ω_t, and BLS's 5-digit price indexes, BEA's four digit aggregate price is calculated as:

$$I_t = I_{t-1} \sqrt{\left(\sum_i \omega_{t-1,i} \frac{p_{t,i}}{p_{t-1,i}}\right)\left(\sum_i \omega_{t,i} \frac{p_{t,i}}{p_{t-1,i}}\right)}, \tag{3}$$

the geometric average of the Chained Paasche and Chained Laspeyres indexes.

3.3.3 The Gap between BEA and BLS

Based on the understanding that the 5-digit prices underlying the BLS PPI and BEA output prices are the same, but the methodology used in aggregation is different, we now have a complete picture and answer to the first question posed in this paper. In Figure 8, we convert

[*23] The ASM in annual sample survey conducted in years between the Economic Census.http://www.census.gov/prod/www/abs/industry.html.

the BEA and BLS prices to a common methodology, the Chained Fisher aggregated index. The BLS price is converted using BEA type gross output weights from the Annual Survey of Manufacturers, the same weights used by BEA. The figure shows that BLS's reconstructed output price and BEA's output price behave almost identically during 1993-2002. BEA's price falls an average of 26.8 percent per year while the recalculated BLS price falls 26.2 percent per year. When comparing the data from BEA and BLS, the discrepancy between BLS's PPI and BEA's Industry Output prices can be explained by aggregation method and weights used in aggregation. Although, each agency and each division is attempting to capture slightly different concepts, so these differences be meaningful.

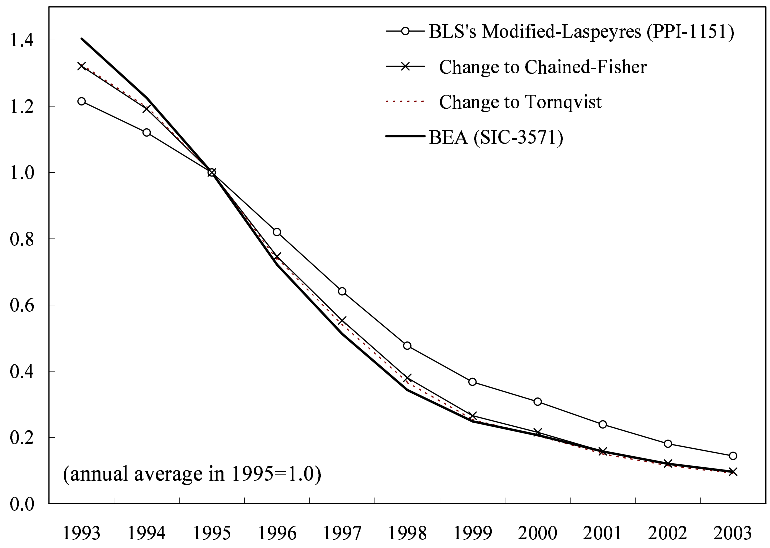


Fig. 8 Impact of Aggregation on PPI: SIC-3571

4 Price Statistics in Japan

In Japan, the two main data sources for price statistics are the BOJ's WPI/CGPI and the Consumer Price Index (CPI) produced by Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT). Here, we examine the available data, explain the classification system and methodology used to adjust for quality change, and describe aggregation methods.

4.1 Quality Adjustment

As with BLS's PPI, BOJ's WPI/CGPI carefully tries to identify the quality change and the pure price change. They use mainly two adjustment methods: the traditional approach and hedonic approach. We use "traditional approach" as a generic name of several methods excluding the hedonic approach. Traditional methods consist of the overlap method, production cost method, and so on. The overlap method assumes that the price difference between old and new products in the market is equivalent to the difference in quality. The production cost method is used to evaluate the additional increased cost for the quality improvement.

Table. 4 Use of Hedonic Approach on WPI/CGPI in Japan

commodity	periods
Personal Computer[1)]	1990(1990 benchmark WPI)– now
Mainframe	1990(1990 benchmark WPI)–2000(1995 benchmark WPI)
Magnetic Disk Devices	1990(1990 benchmark WPI)–2000(1995 benchmark WPI)
Digital Camera	2001(1995 benchmark WPI)– now
Video Camera	2001(1995 benchmark WPI)– now
Servers[2)]	2000(2000 benchmark CGPI)– now

[1)]Desktop-PC and laptop-PC are estimated hedonically, respectively.

[2)]Servers is one of items in "General Purpose Computers & Servers".

As shown in Table 4, BOJ started to use the hedonic approach from the 1990 benchmark revision for Personal Computers, Mainframes, and Magnetic Disk Devices, regressing the hedonic function on an annual basis.[*24] After 2000, Digital Cameras and Video Cameras also are estimated hedonically. On the other hand, BOJ discontinued to use the hedonic approach for Mainframe and Magnetic Disk Devices after 2001, because of a lack of the credible common characteristics data.

In the BOJ's 2000 benchmark revision, WPI was vastly improved. At the same time, they changed the name of statistic from WPI to CGPI. CGPI is composed of DCGPI (Domestic Corporate Goods Price Index), EPI (Export Price Index), and IPI (Import Price Index). BOJ increased the number of sample prices to be surveyed by 69 percent (63 percent only for DCGPI), from 4902 (3379 for domestically produced goods) in 1995 benchmark WPI to 8264 (5508) in the 2000 benchmark CGPI. Since the 2000 benchmark revision, the CGPI uses the hedonic approach for Servers, which is a component of "General Purpose Computers & Servers", in addition to Personal Computers and Digital and Video Cameras.

Compared to the CGPI, the CPI mainly uses the overlap method for quality adjustment. After the 2000 benchmark revision of the CPI, the Statistics Bureau of MPHPT started to estimate quality improvements for desktop and laptop PCs, adjusting these two items hedonically using POS (Point of Sales) data which covers all sales at 3400 major shops across

[*24] Personal Computers in WPI/CGPI consists of desktop-type and a laptop-type PCs below the commodity level. BOJ estimates the hedonic function for two types of PCs and raises the frequency twice per year. The functional form, data, and the estimation results by hedonic approach of the WPI are in BOJ[2002].

Japan.[*25]

4.2 Computer Price Statistics in Japan

Table 5 shows the classification of Electronic Computers under the WPI/CGPI and CPI systems in Japan, with the comparison to that of BLS's PPI. Compared to the U.S. classification in Table 2, the Japanese classification of computers is not as detailed. Before the 2000 benchmark CGPI, WPI has only one published classification, although BOJ estimated it from more detailed items which make up Electronic Computers. However, in a supplemental research study, BOJ[2001b], published the price for Personal Computers after 1995.[*26]

Table. 5 CGPI, CPI, and PPI Classification after 2000

CGPI		CPI	PPI	
Electronic Computers			1151.Eelectronic Computers	
	General Purpose Computers & Servers	(n.a.)		11510111.Large-Scale General Purpose Computers 11510112.Mid-Range General Purpose Computers 11510121.Other Computers
	Personal Computer	Desktop PC		11510114.Personal Computers and Workstations
		Laptop PC		11510115.Portable Computers

CGPI: BOJ(Japan), CPI: MPHPT(Japan), PPI: BLS(U.S.)
CGPI's Electronic Computer has been separated from Computer Peripheral Equipment since 1990 benchmark WPI. PC and Non-PC was separated in 2000 benchmark CGPI.
Personal computer is available also after 1995 on BOJ[2001b].
PCs on CPI is available after 1995 on MPHPT[2000].

Figure 9 portrays the BOJ's revision of the price of Electronic Computers from WPI to CGPI. The annual average growth rate of the Laspeyres price index and Chained Laspeyres WPI is -14.1 percent and -25.8 percent, respectively, from January-2000 and November-2002. The revised CGPI data was -35.4 percent and -36.5 percent, respectively. The revision to Electronic Computers prices results not only from the new application of hedonic estimates to Servers described in section 4.1, but also reflects the increased sample size, changes in the methodology used for mainframes, and other factors.

One interesting property in Figure 9 is that the gap between the fixed Laspeyres price and the Chained Laspeyres price is much bigger in the WPI version than the 2000 CGPI version.

[*25] The results of the hedonic regressions done by CPI can be found in MPHPT[2000]. CPI starts incorporates hedonics for digital cameras after 2003.

[*26] CPI officially publishes the price of laptop and desktop PCs from 2000. However, MPHPT published it from 1995 as trial calculation (see MPHPT[2000]). BOJ[2001b] compares the price of Personal Computers in the WPI with MPHPT's CPI in Japan and BLS's PPI in the U.S. during 1995–1999. They indicate that there is not a big difference among three statistics. We examine the comparison of PC and Non-PC prices in section 5.1.

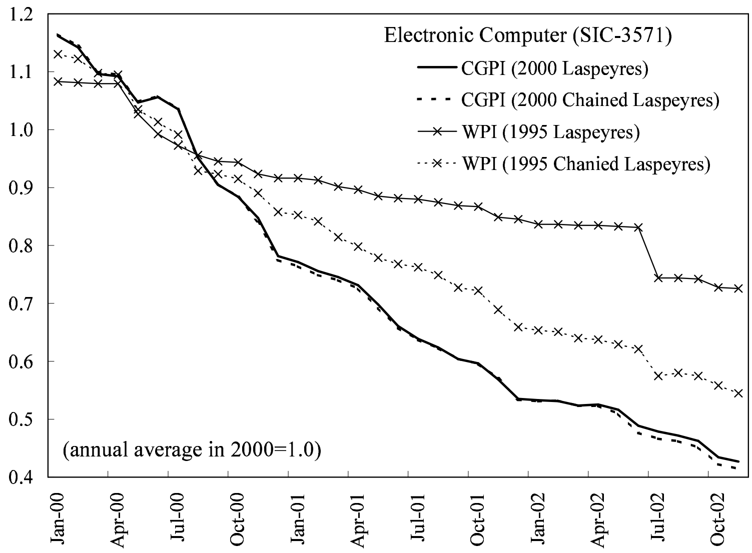


Fig. 9 Revision of Computer Price from WPI to CGPI

This result suggests that the 2000 weights, which are the benchmark weights for the CGPI do not vary much between January 2000 and November 2002, as there is a very small difference between the chained and un-chained versions. On the other hand, this figure indicates that the benchmark 1995 weights used in the 1995 based WPI change considerably over the same time period. Estimates of the CGPI component weights can be seen in below in Table 8.

The comparison of Personal Computer prices between CGPI and CPI is in Figure 10, which shows monthly data from January 2000 to December 2003. Although each price is estimated hedonically with different data sources by BOJ and MPHPT respectively, the results are very similar.

4.3 Aggregation: Weighting and Index Numbers

To aggregate the detailed commodity prices discussed above, WPI/CGPI uses the fix-weight Laspeyres formula as basic index and also constructs aggregate prices using the Chained Laspeyres formula as a reference index (BOJ[2002]). We should note that chained and un-chained versions of the two price indexes of WPI/CGPI are different even at the most detailed commodity level, reflecting different item weighting within the detailed commodities. One commodity usually consists of multiple items ("sample prices"), which are not published. The Laspeyres price index uses arithmetic aggregation of these item prices while the chained version uses geometric aggregation. Although the aggregation method is different, the weights

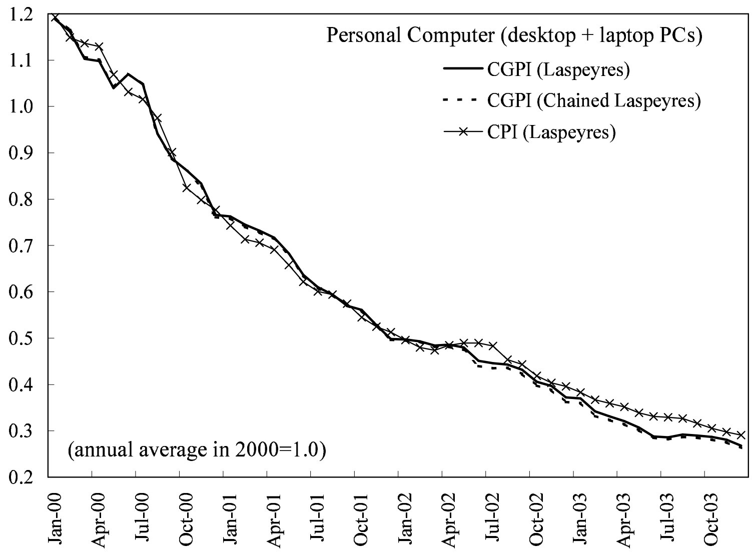


Fig. 10 PC Price: CGPI vs CPI

used in aggregation of different items within one commodity are equalized.[*27]

The weights used in the WPI/CGPI to aggregate different commodities are based on the value of producers' shipments for domestic demand, which are calculated by subtracting the value of exports from the value of total producers' shipments.[*28] Since the target of WPI/CGPI is the domestic demand price, the weights they use for aggregation is different from BLS's PPI and BEA's Output Price. Table 6 shows a comparison of the weight definitions used in aggregation for the PPI Industry Price, PPI Commodity Price, BEA's Industry Output Price, and the WPI/CGPI. For our purpose of comparing computer output prices between the U.S. and Japan, which include exports, we should change the definition of the aggregation weight used in the WPI/CGPI to that of BEA, as we examine in section 5.2.

CPI also uses the fixed weight Laspeyres formula. In the CPI, the weights assigned to items are calculated on the basis of average expenditures per household, derived from the Family Income and Expenditure Survey which is also published by MPHPT.

[*27] Some particular commodities have groups of items instead of individual items. The weights of the different groups are based on the observed values, although the item weight is equalized within one group (BOJ[2003]). On the other hand, BLS's PPI basically uses the observed weights for individual items to aggregate from the item to commodity level.

[*28] Export data is from the Japan Exports & Imports published by the Ministry of Finance (MOF) and total producers' shipment data is from Census of Manufactures published by the Ministry of Economy, Trade and Industry (METI). For those non-manufacturing products whose producers' shipments value is not available from the Census of Manufactures, other statistics compiled by official organizations and cooperating associations are used as substitutes.

Table. 6 Weight Definitions of PPI, BEA, and WPI/CGPI

		Establishment Base		Commodity Base	
		Net	Gross	Net	Gross
Shipment					
	Domestic Demand				WPI/CGPI
Revenue					PPI(Commodity)
Output		PPI(Industry)			BEA-Output

PPI(Industry): PPI Industry Price, PPI(Commodity): PPI Commodity Price.
Domestic Demand=Total Shipment -Export
Revenue=Shipment+Revenue from Processing, Maintenance, Repair, By-product, etc
Output=Revenue+Net Increase of Finished-goods & Work-in-process Inventory

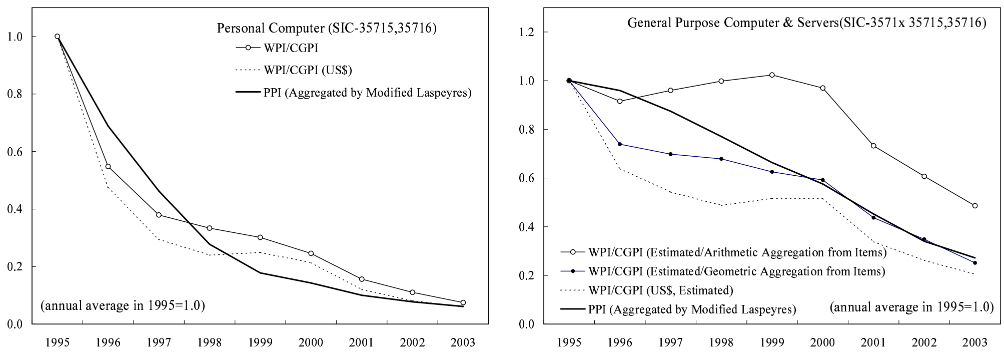
5 Sources of the Price Gap

5.1 5-digit SIC: PCs and Non-PCs

At the 5-digit level, i.e. the components of Electronic Computers (SIC-3571), BOJ's CGPI publishes only two commodities, PCs (SIC-35715,35716) and General Purpose Computers & Servers (SIC-3571x35715,35716), which we refer to as Non-PCs here. However, before the 2000 benchmark revision CGPI, BOJ published only two 4-digit WPI price indexes: the Laspeyres and Chained Laspeyres versions of Electronic Computers (SIC-3571). As mentioned earlier in section 4.2, BOJ[2001b] published the price of PCs after 1995, in addition to the more aggregated price of Electronic Computers. Since our objective is to compare prices at the 5-digit level, we use the information on Electronic Computers (PCs plus Non-PCs) and PCs to back out the price of Non-PCs in the WPI during 1995–2000. This gives us a price index of PCs and Non-PCs during 1995-2000 based on the WPI and from 2000 forward based on the CGPI.

Figure 11(a) compares PC prices produced by BLS(PPI) and those produced by BOJ(WPI/CGPI) over 1995–2003. For comparison purposes, the PPI is aggregated by the modified Laspeyres price index to a PC price index from Personal Computers and Workstations (11510114) and Portable Computers (11510115) using annual gross output weights from the U.S. Census Annual Survey of Manufacturers.[*29] The results at the 5-digit level are similar to the 4-digit comparison in Figure 4(a) which suggests that Electronic Computer prices in the U.S. and Japan have similar declines. Also at the 5-digit level, PC price declines are very similar, declining 32.4 percent in WPI/CGPI and 34.9 percent in the PPI, as shown in Table 7. Additionally, when we factor in the change of the exchange rate between the U.S. and Japan, the annual decrease of WPI/CGPI evaluated in US Dollars is 35.2

[*29] A small caveat is that Workstations are included in PCs in the PPI and in Non-PCs in the WPI/CGPI.



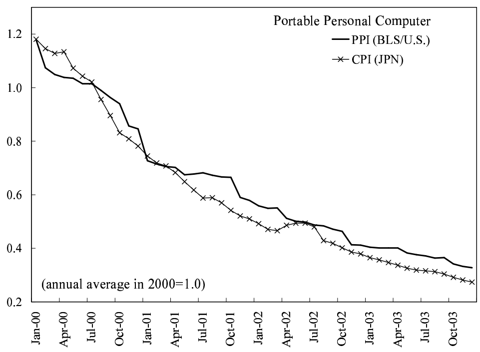
(a) Personal Computers (b) General Purpose Computers & Servers

Fig. 11 WPI/CGPI and PPI: 5-digit SIC

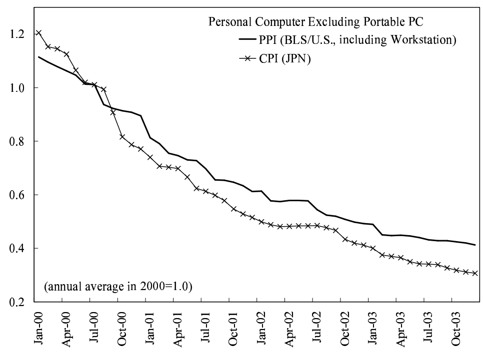
percent, 0.4 percent points faster than that of the U.S. PPI.

After 2000, we can further decompose the PC price, although BOJ does not publish this level of detail in CGPI, and compare the prices of Laptop-PCs and Desktop-PCs using the CPI in Japan and PPI in the U.S. In order to do this comparison, first we assume that the CPI Laptop and Desktop prices are a reasonable proxy for CGPI prices. As shown in Figure 10, the CPI PC price approximates the CGPI price. Since the PC price is an aggregate of laptop and desktop prices, we conclude that the CPI Desktop and Laptop prices reasonably approximate the CGPI prices and compare the prices to the U.S. in Figure 12. From January 2000 to December 2003, desktop prices fall an average of 25.4 percent per year in the U.S. and 34.9 percent per year in Japan. Comparing laptop prices, we see the prices in the U.S. decreased 32.7 percent per year and 37.3 percent per year in Japan. Given the remarkable similarity of PC prices, and the comparability of the more detailed Laptop and Desktop prices, we can conclude that there is not a big gap in PC prices between the U.S. and Japan.

Although the comparison of PC prices is relatively straight-forward, to compare the non-PC price, the other 5-digit piece of Electronic Computers, we have to dig a little deeper because of data constraints. We mentioned in section 4.3, that the "commodity" is the most detailed unit published for price comparisons. However, commodities are made up of items, or groups of similar items. Based on item prices, BOJ, starting in 1995, includes two price series for each commodity by using different item aggregation methods, an arithmetic average and geometric average of the underlying item prices. The arithmetically averaged prices underlie the Laspeyres price, while the geometrically averaged item prices are used in the Chained Laspeyres version. At this point, it is important to consider the difference between items and groups. An item is a single good, while a group is a composite of similar items. In



(a) Laptop PC



(b) Desktop PC

Fig. 12 Prices of Laptop and Desktop PCs: PPI vs CPI

aggregating from items or groups to commodities, item weights are always equal, but groups of similar products may be aggregated using group weights. In the unchained version of the price index, group weights are fixed in the reference year, while the chained version uses group weights that vary over time. Hence, differences between the chained and unchained BOJ price indexes may be due attributed to 1) arithmetic or geometric aggregation of items, or 2)group weights that are fixed in the Laspeyres price, but vary over time in the Chained Laspeyres price index.

For PCs and Non-PCs, we can directly compare the chained and unchained prices from the 2000 benchmark CGPI. The gap of annual growth rates of the two prices of PCs is around 0.6 percent during January 2000–December 2003, almost no difference at all. For Non-PCs, on the other hand, the price gap is 4.4 percent annually. In order to compare prices before 2000, we back out the chained and unchained price index using available information on the PC price and the chained and unchained versions of the price of Electronic Computers, and an assumed base year weight of 0.473 for PCs.[*30] We can see in the 1995 benchmark WPI, the difference between the Laspeyres and Chained Laspeyres price of Electronic Computers

[*30] The 1995 benchmark WPI publishes the Laspeyres and Chained Laspeyres aggregated prices for electronic computers. We compute the arithmetically averaged Non-PC price, assuming that the geometric and arithmetic PC prices are equivalent and that the weights are equivalent to the shipment weights for domestic demand published by JEITA. We compute the geometrically averaged Non-PC price by extrapolating between the 1995 WPI and 2000 CGPI weights estimated using JEITA data. The result of the reverse calculation is sensitive to the base weight. The total shipment weight of PCs is 0.449 in 1995 and 0.618 in 2000 by the survey of JEITA (Japan Electronics and Information Technology) as shown in table 8. On the other hand, the shipment weight for domestic demand of PCs is 0.417 in 1995 and 0.620 in 2000 by JEITA. The weight used in 2000 benchmark CGPI is 0.789. Here, we assume the weight in 1995 is the mean of 0.417 and the 0.789/0.620*0.417.

is 8.1 percent annually (Laspeyres -11.9 percent and Chained Laspeyres -20.0 percent) during 1995–2000. After making the reasonable assumption that the two PC prices are equivalent, most of the gap between the arithmetic and geometric price gets allocated to non-PCs, and the gap is 9.9 percent annually from 1995 to 2000. As shown in Figure 11(b), the Non-PC price gap between the PPI and unchained WPI is much larger than that of PCs as Japanese Non-PC prices are basically flat in the late 1990s.[*31] Overall, the Non-PC price decline is 9.0 percent per year in Japan, 7.3 percentage points slower than that of the PPI during 1995–2003. Obviously, the gap of the Non-PC is more significant than that of the PC.

The gap between PC and Non-PC prices is presented in Table 7. As mentioned earlier, there is almost no price gap when comparing PC prices; the Chained Fisher U.S. PPI falls 34.9 percent during 1995-2003, while we estimate that prices in Japan fall 35.2 percent per year when converted to U.S. dollars. For Non-PCs, when we rely on 1995 weights to estimate the Non-PC price, the price gap between the U.S. and Japan is significant, Non-PC prices fall 17.8 percent per year in the U.S. and only 9.0 percent per year in Japan, a gap of 8.8 percent per year. A possible explanation for this price gap can be seen by understanding the market for Non-PCs in Japan. In the Japanese mainframe market in 1995, unlike in the world market, Japanese vendors had more than half of the domestic market share, so the Non-PC market was less competitive than that of the PC.[*32] Compared to the U.S., where the PC price declines almost twice as fast as the 16.3 percent annual decline in the non-PC price, the Japanese PC price falls about 3.6 times as fast, possibly reflecting the high sunk cost for mainframes and servers and the relatively less competitive market. On the other hand, when we factor in the changing structure of the Non-PC market by incorporating underlying weights that change over time, we see that the price for Non-PCs falls even faster than the U.S. price, 17.3 percent per year, and at almost the same rate relative to Non-PC prices as in the U.S. After making these adjustments, we see the Non-PC price gap vanishes as well!

Although we have clarified the price gap for PCs and non-PCs, we cannot present a full picture at the 5-digit level since more detailed prices and weights are not available.[*33] However, factoring in the similar prices declines of PCs and Non-PCs, we conclude that the price gap during 1995–2003 at the 5-digit level is the true price gap.

[*31] Here, the Non-PC price from WPI is calculated reversely from the Laspeyres aggregated price and that of the PPI is the Chained Fisher aggregated price of Large-Scale General Purpose Computers (11510111), Mid-Range General Purpose Computers (11510112), and Other Computers (11510121).

[*32] In the Japanese market, the vendors of hi-end enterprise servers, unit price of which is more than 50 million yen, are Fujitsu(27.7%), IBM-Japan(23.3%), NEC(16.0%), Hitachi(15.0%), HP-Japan(6.7%), and so on in 2002 (survey of IDC Japan).

[*33] We take note that the price of mainframe computers in WPI during 1995–2000 and servers in CGPI after 2000 were estimated hedonically.

Table. 7 Price Gap of PCs and Non-PCs: 5-digit SIC

	PC		Non-PC	
PPI				
Modified Laspeyres	–34.87		–16.26	
Chained Fisher	–34.86		–17.75	
WPI/CGPI				
[Arithmetic]	–32.39	(2.48)	–9.02	(7.25)
[Geometric]	–32.68	(2.19)	–17.25	(-0.98)
[US$/Geometric]	–35.22	(-0.35)	-19.79	(-3.53)

unit:annnual growth rate(percent). periods:1995–2003. The Price of Non-PC, General Purpose Computers & Servers, on WPI is reversely calculated.
[ ] in WPI/CGPI means the aggregation method from items to commodity.
( ) is price gap between PPI(Modified Laspeyres) and WPI/CGPI.

5.2 4-digit SIC: Electronic Computers

Moving from the 5-digit to 4-digit level, we reconstruct the Japanese price for SIC-3571, Electronic Computers, from the PC and Non-PC prices calculated in section 5.1. Given our conclusion that the 5-digit Japanese prices effectively capture the price change of PCs and Non-PCs, the next piece of the aggregation puzzle is to use the correct weights. Since our purpose is to analyze the production account, we must modify BOJ methodology to use weights that capture total industry production. To do this, we adjust WPI/CGPI aggregation weights from domestic shipment weights, which are defined as total shipments minus exports, to total output weights which include exports. These modified output weights are presented in Table 6. Notice in 2001, when including exports, the adjusted weight of computers in SIC-3571, column JPN, is actually lower, indicating that exports of non-PCs exceed PCs and meaning that the rapidly falling computer prices receive a slightly smaller weight in aggregation compared to the current CGPI weight. Over time, we can see how the computer weight has increased from 37.0 percent in 1993 to 77.6 percent in 2003. On the other hand, in the U.S., the PC weight in SIC-3571 actually decreases over time, falling from 66.2 percent in 1993 to 62.8 percent in 2001, although the weight peeks in 1995 at 79.5 percent.

The second change we make to CGPI methodology is to incorporate an index number methodology that captures the changing weight structure. Relying on a fixed-weight methodology would set the base year weight in Japan equal to 44.9 percent, compared to 79.5 percent in the U.S. in 1995. However, in choosing an aggregation methodology that allows the weights to change over time, we more accurately capture the changing components of industry production.

The results of incorporating these two methodological changes are presented in Table 9.

Table. 8 PC's Weight in Computers

	CGPI	IO	Census	JEITA	JPN	U.S.
1985		24.8			24.8	
1990		34.0			34.0	
1993				27.1	37.0	66.2
1994				31.9	42.6	70.0
1995	(47.3)	56.3		44.9	56.3	79.5
1996				49.1	60.8	77.9
1997				49.1	61.1	63.1
1998				48.9	62.1	69.8
1999			74.0	58.4	71.1	66.5
2000	78.9	74.0	83.7	61.8	74.0	61.1
2001	75.0		81.7	58.0	71.2	62.8
2002			75.8	60.6	73.4	
2003				66.0	77.6	

unit: share of personal computer to the total computer (percent)
CGPI: Shipment weight for domestic demand by CGPI(BOJ)
() WPI Estimated Shipment weight for domestic demand
IO: Output weight by 10-digit production data on Benchmark IO Table
Census: Total shipment weight by Census of Manufacturing(METI)
JEITA: Total shipment weight by JEITA (Japan Electronics and
Information Technology Industries Association (fiscal year)
JPN: Estimated Output weight using JEITA and Benchmark IO
U.S.: Output weight by U.S. Census

We reaggregate 4-digit SIC-3571, Electronic Computers from the two 5-digit WPI/CGPI prices as described above. As shown in section 2 and the top portion of Table 9, the unadjusted WPI/CGPI using a fixed-weight Laspeyres price declines 21.8 percent annually, 7.5 percentage points slower than the BEA Industry Output price during 1995–2003. Table 9 indicates how this gap at 4-digit SIC can be explained by (i)change of the weight definition from shipments for domestic demand to total output weights, (ii)the change of the aggregation method from the item to commodity level, (iii)the change of index number methodology from Laspeyres to Chained Fisher or Theil-Törnqvist , and (iv)the change of price evaluation from local currency to U.S. Dollars.

Focusing on 1995-2003, we can see that, in total, the changed methodology results in a price index that declines 26.95 percent per year, 5.15 percent faster than the BOJ version, explaining 68.8 percent of the price gap. The contribution of each methodological change is decomposed in Table 9 for 1995-2003 and 1995-2001. First, the change to total output weights yields a price index that falls by 0.59 percentage points faster than the WPI/CGPI price and explains 7.9 percent of the price gap. Second, incorporating the price indexes that properly aggregate from items to commodities adds another 0.41 percentage points to the Japanese price decline

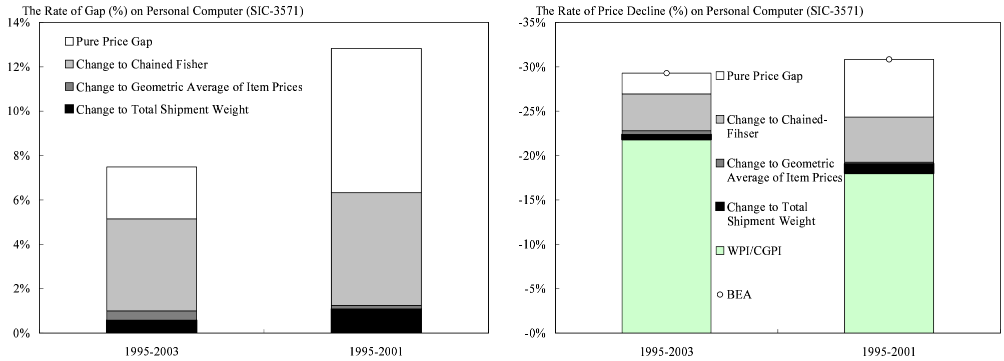
Table. 9 Sources of Price Gap: 4-digit SIC

	1995–2003		1995–2001	
BEA	-29.29		-30.83	
WPI/CGPI(Laspeyres)	-21.80		-18.00	
Price Gap	7.49	(100.0)	12.83	(100.0)
Chained Fisher Index				
Reaggregated WPI/CGPI in Japanese Yen	-26.95		-24.33	
Explained Price Gap	5.15	(68.8)	6.33	(49.3)
Total Output Weight	0.59	(7.9)	1.09	(8.5)
Items Aggregation	0.41	(5.5)	0.15	(1.2)
Chained Fisher	4.15	(55.4)	5.08	(39.6)
Unexplained Price Gap	2.34	(31.2)	6.50	(50.7)
Reaggregated WPI/CGPI in U.S. Dollars	-29.49		-28.60	
Explained Price Gap	7.69	(102.7)	10.60	(82.6)
Theil-Törnqvist Index				
Reaggregated WPI/CGPI in Japanese Yen	-27.34		-24.81	
Explained Price Gap	5.54	(73.9)	6.81	(53.1)
Total Output Weight	0.59	(7.9)	1.09	(8.5)
Items Aggregation	0.41	(5.5)	0.15	(1.2)
Theil-Törnqvist	4.53	(60.5)	5.56	(43.3)
Unexplained Price Gap	1.95	(26.1)	6.02	(46.9)
Reaggregated WPI/CGPI in U.S. Dollars	-29.88		-29.08	
Explained Price Gap	8.08	(107.9)	11.08	(86.4)

unit:annual growth rate(percent). contribution share in ( )

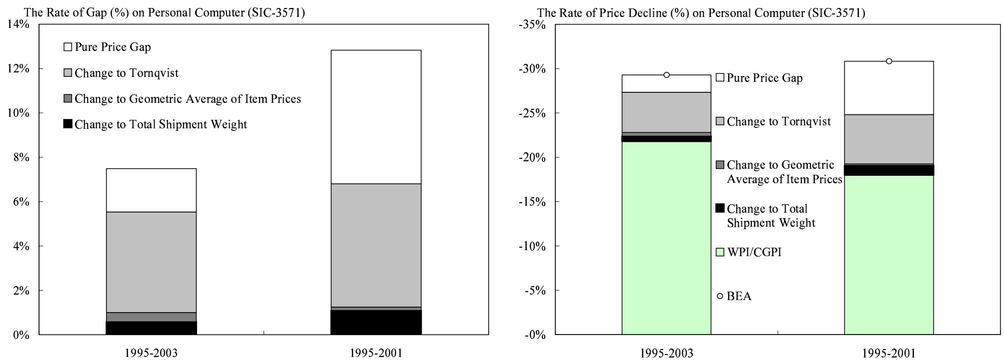
and explains another 5.5 percent of the price gap. The most significant contribution to the faster price decline from 1995 to 2003 is the change in the index number methodology to Chained Fisher. Using this methodology, which takes the changing weights into account, the price index declines an additional 4.15 percent faster per year, which accounts for 55.4 percent of the price gap. Finally, after converting from yen to dollars, the Electronic Computers price falls 29.49 percent per year, slightly faster than the BEA price.

Similar results are obtained when a Theil-Törnqvist index is used instead of the Chained Fisher, the key feature being that both index number methodologies capture how the weights change over time. These contributions are presented in Figure 13(a) and 14(a). Both figures show that the true price gap from 1995 to 2003, after converting to U.S. dollars, is slightly negative, ie prices fall faster in Japan. As shown in 13(b) and 14(b), during 1995-2003, domestic prices fall 29.29 percent per year in the U.S. and 26.95 percent per year in Japan and from 1995 to 2001, 30.83 percent per year in the U.S. and 24.33 percent per year in Japan. For both time periods, we conclude that the incorporating the changes (i)-(iv) described above explains a significant portion of the price gap for Electronic Computers.



(a) Contribution to the Gap (b) Total Decline Rate

Fig. 13 Contribution to the Price Gap between CGPI and BEA: Chained Fisher Index



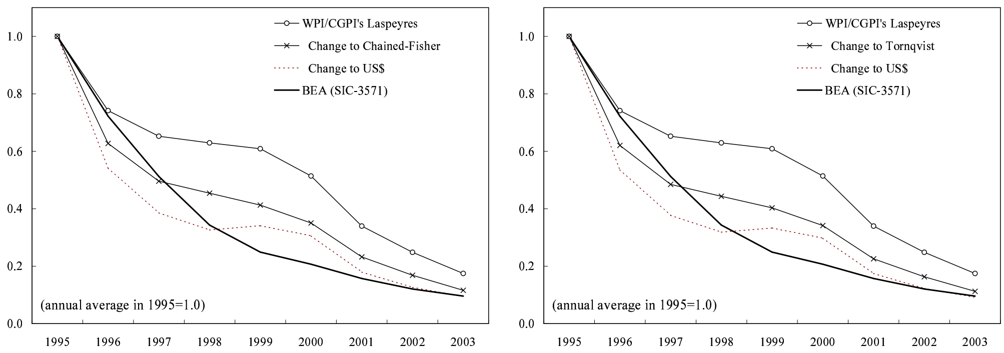
(a) Contribution to the Gap (b) Total Decline Rate

Fig. 14 Contribution to the Price Gap between CGPI and BEA: Theil-Törnqvist Index

5.3 3-digit SIC: Electronic Computer and Peripheral Equipment

After analyzing the price gap at the 4-digit level, the next step is to investigate the price gap at the 3-digit level. Again, we exclude SIC-3578 and SIC-3579, and examine prices for the 3-digit SIC-357x, Electronic Computer and Peripheral Equipment. Although we do not examine the details of peripheral equipment prices in this paper, here we compute the SIC-357x output price based on the reaggregated 4-digit Electronic Computer price presented in section 5.2.

Once again, the first part of the aggregation story that needs to be addressed is the weights.



(a) Chained Fisher (b) Theil-Törnqvist

Fig. 15 Chained Fisher and Theil-Törnqvist Aggregated WPI/CGPI: SIC-3571

The weight of SIC-3571, Electronic Computers in SIC-357x in Japan is shown in Table 10. Similar to the 4-digit level, we adjust the weights used in aggregation from shipment weights for domestic demand to total output weights. Again, the adjusted weights are lower than the CGPI weights, reflecting the fact that in 1995 exports of Peripheral Equipment are almost nine times larger than exports of Electronic Computers. During 1985-2001, the weight of computers in SIC-357x increases from 35.1 to 51.8 percent, dipping to 43.6 in 2002. Compared to the BOJ weights used in the WPI/CGPI, the total output weights increase more rapidly, but start from a lower level, meaning the rapidly falling computer prices are given a lower weight in the beginning of the period, but this weight increases more rapidly than the BOJ weight over time.

To properly capture this changing weight structure, Chain-Fisher aggregation is employed. Based on the weights described above, the 4-digit price of Electronic Computers described in section 5.2 and the Chained Fisher reaggregated price of Peripheral Equipment, and Chain-Fisher aggregation, we construct a price index for SIC-357x and present the results in Figure 16.[*34] The reaggregated Chained Fisher price using the weight of shipments for domestic demand falls 18.9 percent annually during 1995–2003. This decline is 5.5 percentage points faster than the WPI/CGPI Laspeyres price and 1.8 percent points faster than the WPI/CGPI Chained Laspeyres price. However, since the price declines of Peripheral Equipment are more moderate than computer price declines and receive a higher weight when total output

[*34] The price index for Peripheral Equipment is reaggregated using Chained Fisher aggregation, where the weights are shipments for domestic demand. Although the composition within peripheral equipment is changing over time, the price differences of the components is small enough that reaggregation and reweighting does not have a very large impact on the results.

Table. 10 Computer's Weight in Computer and Peripheral Equipment

	WPI	CGPI	IO	JPN	US
1985			35.13	35.13	59.36
1990	41.71		38.92	38.92	66.62
1991				38.05	65.03
1992			35.39	37.09	61.64
1993			35.98	38.58	60.86
1994			39.11	42.88	64.87
1995	52.08		42.45	42.45	68.25
1996	52.08		44.32	44.32	60.88
1997	53.19		44.50	44.50	62.00
1998	53.26		40.23	40.23	60.23
1999	49.81		44.99	44.99	65.08
2000	54.72	55.26	44.57	44.57	64.73
2001	56.92	51.76	50.54	51.76	62.21
2002			43.56	43.56	

unit: nominal share(percent).

WPI/CGPI: Shipment weight for domestic demand by WPI/CGPI(BOJ)

IO: Output weight by Benchmark IO(1985,90,95,2000) and Extended IO

JPN: Estimated Output weight using IO

US: Total Shipment weight by BEA

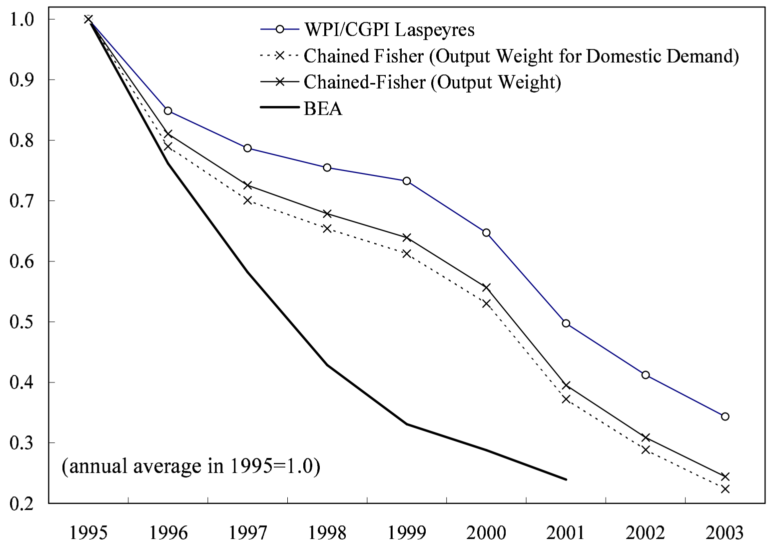
weights are used in aggregation, the decline of the reaggregated Electronic Computer and Peripheral Equipment price using total output weight is more moderate, as the output price for SIC-357x in Japan falls 17.6 percent annually, 1.3 percent slower per year then the price using shipments for domestic demand.

In the U.S., where the output weight of computers in SIC-357x is much higher, the BEA price for SIC-357x falls 23.8 percent annually during 1995-2001, compared to annual declines of 15.5 percent in the Japanese price for the same period. At this level, the price gap reflects the higher computer weight in addition to computer prices that fall slightly faster in the U.S., but may include some other non-explained items. But, at the 3-digit level, while there is still a price difference between the U.S. and Japan, part of this difference can be accounted for by incorporating the methodological changes we have highlighted in this, and previous sections.

6 Extensions: Filling in the Missing Pieces

In the above sections, we carefully examined the computer price gap between the U.S. and Japan at 5-, 4-, 3-digit levels after 1995. Comparing prices before 1995 is difficult because there is no statistical agency in Japan that publishes historical output price indexes at the 3-, 4-, or 5-digit level, unlike in the U.S. where the BEA produces long-term output prices. To fill this gap, although the data constraints are formidable, we construct a long-term price index for

Fig. 16 Reaggregated WPI/CGPI: SIC-357x



Electronic Computer and Peripheral Equipment output in Japan, and extend our analysis to other components of IT, Communications Equipment and Electronic Components.*35 Based on these time series of output prices, we calculate investment prices in section 6.3.

6.1 Long-term Price Index

To construct a historical price index for SIC-357x we rely on multiple data sources. Prices for 1990-1995 are estimated based on available WPI data, while 1970-1990 prices are gleaned from the Linked Input-Output tables published by the Management and Coordination Agency, which has since become part of MPHPT, and prices before 1970 are based on data available from Nikkei data.*36

In order to compute 1990-1995 prices, we reaggregate the basic Laspeyres WPI prices for Electronic Computers and Non-Computers with Chained Fisher aggregation using the weights given in Table 10, although the original Laspeyres price actually declines more rapidly than our reestimated Chained Fisher version.*37

*35 Software, the remaining piece of IT, is not discussed in this paper.

*36 Nikkei data is time series data covering real and nominal output, imports, and exports. Output data covers 1951 to 1968 and import and export data covers 1951 to 1972. This data was estimated at the Nihon Keizai Research Center, directed by Prof. Ozaki at Keio University. Unfortunately, the documentation for this data is no longer available.

*37 The faster price decline for the WPI version relates to our above discussion on weights used in aggregation. The WPI price uses shipments for domestic demand, while the reestimated Chained Fisher price uses gross output weights. Again, the high proportion of exports of Peripheral Equipment results in PC weights that are

Price data from 1970 to 1990 is based on the Linked Input-Output tables which provide nominal and real output data for SIC-357x. This data, which is published in groups of three, covers 1970-1975-1980, 1975-1980-1985, 1980-1985-1990, and 1985-1990-1995.*38 The implicit price of this output is used to determine the price index level in 1970, 1975, 1980, 1985, and 1990.*39 From 1986 to 1990, growth rates are taken from the only available WPI data, a Laspeyres price for PC output, and then linked to the 1985 implicit price given in the Linked I-O table. For years between the available data, simple extrapolation based on similar or slightly broader concepts is used to form the complete time series, and data prior to 1970 is taken from Nikkei.

The results of these estimates are shown in Figure 18 and Table 11 along with the long-term price indexes in the U.S., based on BLS PPI and BEA price data described in section 3.*40 Focusing on the earlier periods, in Japan prices fall 4.3 percent per year from 1960 to 1975, and 5.7 percent per year during 1975-1980, less rapidly than the U.S. for each of the subperiods presented in Table 11.

From 1980 to the early 1990's, as discussed in section 2, this probably relates to the market dominance of NEC in Japan where price declines due to quality improvements may have been dampened by the market power of NEC. Early in the 1990's (1993), NEC introduced a new model PC, priced 50 percent lower than the previous model. Additionally, the competition from increasing imports, as shown in the rising import share in Figure 17, may have spurred downward price pressures. However, this drastic reduction of PC prices in the early 1990's was counter-balanced by rising exports of Peripheral Equipment, whose prices are estimated to fall only 1-1.5 percent per year in the period, resulting in an aggregate price that declines only 5.8 percent per year during 1990-1995, compared to 14.0 percent per year in the U.S. From 1980-2000, for which we have data from all three sources, prices fall 8.6 percent per year in Japan compared to 16.1 percent per year in the U.S. based on BEA data, and 15.2 percent per year based on PPI data. Overall, prices in the U.S. fall almost twice as fast as prices in Japan.

6.2 Extension to Other IT Prices

After comparing the long-term price of Electronic Computers and Peripheral Equipment in Japan to the U.S. price, it is important to determine whether computer prices are a unique

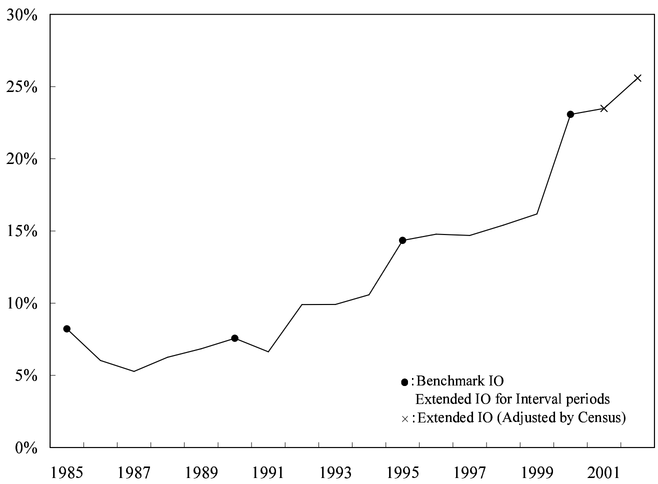
lower and, therefore, slower price declines for SIC-357x. The basic Laspeyres WPI price declines 6.1 percent per year during 1990-1995 while the Chained Fisher version declines 5.8 percent per year.

*38 The first linked Input-Output table covers 1965-1970-1975, but this version does not have details on SIC-357x.

*39 There is some discrepancy between growth rates of the of the implicit deflators in different versions of the tables. We choose the most reasonable deflator with the fastest price decline.

*40 The BEA price is for SIC-357x. Due to data constraints, the BLS price index is for SIC-357.

Fig. 17 Import Share of Electronic Computers in Japan: SIC-3571



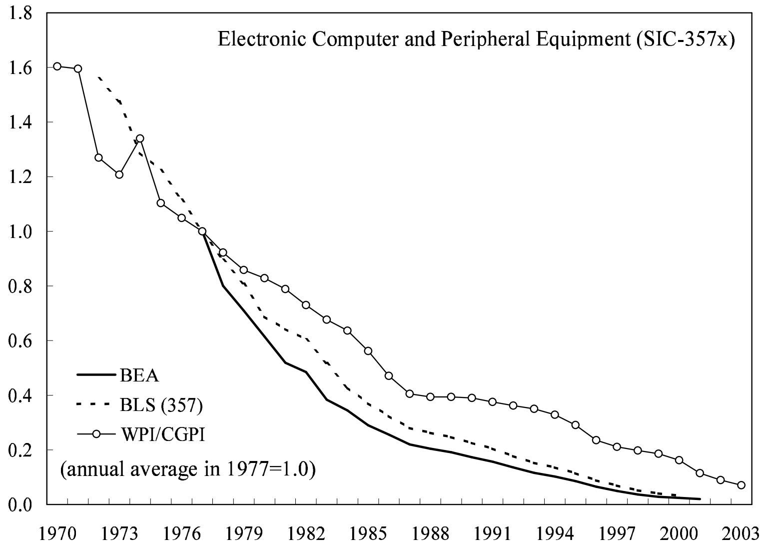
case, or other components of IT behave in a similarly. Moving to these other components, we calculate Japanese price indexes for Communications Equipment (SIC-366) and Electronic Components (SIC-367) based on the best available source data and compare these to data in the U.S.

The time series for the price of Electronic Components is based entirely on BOJ price data from 1970 to 2003.[*41] From 1995 to 2003, we reaggregate monthly WPI/CGPI Chained Laspayres prices for Electronic Components and Electronic Devices as a Chained Fisher index. From 1985 to 1995, the monthly WPI Laspayres price is used, and between the 1970 and 1985, we use annual Laspayres prices for Electronic Devices, which BOJ presents as an aggregate of the prices of Electron Tubes and Semiconductor & Integrated Circuits. Data before 1970 is based on Nikkei data, in a similar manner to the Electronic Computer and Peripheral Equipment price.

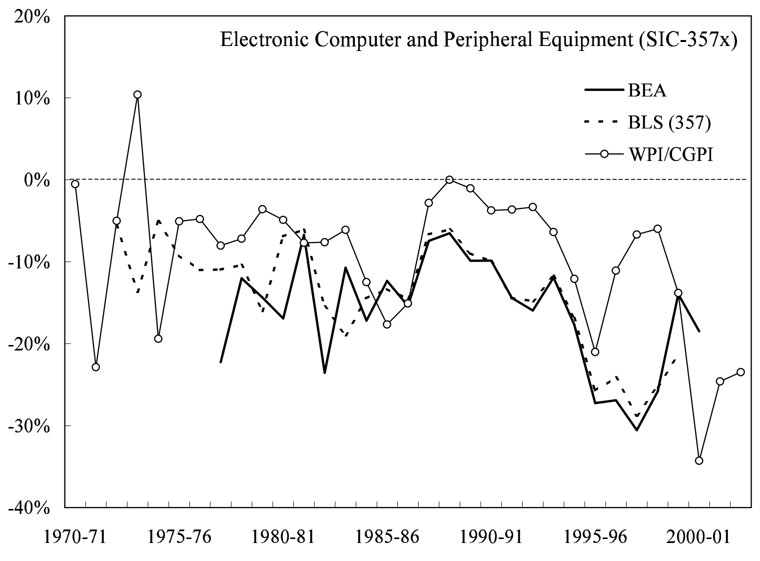
Using these estimates, we present the results in Figure 19 and Table 11. In the early years, from 1960-1975 prices fall 4.7 percent per year and 8.8 percent per year from 1975-1980. Compared to the U.S., during 1980-2000, prices fall 9.6 percent per year in the U.S. based on BEA data, and 8.8 percent per year based on BLS data, while prices fall 7.2 percent per year in Japan. From 1970 to 1990, prices actually fall more rapidly in Japan than in the U.S., as prices decline 8.8 percent during 1975-1980, 6.4 percent from 1980-1985, and 8.1 percent from 1985-1990, compared to 0.2 percent, 2.8 percent, and 3.4 percent per year in the U.S.[*42]

[*41] Electronic Components (SIC-367) consists of eight 4-digit industries; 3671.Electron Tubes, 3674.Semiconductors And Related Devices, 3672.Printed Circuit Boards, 3675.Electronic Capacitors, 3676.Electronic Resistors, 3677.Electronic Coils, Transformers, And Other Inductors, 3678.Electronic Connectors, 3679.Electronic Components, Not Elsewhere Classified.

[*42] The 1975-1980 U.S. data is based on PPI data, while the other periods are based on BEA data.

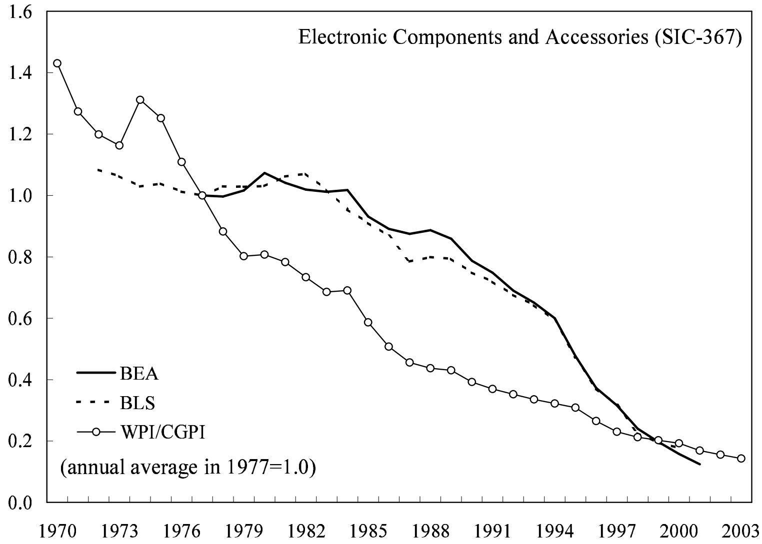


(a) Price Index

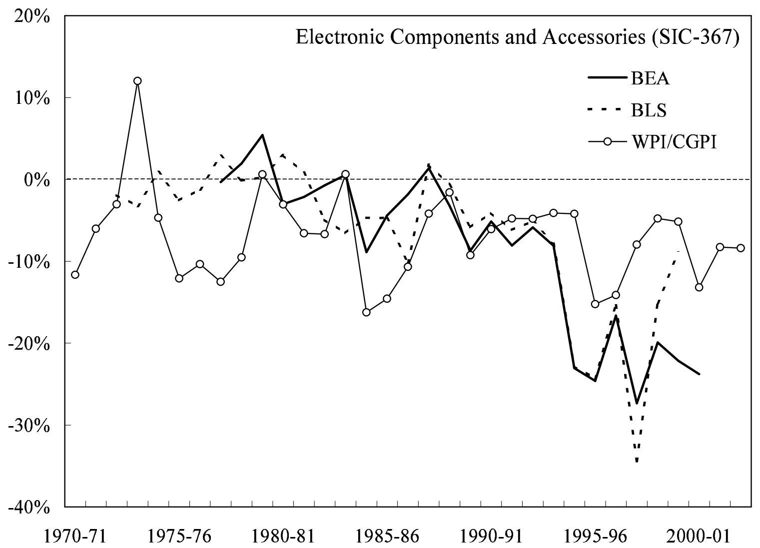


(b) Growth Rate

Fig. 18 Long-term Price of Electronic Computer and Peripheral Equipment (SIC-357x): BEA, BLS, WPI/CGPI

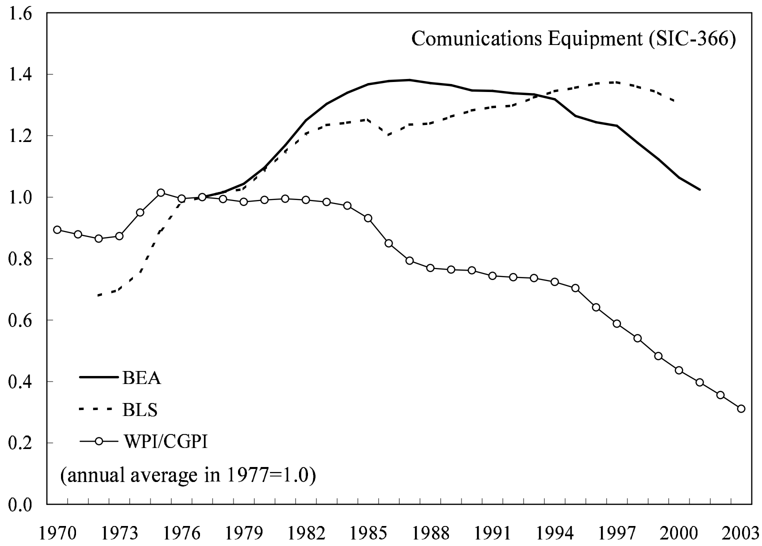


(a) Price Index

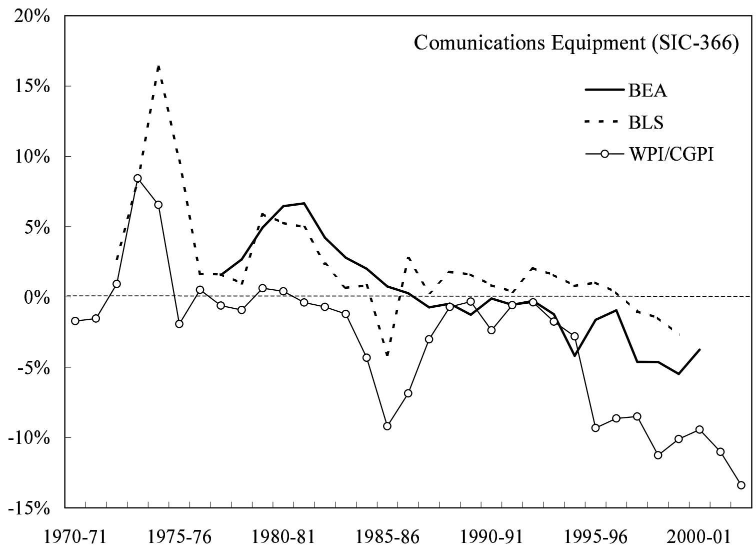


(b) Growth Rate

Fig. 19 Long-term Price of Electronic Components (SIC-367): BEA, BLS, WPI/CGPI



(a) Price Index



(b) Growth Rate

Fig. 20 Long-term Price of Communication Equipment (SIC-366): BEA, BLS, WPI/CGPI

After 1990, price declines in the U.S. accelerate, dropping more than twice as fast as the prices in Japan. The striking differences pre and post 1990 are probably related to developments in the semiconductor industry which began to flourish in the U.S. in the 1990's, but did not develop to the same extent in Japan. The loss of Japanese competitiveness in the Semiconductor industry is reflected in the 31.3 percent output share of Semiconductors and Related Equipment within Electronic Components in Japan, almost the same as the 1987 level. On the other hand, in the U.S., the output share grew to 54.2 percent, well above the 39.3 percent share in 1987.

Similar to Electronic Components, the time series for Communications Equipment (SIC-366) from 1970 to 2003 is based on published BOJ data.[*43] The aggregate price for 1995-2003 is recalculated as a Chained Fisher index, under lied by monthly WPI and CGPI data on Wired, Radio, and Other Communications Equipment, which are Chained Laspayres prices based on geometric averages of the detailed item data, and WPI weights given by shipments for domestic demand.[*44] Between 1990 and 1995, the procedure is similar, except the underlying WPI data is unchained Laspayres. WPI Laspayres prices are used between 1985 and 1990. From 1970 to 1985, the annual WPI Laspayres price index for Communications Equipment is used to extrapolate the time series. Prior to 1970, the price index is based on a combination of 1965-1970-1975 linked Input-Output and Nikkei prices.

The results of this calculation are given in Figure 20 and Table 11. From 1960-1975 prices increase 0.4 percent per year in dip 0.5 percent per year from 1975-1980. After 1980, price declines of Communications Equipment in Japan exceed those in the U.S. in every subperiod. The biggest gap is in 1995-2000, when prices in Japan fell an average of 6.1 percent per year faster than U.S. prices. Comparing BEA and BOJ prices from 1980 to 2000, prices in Japan fall 4.1 percent per year compared to 0.2 percent per year in the U.S., a gap of 4.0 percent per year. Overall, Communications Equipment prices fall faster in Japan, actually opposite to the case of Electronic Computers and Peripheral Equipment.

In summary, Communication Equipment (SIC-366) prices fall faster in Japan, while Electronic Computer (SIC-357x) prices fall faster in the U.S. Electronic Component (SIC-367) prices fall more rapidly in Japan in the early period, but faster in the U.S. after 1990. These results clearly show that price gaps for other IT goods are not similar to the price gap for SIC-357x. Each of these price trends reflect variation in the composition of the underlying goods and differences in production and market structures in the U.S. and Japan, although it should be noted that these trends are based solely on the data described and data constraints may lead

[*43] Communications Equipment (SIC-366) consists of three 4-digit industries; 3661.Telephone And Telegraph Apparatus, 3663.Radio And Television Broadcasting And Communications Equipment, 3669.Communications Equipment, Not Elsewhere Classified.

[*44] The discussion of the role of arithmetic versus geometric aggregation of items within commodities is in section 4.3.

Table. 11 Growth Rate of Output Prices for IT Goods

	SIC-357x Electronic Computers and Peripheral Equipment			SIC-366 Communications Equipment		
	BEA	BLS[1)]	BOJ[2)]	BEA	BLS	BOJ
1960–75			-4.25			0.40
1975–80		-11.51	-5.73		3.96	-0.47
1980–85	-15.02	-12.37	-7.76	4.42	2.81	-1.25
1985–90	-10.32	-9.91	-9.15	-0.30	0.46	-4.02
1990–95	-13.97	-13.55	-5.83	-1.27	1.12	-1.58
95–2000	-24.90	-25.04	-11.72	-3.46	-0.77	-9.56
2000–03			-27.45			-11.28
72–2000		-13.79	-7.68		2.33	-2.44
80–2000	-16.05	-15.22	-8.61	-0.15	0.91	-4.10

	SIC-367 Electronic Components		
	BEA	BLS	BOJ
1960–75			-4.71
1975–80		-0.15	-8.77
1980–85	-2.84	-2.47	-6.38
1985–90	-3.35	-3.92	-8.05
1990–95	-10.04	-9.20	-4.79
95–2000	-22.12	-19.61	-9.45
2000–03			-9.95
72–2000		-6.46	-6.53
80–2000	-9.59	-8.80	-7.17

unit:annual growth rate(percent).

[1)] BLS for SIC-357.

[2)] BOJ after 1985, and Linked-IO before 1985.

to unexplained price differences.

6.3 IT Investment Prices

The output prices described in sections 6.1 and 6.2 capture price of IT goods leaving the factory. Here, we complete the IT price story by computing the prices of IT goods sold to final demand. We make use of the Japanese domestic output prices discussed along with data on import prices, Wholesale and Transport prices, and margin rates to compute Japanese investment prices for Electronic Computers and Peripheral Equipment and Communications

Equipment.[*45]

In contrast to the weights used in construction of the output prices, the investment price weights should reflect investment demand. Therefore, the first step in assembling the investment price is to return to the weighting scheme in the original BOJ's WPI/CGPI, shipments to domestic demand, and to incorporate data on import shares. These weights, along with the reestimated output prices using these weights, and import prices are aggregated to a composite price. Finally, wholesale and transportation prices, and the corresponding shares, are aggregated with the composite price to calculate the investment price index, effectively converted from producers' to purchasers' prices.[*46]

Following the methodology used to construct the Japanese investment price indexes, the U.S. Price Index for Private Fixed Investment for Computer and Peripheral Equipment and Communications Equipment, which BEA does not adjust to reflect margin rates, margin prices, and transportation costs, are adjusted in a similar manner to the Japan price.[*47] The theoretical underpinning for this adjustment is that final investment prices should be in purchasers' prices, reflecting all margins and transportation costs, a detail apparently overlooked in BEA investment prices. Furthermore, the numerous studies that analyze the contribution of computers to economic growth using this price, and harmonized prices based on this BEA price, may be overestimating declines of the Computer and Peripheral Equipment investment price.

The wholesale margin rates and transportation costs used in this adjustment are presented in Table 12. These rates represent the additional cost charged by the wholesale and transportation sectors as a percentage of total cost paid by the purchaser. In the U.S., the wholesale margin for sales of computers has increased from 8.7 percent in 1972 to 21.9 percent in 1997. In Japan the margin rate peeked at 22.0 percent in 1990 and has declined to 12.9 percent in the 2000. For Communications Equipment, margin rates are higher in Japan, although the most recent data shows that U.S. margin rates are catching up. In both countries, transportation costs add between 0.3 percent and 1.4 percent to purchasers's prices.

The impact of these margin rates and the other methodological changes described above are shown in Table 13. As shown in the table, the recalculated investment price falls 3.2 percent per year slower from 1960 to 2002 and 4.4 percent slower from 1980 to 2002. Furthermore, before the adjustment, BEA investment prices actually fall more rapidly than the output

[*45] Electronic Components are not sold to final demand, thus there is no investment price for this component of IT.

[*46] In Japan, Transportation on Wholesale Margins are from the benchmark Input-Output Tables. Wholesale and Transportation Output prices are based on the Linked Input-Output Tables. Interval period data is estimated based on the Extended Input-Output Tables, published by METI. Import Prices are from the BOJ's IPI.

[*47] In the U.S., margin rates and transportation costs are taken from the benchmark Input-Output Tables, published by BEA. Wholesale and Transportation prices are from GDP-by-Industry data.

prices in Table 11, reflecting import prices that fall more rapidly than domestically produced prices. When we adjust the investment price for margins and transportation costs, however, the investment price declines less than the output price.

Table. 12 Wholesale Margin Rates and Transportation Costs

	SIC-357x Electronic Computers and Peripheral Equipment		SIC-366 Communications Equipment	
	Wholesale	Transportation	Wholesale	Transportation
U.S.				
1972	8.73	0.88	2.33	0.36
1977	5.85	0.56	2.26	0.34
1982	13.02	0.86	8.56	0.53
1987	16.22	0.94	5.11	0.53
1992	17.12	0.94	10.07	0.58
1997	21.91	0.94	9.19	0.47
Japan				
1970	16.82	0.73	4.75	0.78
1975	16.47	1.19	6.70	1.89
1980	14.95	0.95	7.03	1.21
1985	16.19	0.66	12.15	0.98
1990	21.99	1.36	12.65	1.39
1995	19.03	0.89	15.38	0.90
2000	12.85	0.60	11.17	1.02

unit:nominal share(percent).

Rates are defined relative to the Purchaser's Price.

Data in both countries are based on Benchmark Input-Output Tables.

Comparing the U.S. investment price to Japan from 1960 to 2002, the U.S. price declines 15.8 percent per year, compared to only 5.8 percent per year in Japan. However, during 1980-2002, the gap is smaller, as U.S. prices fall 13.0 percent per year, while Japan prices dip 8.3 percent per year. In Japan, the accelerating declines in investment prices over the period can be traced back to underlying output prices and import prices that decline more rapidly than output prices. Furthermore, the most recent data from 2000-2002 suggests that the price gap is starting to narrow as the import share in Japan continues to rise and investment prices fall 17.6 percent in Japan compared to 13.4 percent in the U.S.

In contrast to the price gap for Computers, the investment price gap for Communications Equipment remains large. During 1995-2000 the U.S. investment price, where lower margin rates result in a smaller difference between adjusted and un-adjusted BEA investment prices, falls 3.2 percent per year, less than half of the 7.7 percent decline in Japan. The latest data from 2000 to 2002, show a similar 4.8 percent per year price gap, as the earlier data. Overall investment prices from 1960 to 2002 increase 1.4 percent per year in the U.S. compared to decreases of 1.7 percent per year in Japan. During 1980-2002, U.S. prices fall 0.2 percent per year, compared to 3.8 percent per year in Japan.

Table. 13 Growth Rates of Investment Prices

	SIC-357x Electronic Computers and Peripheral Equipment			SIC-366 Communications Equipment		
	U.S.		JPN	U.S.		JPN
1960–65	-25.42	(-28.72)	-2.02	0.06	(0.04)	-0.89
1965–70	-16.19	(-18.56)	-1.36	3.78	(3.79)	-0.10
1970–75	-14.15	(-16.43)	-4.96	5.88	(5.89)	3.07
1975–80	-20.16	(-22.92)	-3.98	3.14	(3.00)	-0.08
1980–85	-12.97	(-15.93)	-6.31	4.13	(4.19)	-0.96
1985–90	-8.64	(-10.98)	-7.40	0.35	(0.22)	-3.39
1990–95	-11.38	(-14.70)	-6.43	-0.95	(-1.25)	-1.29
95–2000	-18.66	(-24.37)	-9.51	-3.23	(-3.46)	-7.70
2000–02	-13.41	(-17.45)	-17.58	-3.18	(-3.43)	-7.96
60–2002	-15.83	(-19.00)	-5.84	1.41	(1.32)	-1.73
80–2002	-12.96	(-16.58)	-8.34	-0.22	(-0.38)	-3.76

unit: annual growth rate(percent).

( ) is the original BEA price, defined in producers' prices.

The U.S. price is the adjusted BEA investment price.

The Japan price is based on WPI/CGPI, Input-Output Table, etc.

7 Conclusion

In this paper, we examine the computer prices in the U.S. and Japan at the SIC 3-, 4-, 5-digit level. Focusing on the U.S. data, we conclude that the discrepancy between the BLS's aggregated PPI and BEA's Output Price can be explained as differences in aggregation method and weights used in aggregation.

Comparing the U.S. and Japan data for PCs and Non-PCs at the 5-digit level from 1995 to 2003, we conclude that there is not a big gap across countries, and any gap that exists should be thought of as a true price difference. We trace the acceleration of computer price declines in Japan to the introduction of DOS/V in 1991 which lead to increased compatibility of computer imports, a higher import share, and increased competition within Japan. At the 4-digit level, we explain a significant portion of the price gap by making adjustments to aggregation methodology, and the resulting price declines for Electronic Computers are comparable, as prices fall 29.3 percent per year in the U.S. compared to 27.0 percent per year in Japan. Moving to the 3-digit level, we aggregate the price of Electronic Computers and Peripheral Equipment and show that prices fall 23.8 percent per year in the U.S. compared to

15.5 percent per year in Japan. At the 3-digit level, a significant portion of the remaining price gap can be explained by the Peripheral Equipment price, which falls less rapidly in Japan and has a bigger share of total output when exports are included.

We extend our analysis to cover a longer time period and show that from 1980 to 2000, Electronic Computer and Peripheral Equipment prices fall almost twice as fast in the U.S., as prices decline 16.1 percent per year in the U.S. compared to 8.6 percent per year in Japan. On the other hand, prices of Communications Equipment fall much faster in Japan, where prices fall 4.1 percent per year, while the U.S. price falls only 0.2 percent per year. The price of Electronic Components falls slightly faster in the U.S. from 1980 to 2000. However, price declines in Japan exceed those in the U.S. until 1990, when the industry focused more on non semiconductor Electronic Components. After 1990, semiconductor production dominated the industry and the technological improvements in semiconductors that led to decreasing prices in the U.S. did not play as large a role in Japan. We conclude that the IT output price gap for each of the components of IT reflects underlying market structure, production technology, and import price pressures, but also absorbs underlying data constraints.

Many of the same forces driving the output price gap affect investment prices in the U.S. and Japan. We show that from 1980 to 2002, investment prices for Computers and Peripheral Equipment fall 13.0 percent per year the U.S. and 8.3 percent per year in Japan, and the latest data shows that the price gap is starting to narrow. On the other hand, the investment price gap for Communications Equipment remains wide, even in the latest available data.

Of the remaining price gaps between the U.S. and Japan, some of the gaps reflect true price differences, and some reflect data constraints which may be addressed with additional data. But, the time series data presented in this paper improves upon the current practice of price harmonization by carefully constructing IT output and investment prices that build on official price statistics in Japan. Although the prices presented in this paper are only the first step, future research that builds on the indexes presented in this paper will more effectively capture the changing productivity of the world's two largest producers of IT equipment.

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