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Quality Adjustment of Price Indexes

Wholesale Price Index and Corporate Service Price Index: The Current Situation and Future Implications

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Research and Statistics Department

Bank of Japan

C.P.O BOX 203 TOKYO

100-8630 JAPAN

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1. *Introduction*

As low levels of inflation continue to spread globally, further attention has been paid to the accuracy of price statistics in the process of discussing price stability.[1] In Japan, prices have been stable since the 1990s, although some declining phases have also been observed (Chart 1). Under these conditions, lively discussions are emerging regarding the "actual trend" of prices while focusing on the accuracy of price indexes.

Hayakawa and Yoshida (2001) present the idea that the problems surrounding price indexes are not limited to how statisticians confront technical problems of price indexes. Moreover, they insist that the problems are how they grasp the prices of a good or service, and furthermore they are connected to more fundamental issues of how price stability should be defined. In fact, from the viewpoint of the statistics section compiling the Wholesale Price Index (WPI) and Corporate Service Price Index (CSPI), we regularly face such problems as how to grasp the prices of goods and services and thus more or less agree with this opinion. Even if we limit the topic to price indexes compiled by the Bank of Japan, concerns still abound. These include the extent to which the WPI incorporates productivity growth represented by Information Technology (IT) as the Japanese economy undergoes rapid change through IT, and the question of whether the CSPI accurately reflects the progress in services and permeating effects of IT on nonmanufacturing. Furthermore, by taking these discussions into account, there is the issue of how effectively the price indexes reflect the balance between supply and

[1] See Research and Statistics Department (2000a) for further details on this discussion. As for the bias problem regarding the Consumer Price Index, see the *Boskin Report* (Advisory Commission to Study the Consumer Price Index; 1996) and Shiratsuka (1998).

demand. To provide price indexes that reflect the actual conditions of the economy as accurately as possible in response to such discussions, quality adjustment of price indexes has become the most essential issue among the many difficulties of price indexes.[2]

This paper will discuss in detail some ideas from the viewpoint of statistics compilers on how important quality adjustment is for price indexes when grasping prices. It will also attempt to clarify some issues concerning the use of price indexes obtained from previous studies. In line with this, the paper will highlight problems that cannot be solved even by using various quality adjustment methods and will, we hope, provide some insights for future domestic and international research.

Hereafter in this paper we briefly present ideas on quality adjustment and add views on unsolved conceptual and technical problems regarding quality adjustment. We then simply discuss quality adjustment methods currently used for various price indexes statistics and introduce the actual application of the methods on the WPI and CSPI, along with a discussion of quality adjustment methods overseas. Finally, we indicate how price indexes are actually affected by quality adjustment and what implications can be obtained on using price indexes from such examination results.

2. Significance of Quality Adjustment

To discuss the methodology of quality adjustment, it is first necessary to make clear the background of the methodology.

To make it simple, assume that the "utility" of the people and the "selection criteria" of a good or service are known. Based on this assumption, as prices represent the value of a good or service, it can be understood that the quality adjustment of price indexes is a

[2] For basic discussions on the idea of quality adjustment, see Ohta (1980).

method to measure the value of a good or service by making the characteristics units of the good or service identical. Here, characteristics are factors constituting quality. The surveyed good or service is an accumulated unit of those characteristics. Based on this idea, we can grasp quality quantitatively.

Next, we discuss how the meaning of the quality of a good or service changes according to the surveyed stage of prices in price indexes.[3] This discussion is necessary since the WPI and CSPI—the two indexes chosen at this time—do not incorporate one stage of prices as observed in the Consumer Price Index (CPI) which focuses only on the final consumer demand stage of households. Instead, the WPI and CSPI are price indexes that reflect the prices of inter-corporate transactions. First, under perfect competition, firms typically purchase raw materials for production or buy machinery for investment. Hence, as for input price indexes,[4] which incorporate the prices of a good or service at the input stage, the prices are usually fixed at the point where the production isoquant—a curve obtained by the input of a good or service using the same characteristic unit measured by user value—meets the isocost line, which constitutes the same cost of purchase of a good or service. When the quality of a good or service changes, it forces the production isoquant to shift; thus, the shifted isoquant should be moved back to "the original" by making the characteristics units the same. This is called quality adjustment. This means that the amount of output must be constant to observe price changes. As for output price indexes, which focus on the stage where firms produce and make the good or service, prices are determined where the production possibility curve, which shows the same good or service produced by firms in terms of characteristics units, meets the isoprofit curve. In this case, "quality adjustment" refers to the adjustment of the good or service in terms of characteristics units to stay on "the same" production possibility curve. This indicates that the input of resources must be constant for prices to change. Although the index theories of input and output price indexes in terms of quality adjustment focus on different surveyed stages, it can be

[3] For the basic framework of this concept, see Triplett (1983).

[4] See Diewert (1983), and Fisher and Shell (1998) for details on the idea of output price indexes, which will be mentioned later, and input price indexes.

understood uniformly when observed using the characteristics units. Even from this framework, output prices are regarded as input prices from the viewpoint of purchasers; at the equilibrium point under perfect competition, the marginal increase in user value and the marginal cost of producers are equal. Thus, the same price can be obtained from a good or service using either approach. In the real world, however, prerequisites do not always satisfy perfect competition. For example, when the actual price is determined not under perfect competition but under monopolistic competition,[5] it is thought that the result of quality adjustment differs depending on whether the price index is perceived from the perspective of input or output.

Next, we would like to examine how this concept is applied to actual price indexes. In general, the producer price indexes used in many countries are output price indexes—they are compiled based on shipment prices at the producer stage. The Bank's WPI[6] and CSPI[7,8] are compiled at the stage where the supply and demand condition of a good or service is sensitively incorporated, taking into account the current distribution environment. As a result, the characteristics of output and input price indexes are intermixed. As for the WPI, prices at the primary wholesaling stage are collected if primary wholesalers have their own inventories and are playing an active role in

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[5] In this case, it should be noted that the isocost line and the isoprofit curve presented here cannot be used.

[6] The WPI is a price index measuring goods traded among firms. It has been compiled and released by the Bank of Japan since 1897. The current WPI consists of the following major indexes: (1) "Domestic Wholesale Price Index (DWPI)," which measures the price movement of domestically produced and domestically used goods; (2) "Export Price Index (EPI)," which measures the price movement of export products; (3) "Import Price Index (IPI)," which measures the price movement of import products; and (4) "Indexes for Special Groups by Stage of Demand and Use," an index compiled by rearranging the former three indexes by stage of demand and use. For details, see Research and Statistics Department, Bank of Japan (1999a,b,c) (2001).

[7] The CSPI focuses on the prices of services traded among firms. It has been compiled and released by the Bank of Japan since 1991. For details, see Research and Statistics Department, Bank of Japan (1999d), (2001).

[8] In addition to the WPI and CSPI, the Bank compiles the Input-Output Price Index of Manufacturing Industry by Sector. This index was first compiled and released in 1963 as a supplementary index of the WPI, with the name, "Index by Sector." For details, see Research and Statistics Department, Bank of Japan (2000b).

adjusting the supply and demand, or at the producer price stage if the commodity is sold directly from producers to retailers or users. As observed in this case, the WPI holds the characteristics of both input and output price indexes, as prices surveyed are at the selling stage of producers and at the purchasing stage[9] of producers and final users. The number of commodities surveyed at the producer stage is increasing gradually and currently comprises 70 percent of overall Domestic WPI because: (1) the weight of machinery based on the made-to-order system is rising considerably due to changes in the industrial structure in Japan; and (2) an increasing number of cases are observed in which manufacturers and retail stores are negotiating the prices of commodities directly. This shows that the WPI is gradually becoming more of an output price index. Moreover, the CSPI is more of an output price index from the point that most prices collected are the prices of services provided by firms.

Taking these characteristics of price indexes into account, we will now examine the actual quality adjustment. Originally, price indexes as long-term time series data are defined as indexes comparing the price data of a commodity or service with "the same" characteristics or the aggregated price data weighted by a certain criteria to the base period. If, despite this definition, quality adjustment in line with changes in surveyed commodities or services is not taken into account, it becomes impossible to understand whether the changes in indexes are from the changes in the characteristics of surveyed commodities or services, or from the price changes. On compiling the WPI at the Bank, the manufacturer, administrative number, material, quality of the material, shape, function, use, client company, and transaction conditions (such as place of receiving the commodity, payment method, etc.) of the commodity are basically fixed when surveying prices so as to make the characteristics mentioned above identical. The same applies for the CSPI. Thus, if prices can be surveyed based on fixed characteristics, quality adjustment is not needed.

In reality, however, it is extremely difficult to survey the price of the same commodity

[9] A few prices are actually adopted at the purchasing stage. In addition, the selling price of wholesalers reflects the relatively strong intentions of users compared to the selling price of producers.

of service for a continued period. For instance, models of durable consumer goods such as automobiles and household electrical appliances (TVs, air conditioners, etc.) change frequently; old products are replaced when new products are released. This cycle is even faster for personal computers and cellular phones, as new products are released about every six months. Consequently, the quality of personal computers sold during the 1980s is completely different from those sold today. Furthermore, apparel products and processed food, the trends of which change drastically, typically go out of fashion in less than a year and are taken over by new products. As for imported apparel products, which are surging recently, more than ten thousand clothing items are imported per order and the trend is that those of the same design and style are not ordered thereafter. Moreover, nearly 20,000 new snacks are released to the market annually, but only about 100 of these products are said to survive the market competition a year later. This shows that the life cycle of these products is very short. Meanwhile, basic industrial materials such as steel, nonferrous metal, chemicals, and textiles are usually traded in the same standardized products for several years. The traded product may remain the same, but often the client company or transaction conditions (place of receiving the products, payment method, etc.) change over the years. Therefore, even though the commodity or service remains the same, it is more common for prices to change according to the new client company; that is to say, the trading price is no longer based on the same conditions.

It is impossible to compile the WPI and CSPI without comparing the prices of nonidentical products. To compare these “different” prices, the Bank regards model changes as changes in characteristics of the same product. We extract the differences in characteristics from the differences in prices of the old and new products to incorporate only this “pure” price change into the index. Both price indexes have intermixed characteristics of output and input price indexes as mentioned above. The WPI, in particular, includes prices of both the intermediate demand and final demand stages. As a result, it is not suitable for the WPI and CSPI to adjust the quality of products based solely on the utility of final users like those of the CPI. We must select the quality adjustment method from the perspective of both output and input goods.

From the viewpoint of compiling price statistics, we stress the importance of using quality adjustment to make price movements as close to the actual price trend as possible. If quality change is not excluded from the movement of price indexes, errors will accumulate and a substantial divergence will occur in the long run between the movement of actual prices and indexes. This in turn is likely to make us misinterpret the actual conditions of the economy. Price indexes are used to deflate nominal transactions (production) amounts and to obtain the quantity index. Thus, if the price decline caused by technological innovation is not incorporated into price indexes in the long-term, economic growth on a quantity basis, as in real GDP, and the economic growth rate will be underestimated.

Moreover, quality adjustment has recently become even more important for accurate price indexes statistics. There are two reasons for this. First, as the effects of price declines due to quality adjustments are expected to continue while the percentage change in prices gets smaller from the 1970s, 80s, and 90s onwards, the relative weight of the impact of quality adjustment on price fluctuations seems to be rising. Second, an increasing number of cases have been observed in the past few years in which the surveyed commodities or services are changed. Against this background lies the progress in technological innovation, especially of IT. Furthermore, deregulation and restructuring conducted by Japanese firms have changed the industrial structure and reinforced the streamlining of corporate businesses. Hence, it is essential to adjust the quality of price indexes as accurately and to the greatest extent possible.

3. *Difficulties in Quality Adjustment*

Here, we would first like to note that on adjusting quality, it is difficult to grasp the "utility curve" explained in the previous section.[10] Moreover, no clear consensus exists on what characteristics actually indicate; many conceptual and technical problems

[10] Needless to say, it is the most difficult definition to describe. This is a fundamental problem, but we will not discuss it in this text. For details, see Hayakawa and Yoshida (2001) and Sen (1982).

remain in terms of characteristics. Before introducing the quality adjustment methods of the WPI and CSPI, we will first discuss the obstacles of quality adjustment in terms of characteristics from the viewpoint of statistics compilers.

A. *Discrepancy between the concept of characteristics based on microeconomic foundation and the actual category*

As discussed above, the quality of commodities or services is arranged by the concept of characteristics when compiling price indexes. However, it is difficult to categorize quality based solely on characteristics. Moreover, the categorization of characteristics actually does not exist. Consequently, the actual classification of price indexes is compiled referring to the Ministry of Economy, Trade, and Industry's *Census of Manufacturers* or to the statistics released by other ministries and industries that are used as weight data. These statistics are also categorized by materials, quality of material, shape, and function of commodities or services, but this does not perfectly match with the categorization based on "characteristics" in economic terms. If the category of commodities or services for price indexes can be defined from the viewpoint of unifying them that have the same characteristics, and if price indexes are compiled as a collective unit of them, this differs from the common concept of classification of commodities or services and will diverge from the "actual perception" of the society. Thus, it will be difficult to obtain the understanding of users.

Quality adjustment is conducted for commodities or services within the same category. Thus, this restriction on the definition of category prevents the quality adjustment from exceeding the category. On adjusting quality, if commodities or services to be compared are categorized as different items, the two commodities or services cannot be compared before quality adjustment. For example, consider a case in which a DVD player is invented and the transaction share of the product in the market increases. If the product were classified as the same category as a CD player, a substantial quality adjustment would be needed. If, however, it were classified as a completely new category, then it will not be incorporated into price indexes. Even if it is added as a new category when the base period is revised, the quality change of the product will not

influence prices in the first place, since the product will be adopted as a new category. In this case, before arguing whether quality adjustment should be conducted according to the characteristic, there is the problem that the classification of the product is determined due to restrictions of the categories of commodities or services.

When a commodity or service is the only product produced, a problem arises: no other commodities or services to compare within the same category exist. This is particularly apparent in commodities not intended for general-purpose use. For instance, many kinds of order-made industrial machinery, such as metal-cutting tools, are increasingly being manufactured. These machines are statistically classified as the same category, but as each product has its own characteristics, and is shipped only once due to these characteristics. This means that there is a discontinuity in the category; it is, thus, difficult to adjust the quality.[11] This problem has emerged rapidly; it became manifest as the main manufacturing industry in Japan shifted from the materials-related industry to the capital goods-related industry. In addition to this, the so-called IT revolution (sometimes called “digital revolution”), which is currently progressing throughout the Japanese economy, is likely to intensify the individuality of commercial transactions. For example, cross trade is becoming popular through the Internet. Under these circumstances, it is highly possible that the world will change from one in which every consumer has the opportunity to obtain commodities or services at the same price to one in which prices may differ by consumer according to his/her transaction volume and history. Here, a discrepancy exists between the statistical item categorization and the commodity or service categorization based on the characteristics. It can be easily imagined that the prices of products may diversify due to differences in the conditions of transactions. As a result, it will become increasingly difficult to judge to how the differences in characteristics have affected the price gap and to what extent quality adjustment is needed to make the characteristics the same.

[11] Although the problem of quality adjustment will not be solved completely in these cases, we are surveying the basic function part of some prices by dividing the product into the basic function section and custom-made option section in order to maintain the continuity of the price indexes.

B. *Difficulties in grasping characteristics*

As long as it belongs to the same category, quality adjustments are possible for commodities with increasing characteristics. However, we must keep in mind that what is meant by characteristics—which are a prerequisite for quality adjustment—is not necessarily clear in actual terms. This difficulty can be seen when we confront the evaluation of: (1) how the introduction of new products or functions should be specified as the change or increase of characteristics; and (2) how the introduction of new products or functions affects outdated existing products from the viewpoint of users.

Consider an extreme case in which an innovative technology called electric lighting is invented. According to a measurement example of Nordhaus (1998), the price of lighting changed by 1000 times in 200 years whether we classify candles, gas lighting, and electric lighting as belonging to the same characteristics of "lighting"—and thus not affect the characteristics at all—or whether we adjust the quality of the product by focusing on its characteristics of the extent of lighting. And another complex problem arises: how will new inventions (electric lighting) affect existing competitive commodities and services (gas lighting)? This is noticeable for commodities with the characteristics of public goods that do not have market prices. A typical example: As the manufacture of automobiles and the construction of highways increased, the value of railways declined. However, prices of railway services from the perspective of costs cannot incorporate this effect.

In specific areas of a commodity or service, even if technological innovation is not so drastic as to change the economic structure explained above, it would be difficult to adjust the quality by using the usual quality adjustment method, even when unexpected technology is invented and old commodities rapidly become obsolete. Consider a case in which a system of video cameras was switched from analogue to digital, or in which TVs stopped using cathode-ray tubes and switched to liquid crystal. When adjusting quality from the viewpoint of user value, quality changes reflecting such functional

changes may affect other characteristics as well; it is thus difficult to grasp the changes quantitatively. For example, if the system of TVs were switched from cathode-ray tube to crystal liquid, the TV will become much thinner, while the screen of a cathode-ray tube will still have higher resolution. However, the real merit of changes in the thickness of TVs in line with the transformation to liquid crystal may depend on living space, and this transformation may affect characteristics other than thickness and resolution.

It gets even more complicated when it comes to service prices. It is difficult to measure the increases in user value and characteristics due to the convenience of services objectively compared to those of goods. Furthermore, there are cases in which it is difficult to acknowledge the increase in user-value such as designs and brands.

Among these problems, some of them can be solved by using, for instance, information regarding costs collected from firms. But even in these cases, new problems emerge, as described below.

C. *Difficulties of information collection—asymmetric information*

There is an asymmetrical relationship not only between manufacturers and wholesalers but also between respondents and the Bank regarding information on prices and other related information. To adjust the quality as accurately as possible, the information related to a certain commodity needs to be collected thoroughly. Under these conditions, quality adjustment relies quite heavily on the quality and quantity of information reported by the firm. Because the reporting burden of firms will be significant if we try to obtain vast amounts of information, there are limitations for the Bank on obtaining price information and other related information from these respondents.

In these circumstances, the Bank has constructed a reliable relationship with firms from which we obtain price information. We carefully research price information by

commodity or service. In fact, we know to a large degree whether the selling price is actually contracted between the seller and the buyer or whether quality adjustment is necessary when replacing the surveyed commodity or service.

Recently, however, the contents of commodities or services are becoming complex. If the Bank tries to increase the number of sample prices and times of quality adjustment on compiling the price indexes, it will further increase the reporting burden of respondents. Meanwhile, amid ongoing cost-reduction measures taken by firms, including restructuring, it can be argued that the capacity of firms to provide information has become smaller.

Even under these increasingly severe conditions on collecting information, the value of price indexes as public goods will only continue to increase. The Bank intends to reduce the reporting burden of respondents and to obtain further cooperation of firms regarding necessary price information, by examining the importance and needs of each procedure in compiling price statistics at all times and through a scrap-and-build of the price survey procedure from a new perspective. As a result of these efforts, the Bank must incorporate actual price trends into the price indexes as much as possible.

4. *Various Quality Adjustment Methods and Actual Usage*

Although we acknowledge the various obstacles in terms of the quality adjustment of price indexes, we are endeavoring to adjust the quality as much as possible by using several quality adjustment methods. In fact, the frequency of quality adjustment conducted by the Bank is extremely high. The number of quality adjustments made in replacing price data during 2000 alone for the WPI and CSPI were 919 and 361 respectively. The number of price data was 4,894 for the WPI and 2,957 for the CSPI as of December 2000, indicating that the number of replacements of price data comprise slightly less than 20 percent of the WPI and more than 10 percent of the CSPI in one year (see Charts 2 and 3). In such a situation, where products are frequently rearranged, it is evident that quality adjustment will have substantial effects on the accuracy of price

indexes.

On replacing price data, several methods are used internationally for adjusting quality between old and new price data. Commonly used methods are: the direct comparison method, the unit price comparison method, the overlap method, the hedonic regression method, the production cost method, and the imputation method (Chart 4).[12] The Bank selects the most appropriate method from these. In doing so, we keep in mind the concepts of the following three methods: the method that measures the characteristic directly by putting emphasis on the feature as input goods; the method focusing on costs by emphasizing the feature as output goods; and the method using price information on the foundation that market prices include such information at the equilibrium point. Based on these concepts, we select what is to be the most accurate method, taking the above-mentioned features into account.

Among these methods, the Bank uses five, excluding the imputation method for the WPI, and four, excluding the imputation and hedonic regression methods for the CSPI, according to the case. When none of the methods can be applied, we reluctantly class the case as "difficult to compare" so that the index level does not move (see Charts 2 and 3 for the actual application of various quality adjustment methods). We try to avoid "difficult to compare" cases but 30 percent of these cases were observed for WPI and about 40 percent of those for CSPI.[13] Hereafter, we introduce cases that have actually occurred during 2000. We will try to make clear the advantages and disadvantages of each method.

A. *Direct comparison method*

[12] The Consumer Price Index compiled by the Ministry of Public Management, Home Affairs, Posts and Telecommunications uses the direct comparison method, the unit price comparison method, and the overlap method.

[13] An example of this would be a case in which the surveyed company stops handling the price data, forcing us to ask another company for a price survey. Even when we survey the same category of commodities or services from the same company, when the quality or use of the product changes drastically due to changes in technology, consumer preference, or the client company, we are sometimes forced to follow the same procedure.

When no quality differences exist between old and new products, the direct comparison method can be used. This method incorporates the prices of new products into the index by comparing them with those of old products directly. It was applied to about 20 percent of replacement of price data for the WPI and to around 40 percent of those for the CSPI. This was typical for cases such as processed or assembled products in which the administrative number of models or commodities has changed but not the quality itself, or for cases in which the reporting company has changed mainly due to affiliations and the commodity or service in transaction and the company itself or condition of transaction remains the same. When compiling the index, "no changes" become the basic stance. The price replacements with the changes in the number of surveyed companies have increased recently in line with corporate restructuring and reorganization of businesses.

B. ***Unit price comparison method***

This method is applied when there are changes in the transaction volume while the actual quality of products remains unchanged. For example, when there are changes in the number of sweets contained in a packet, or when there are changes in the size of beverages, the prices of new and old products are compared based on the same quantity unit. The difference between these prices per same quantity unit is considered as either an increase or decrease of prices. This is based on the same way of thinking as the direct comparison method, since it regards the quality of old and new products to remain unchanged in real terms. It can be considered as a modified version of the direct comparison method. Examples applied to this method are relatively few and comprise only 1 percent of replacements of price data for the WPI and about 5 percent of those for the CSPI during 2000. Caution should be taken so as not to confuse this with "volume discounts," which reduces the unit price according to the transaction quantity. Therefore, confirmations are made to the surveyed companies on whether there are changes in the transaction condition between old and new prices.

Example of WPI

Here, we introduce the example of changes in the price data "crude drugs and Chinese medicines" among "chemicals." Prices of "crude drugs and Chinese medicines" are surveyed at the shipment price when shipped from wholesaling to retailing. At one stage, the quantity of a box of common cold preparations (Chinese medicine) increased by 5.0 percent and the price of the drug per box fell by 4.2 percent, while the ingredients of the drug remained the same. Comparing the unit price of the old and new products per gram, the price for the new product declined by 8.8 percent which is more than the decrease in nominal prices. Since the qualities of the old and new products are the same, it is regarded as an 8.8 percent reduction in prices in the WPI.

Example of CSPI

Among "fire insurance" of "finance and insurance," the price data (damage insurance premium) of normal fire insurance was changed. The price of the surveyed product is the selling price from agents to firms and is the insurance per insurance unit of storage. The insurance unit was changed from 170 million yen to 100 million yen, but as the insurance rate and the content of service was unchanged, the CSPI also remained the same.

C. *Overlap method*

When old and new products are sold simultaneously during a certain period of time and when the difference between the two prices is steady, this method judges that the difference between the two prices is due to quality difference. In this case, the price gap between old and new prices comes solely from differences in quality; thus it is not judged as an actual price increase or decrease. Under this judgment, the basic rule is to

maintain the level of the new and old price indexes. However, if the price movement of the new product occurs during the month it is adopted, this movement is also incorporated into the index. In this case, either a price increase or decrease is conducted.

The overlap method during 2000 was applied to about 10 percent of cases in the WPI and to an extremely small percentage (around 1 percent) in the CSPI. As mentioned later, quality adjustment other than the overlap method such as the production cost method and the hedonic regression method restricts the range of quality adjustment, and is forced to ignore those outside the range. This can be observed as the differences in quality between old and new products are "limited to the differences in the marginal cost corresponding to the quality differences" in the production cost method while the hedonic regression method defines it as "limited to those which have objective data representing the quality differences." As for the case of the overlap method, however, the observable market price gap between old and new products reflects the difference of the value of the products, including those that cannot be specifically extracted by any technical method. Thus, this method has the advantage of comparing the quality of overall products thoroughly. This is considered a rational method when conditions are ideally satisfied in comparing the quality.

Example of WPI

As for the product "shampoos" in "chemicals," the selling price per dozen from wholesalers to retailers is adopted in one case. In this example, with the emergence of new well-sold products in wholesaling during 2000, the new well-sold products were surveyed instead of the old products. The new product is produced by a different manufacturer and is high in quality compared to the old product, thus the price was 2.2 times higher than that of the old product. However, the wholesaler has been selling both old and new products at the same time, and the price gap between the two products remained stable. Because of this, the index remained unchanged.

Example of CSPI

Among the price data of “software development” in “information services,” some products adopt the unit price by the required programming language to order software development. In this example, while the quality of computers is improving, the amount of orders for assembly languages has decreased. Programs written in assembly languages are relatively small in terms of the size of program, but the mechanic language must be rearranged by using ideographical match-marking. In contrast, orders for programs written in the high-technological and easy-to-understand C Programming Language, despite their large size, are increasing, and have become the mainstream. Consequently, price data were switched to those written in the C Programming Language. The same company has simultaneously been providing both services and the prices of the two products were almost parallel. Thus, the index was unchanged based on the overlap method.

In reality, however, the application of the overlap method is limited, for reasons explained below. First, for the price gap between old and new products to be stable for a certain period, the two products must be transacted simultaneously and the transaction volume of both products should be stable. This does not usually occur in items facing relentless technological innovation. As soon as a new product incorporating the latest technology emerges, or as soon as this information is provided to the market, the prices of the old product usually plunge, and the product itself disappears from the market. Typical examples of this are IT-related machinery such as personal computers and printers, household electrical appliances such as air conditioners and TVs, and automobiles. As for these products, old products rapidly lose their attraction within the market due to the introduction of new commodities. This fact makes the coexistence of old and new products hard; it has hence become difficult for the market to evaluate the relative price of technology. The short life cycle of new products such as personal computers, air conditioners, TVs, and automobiles to the market have been explained in the second chapter. As a result, these products are changed most frequently, and it is necessary to compare the qualities of the old and new products at the time of each

replacement. The overlap method has the disadvantage that it is hard to apply to these highly important products—essential for statistical accuracy in terms of quality adjustment.

D. *Hedonic regression method*

The hedonic regression method[14] regards products as a collective entity constituted by several functions and degree of performance (both are a part of "characteristics"). As for the old and new products, the theoretical price is calculated based on the volume of the characteristics; the figure obtained is the difference due to quality change within the price gap between old and new products. The differences excluding the quality factor are considered purely as price fluctuations.

Explaining the process in somewhat more detail, we estimate the price change due to quality change reflecting the switch from old to new products by using the already-calculated regression equation based on extensive information on prices and quality. The difference between the actual price change and the theoretical price change obtained from the estimation can be counted as the actual price change other than that due to quality change (for the detailed estimation, see Chart 5). The greatest advantage in using the hedonic regression method is that subjective judgments and intentions are excluded and the judgment criteria is objective data, representing function and the degree of performance, and statistical methods when evaluating quality. Thus, this method is useful: it is both objective and transparent. Moreover, quality adjustment of the product can be easily conducted so long as related data are collected. This means that it is advantageous when used for products with a short product cycle such as

[14] The actual application of this method on price indexes originally comes from the research of

personal computers, whose quality changes drastically with time.

Example of WPI

> Among “computers” in “ electrical machinery,” consider an example in which various functions and degrees of performance of personal computers change. These changes include the size of main memory, clock frequency, hard-disk drive capacity, and display unit. They also include whether the PC accommodates TFT (thin film transistor) crystal liquid, a variety of CPU and auxiliary storage, and the contents of software. In this case, the degree of changes in value is measured by regression analysis. Let us introduce a case during 2000 in which the model change of notebook computers exerted upward pressure on nominal prices. In new products, the clock frequency increases and the CPU gets faster. In addition, auxiliary storage is switched to DVD-ROM, and the operating system gets upgraded. A quantitative evaluation indicated that although nominal prices of new products rose, the theoretical price increased even more. The price adjusted to account for the price increase by quality improvement decreased by 3.7 percent. Therefore, the same rate of decrease was made in the WPI.

Various problems arise when applying the hedonic regression method, and hence only several applied categories exist. In the WPI, the hedonic regression method is used for personal computers and furthermore, digital cameras and video cameras (the production cost method used to be used for both digital and video cameras). Meanwhile, this method has not yet been applied to the CSPI.

Various issues must be solved before the hedonic regression method can be used. First, the possibility to be able to specify the principle characteristics representing the quality of each product comprising the item must be secured before using this method. Next, these characteristics need to be grasped in figures. For instance, “designs” and “brand images” cannot be shown in figures. This means that it is difficult to take these factors

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Griliches (1961) and others.

into account, even though they apparently affect user values.[15] When a new unpredicted function is added to characteristics, which indicate quality that reflects technological innovation, price changes corresponding to quality changes obtained by the hedonic regression method cannot be grasped in figures.[16] This is problematic. Furthermore, even if it is possible to grasp the characteristics in figures, a vast amount of data on prices and characteristics collected during a short period are needed to obtain a stable estimation. This often restricts the selection of price data for adopting the hedonic regression method.[17] The hedonic regression method is an excellent method, but as there are still many issues to be solved before it can be applied more widely. We must keep in mind that it is not necessarily an all-round method, especially when we take disruptive new technologies into consideration.

E. *Production cost method*

The production cost method adjusts prices on the foundation that the difference between the qualities of old and new products is equal to the difference in costs to produce that difference. As for automobiles, for instance, while a "brake assist" (a device which increases the braking power in case of emergency stops) is equipped as a result of the model-change, equipment known as "fog lights" (lights that increase driver visibility in fog) is terminated. In this case, the costs needed to equip fog lights are subtracted from the increase in costs caused by the equipment of the brake assist and the subtracted

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[15] As for the CPI of the United States, the hedonic regression method is used on adjusting the quality change of apparel products, which greatly reflect designs and brand images. On estimation, however, because extensive use is made of dummies, thus we consider that the technological difficulties have not yet been solved. See Shiratsuka and Kuroda (1996) for research being done in Japan.

[16] To expand the application range of quality adjustment further, we are considering using a method that combines the hedonic regression and production cost methods by incorporating the production cost method into the new function part when a new characteristic is added to the commodity unexpected in the hedonic regression method.

[17] From a somewhat technical aspect, there are many cases in which a high correlation exists among characteristics that comprise prices (for example, high-grade personal computers with high processing speeds, high-capacity hard disks, and large displays). Thus, cases exist in which some contrivances are needed to obtain statistically stable results. This, however, is not an obstacle.

amount obtained is added to the price of the old model. This price is the quality-adjusted new model price. If the actual new model price surpasses this price, then it will be incorporated into the index as an actual price increase. The same process is followed if the new model price falls short of this price. The advantage of the production cost method is that so long as the data can be obtained from each surveyed firm, the information can be incorporated instantly. This means that the application range can be broad. The Bank constantly exchanges information with firms and uses the obtained information after judging whether any bias exists regarding the evaluation on quality changes. This is convenient: quality adjustment becomes possible even if objective data on the function and degree of performance of the product and information regarding market value to specify major characteristics are unavailable, unlike the hedonic regression method. As a result, this method is applied to about 30 percent of replacements of price data for the WPI and more than 10 percent of those for the CSPI.

Example of WPI

During 2000, as for “other passenger cars” and “small passenger cars” among “transportation equipment,” the production cost method was used in many cases to deal with the full model changes of these vehicles. When a model-change of a vehicle takes place, the full efficiencies and environmental capacities improve due to the enhancement of the engine. Additionally, safety is enhanced by incorporating various electronic devices used in line with the traditional brake function, the anti-lock brake system. Furthermore, the comfortableness of the vehicle also increases due to the technological progress of transmissions and the improvement in the function of air conditioners. These improvements increased the nominal price, but the price was reduced by 9.5 percent in real terms. Hence, this was incorporated into price indexes.

Example of CSPI

As for “motor vehicle maintenance” among “motor vehicle and machinery maintenance,” the checklist of motor vehicle inspections was reduced due to the

revision of the Road Trucking Vehicle Law (which took effect in May 2000). While costs were reduced due to this revision, the duration of compulsory motor vehicle inspection for motor vehicles lengthened, which increased the cost per inspection. As for motor vehicle inspection overall, if the nominal price increases only slightly, prices in real terms tend to be flat and unchanged. In fact, however, since there was a rebound in the recent decrease in prices due to negotiations with users, a 20.5 percent increase in real terms was applied to the index.

Indeed, various restrictions exist when using the production cost method. In the first place, it is difficult to evaluate characteristics such as designs and brands, which are hard to grasp in terms of costs. Moreover, if functional changes corresponding to the increase or decrease in quality are diverse, the trouble of calculating the cost changes by surveyed companies cannot be ignored; there are cases in which only simple calculations can be made, taking the burden of respondents into account. This method only uses the quality change which is equivalent to the cost change observed from producers. Hence, if technological progress is extremely fast, this does not necessarily guarantee that the quality change is the same as that observed from the user side. The production cost method adjusts the quality based on relatively little information. Consequently, the application range is broad, but the accuracy of the method may not be so high.

F. *Imputation method*

This method is used when it is impossible to compare the qualities of the old and new products. The price information of other similar products is imputed to the price index and the price gap caused by quality differences is eliminated from the price index. This method is not used for quality adjustment in Japan, but at the Bureau of Labor Statistics (BLS), Department of Labor of the United States, two approaches within this method are used for quality adjustment in CPI.[18] One approach is based on the assumption that

[18] See Bureau of Labor Statistics (1997).

the incomparable price gap between old and new products is the same as that of the average price change of other products overall. This approach is used for foodstuffs and services. The other approach is used in cases when new products are introduced to the market on a regular basis, but it is inappropriate to impute the information including the price change when new products are not introduced and is thus excluded from price data. Hence, the percentage change of surveyed products such as those to which the direct quality adjustment (such as the production cost method) can be applied, should be imputed. The latter approach was mainly used for model changes in automobiles since 1989. This approach, excluding foodstuffs, has been used since 1992. It is expected that this method will be applied to more cases in the future.

G. *Comparison of quality adjustment methods*

Finally, we introduce the differences that occurred when using various quality adjustment methods in line with the actual examples of how the Bank has been replacing the price data.[19] First let us examine the differences of the effects in selecting the overlap method and the production cost method. In the overlap method, from the point when new products are projected to be released, prices of existing competitive products start to decline, reflecting the obsolescence of existing technology. When prices of old and new products become parallel, the price difference can be regarded as the quality difference. If the quality adjustment is done appropriately, the amount of quality adjustment conducted by using the overlap method is expected to be the same as that conducted by using the production cost of the new product. In fact, however, even though quality can be adjusted in the production cost method, there are cases in which the prices of old and new products cannot be compared thoroughly in the overlap method, especially for electrical machinery, because old products are removed from the market as soon as new products are introduced.[20] Next, we compare the quality

[19] This calculation is based on an actual example. Thus, the calculation process will be omitted in this paper to protect the privacy of firms.

[20] Of course, even when using the production cost method, if the timing of quality adjustment is late, there is the danger of adjusting the quality too much, as some quality change has already been

adjustment results of the production cost method with those of the hedonic regression method. Because not many cases exist in which the results of both methods can be compared, they should be viewed with a certain margin of error. For example, when there was a model change in video cameras during 2000, in the case where the changes in characteristics can be grasped by regression equation of the hedonic regression method, the rates of price decline were almost the same in both methods.

5. *Discussions Regarding Quality Adjustment Overseas*

Various discussions have been made overseas on the quality adjustment methods of the price indexes mentioned above. For Consumer Price Indexes and Producer Price Indexes, the ILO (International Labor Organization) and the IMF (International Monetary Fund) are each working on manuals aimed at creating an international standard for compiling price indexes. In this manual, quality adjustment methods are also to be incorporated.

International discussion regarding quality adjustment can be broadly divided into the following two streams: (1) enhancing the accuracy of price indexes through active quality adjustment using various methods while emphasizing the method measuring the effects of quality adjustment directly; and (2) prioritizing the fact that it is possible for countries to compare the price indexes and putting importance on the objective and unified quality adjustment method by extracting the price gap corresponding to quality change indirectly from market prices.[21] In the former, among the various methods—including the method directly measuring the quality adjustment effect—selecting the most effective method and taking the situation of each country into consideration will in turn increase the accuracy of the statistics. On the other hand, certain risks accompany that approach: the subjective view of the statistics compilers will to a certain degree be included, resulting in a distortion of the statistics. As for the latter, the results remain

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incorporated into the prices.

[21] See Bureau of Labor Statistics (1999) for the former and Turvey (2000) for the latter.

unchanged, regardless of the statistics compiler, because they are obtained from prices—an objective indicator—but a thorough quality adjustment may not be conducted unless enough objective indicators are available. A global conclusion is yet to be reached on whether the former or the latter is more preferable in terms of quality adjustment, but the problem remains that the influence on actual price indexes may differ depending on which stance is taken on quality adjustment.

From the viewpoint of international comparison, it is not necessarily true that the more unified the criteria, the more the quality or the more the situation of individual countries included, the closer it is to the actual trend of price indexes of each country. The Bank takes into account the fact that the situations of each country cannot be grasped by an internationally unified method and that the technical problem of indirect methods is unable to incorporate the quality change in case of removal of old products from the market with the emergence of new products. In these circumstances, although the issue that a subjective judgment may be incorporated is yet to be solved, the basic idea is that selecting the most appropriate quality adjustment method per each replacement of price data will make the indexes more likely to be closer to the actual price trend. Thus, the Bank is more or less taking the former stance in terms of quality adjustment. Moreover, we are planning to take an active stance on quality adjustment such as by using not only the production cost method among the direct quality adjustment methods but also by widening the range of applying the hedonic regression method gradually, in addition to the indirect measurement of quality change obtained from price information.

6. *Effects of Quality Adjustment*

We have already presented our stance on quality adjustment to increase the accuracy of price indexes. With regard to the importance of quality adjustment, constant technological innovation within the economy has exerted downward pressure on prices through increases in productivity and the rightward shift of the aggregated supply curve. This is observed mainly in machinery, which makes the growth rate of the WPI substantially low on average in the long term. The price decline caused by the increase

in productivity is realized through a decrease in nominal prices of goods and services and through price reduction in real terms brought on by improvements in quality. As for the former, since the decrease in nominal prices actually appears in transaction prices, this will be incorporated into price indexes automatically. The latter, however, is not reflected in price indexes if the quality change is not adjusted. Therefore, quality adjustment becomes essential to make prices indexes as close as possible to the "actual" prices from the viewpoint of both user values and the production function of firms. Since the gap between the percentage change of productivity between manufacturing and nonmanufacturing is large, particularly in Japan, the effects of quality adjustment on the WPI are expected to be substantial.

As an estimate, let us calculate the movements of price indexes prior to quality adjustment on the so-called "nominal basis" for both the WPI and CSPI and see the degree of decline in the percentage change of price indexes due to quality adjustment.[22] Of course, problems in terms of the accuracy in quality adjustment of price indexes should be kept in mind. For example, if the price decline due to quality adjustment of price indexes is not enough, this may make productivity of the Japanese economy look low. In particular, it is difficult even for those involved in the transaction to grasp how much of the price change of services transacted among firms matches quality change.[23] It is even more difficult to specify costs and qualities, which form the basis for prices, when compiling the CSPI compared to the WPI. The increase in productivity originally appears also in price changes on a nominal basis and thus is hard to obtain economic implications only from the impact of quality adjustment. Nonetheless, the estimation

[22] In this estimation, to extract the pure effects of quality adjustment, the effects on selecting the direct comparison method and the unit price method have been excluded, based on the judgment that the quality remains unchanged. (This is for cases in which the qualities of the old and new products remain unchanged and prices are the same if measured using the same size unit, although the nominal price increases/decreases since the size of the product is enlarged/reduced. In that case, there is a large price change when comparing only the nominal prices of the old and new commodities.)

[23] Taking the case of motor vehicle maintenance, services changed in complex ways in line with the revision of the law related to motor vehicle inspections. Thus, it can be said that the users of the services were not really familiar with whether the new prices increased in real terms compared to prior services prices, in other words, whether prices actually increased or decreased after quality adjustments.

results of the quality adjustment effects presented below are in fact consistent with discussions on the productivity of manufacturing and nonmanufacturing. Let us examine the results below by taking the limitations discussed into account.

First, estimations were conducted on Domestic WPI by extracting a total of four years from the 1990s until present (1993, 1995, 1998, and 2000). As a result, the adjusted price decline due to quality adjustment throughout the past decade was likely to be below the range of 0.5 percent per annum, indicating that the range was stable (Chart 6[1]).[24] The constant downward shift in prices due to quality adjustment seems to reflect an increase in productivity in Japan's manufacturing sector.[25]

Let us examine this in more detail. Taking the recent example of 2000 (Chart 6[2]), the annual percentage change of Domestic WPI was a somewhat negative of 0.1 percent (figure for December 2000 on a year-to-year basis). On the other hand, the price index based only on nominal prices (disregarding quality adjustment) showed a slight positive figure of 0.3 percent. The gap between these two figures was -0.4 percent, which is to be regarded as the price decline caused by quality adjustment. The large rate of decline was observed in machinery, such as transportation equipment, precision instruments, general machinery, and electrical machinery, sectors in which the increase in productivity is significant. The rate of decrease due to quality adjustment of electrical machinery, which is considered the most amenable to technological innovation, seems not to be so significant. The rate of decrease in nominal prices, however, was particularly substantial; this may be because a large part of technological innovation is already included in the actual price decline.[26] On the contrary, the differentiation of

[24] The degree of influence of quality adjustment is indicated clearly for the first time. Only simple estimations were conducted until now. See Research and Statistics Department, Bank of Japan (2000c) for time series data of the effects of quality adjustment during the 1990s using the simple method.

[25] The recent trend is that although the frequency of quality adjustment has increased along with rapid changes in the economic structure, the rate of price decline due to quality adjustment has not been expanding as much.

[26] In electrical machinery, the divergence from the base period of commodities such as personal computers, whose price decline is substantial each year, is affecting the decline in the index level.

products in transportation equipment and general machinery continues. Hence, a fixed transactional relationship is generally maintained, at least for the short term. This may make prices sticky during the period when products are the same model and makes the margin of price change significant in line with model changes. Meanwhile, there seems to be a price increase in some products due to quality adjustment in material-related categorizations. This, however, does not mean that a deterioration in quality is occurring (in contrast to technological innovation); it is only an adjustment made due to switching mainstream commodities to those of lower quality and prices that correspond to the needs of users.[27]

Second, the developments of Domestic WPI show that prices basically continued to be negative on a year-to-year basis throughout the 1990s, even including the economic recovery period. The decline from FYs 1990 to 1999 on an annualized basis was 0.7 percent on average. As a result, it can be estimated that the decline was half due to the decrease in the nominal price itself and half due to quality adjustment. The decline in nominal prices is based on the strength in demand and on changes in the rate of productivity growth. There are no data to judge whether this margin of price decline due to quality adjustment is small or large compared to past declines. In the long run, however, it can be considered that the price decline effect due to quality adjustment is gradually becoming larger.[28] This is because the share of processing and assembling industries such as transportation equipment and electrical machinery, whose nominal price is unlikely to change compared to materials industries, gradually became significant and an increasing number of firms are adopting a price strategy that focuses more on optional functions attached to commodities than on nominal prices compared to the 1960s and 70s. Quality adjustment methods have developed under these

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When the index level is low, the downward contribution to the total price index becomes small even though the declining rate of the commodity is conspicuous. Although this point is not discussed in this paper, this is one of the problems of the Laspeyres index.

[27] For example, effects from the rate of productivity growth are often seen through the increase in the efficiency of products in materials-related commodities. This effect is frequently observed in the decline in nominal prices and does not appear in quality adjustment effects.

[28] Needless to say, this does not mean that the rate of productivity growth of the Japanese economy was higher in the 1990s compared to that of the 1960s and 1970s. In fact, labor productivity has declined conspicuously. It should be noted that only the effects of quality adjustment are discussed

circumstances.

Third, from the substantial downward contribution to prices from electrical machinery and transportation equipment due to quality adjustment, it can be suggested that the effects of quality adjustment on final goods, particularly durable consumer goods, are rather strong. Estimations of the effects of the downward contribution to prices due to quality adjustment on consumer goods during 2000 through rearranging the WPI by stage of demand and use indicate that although downward contribution to non-durable consumer goods was small, the effects on durable consumer goods was substantial. Thus, prices of consumer goods overall declined by 0.6 percent (-0.8 percent for domestics products alone), which was slightly larger than the overall Domestic WPI (Chart 7[1]). The actual downward contribution to prices aided by quality improvement at the producer and wholesaling stages seems to have a somewhat larger impact on consumer goods purchased by households rather than materials and intermediate goods.

We estimate the quality adjustment effect during 2000 (year-to-year changes as of December 2000) by switching the weight of commodities in the WPI to the weight of commodities in the CPI (Chart 7[2]). From this result, the quality adjustment effect of WPI corresponding to CPI was slightly smaller than the above-mentioned consumer goods (-0.4 percent). Part of the reason that differences occur even in the same consumer goods is probably because the weight of household expenditure and the surveyed range differ, since the weight of each item of consumer goods by stage of demand and use includes the consumption of firms. However, the more substantial reason would be because some large electrical machinery such as personal computers and cellular phones—which reinforce the margin of decline—are not included in the current CPI.

Fourth, unlike Domestic WPI, there is not a large difference in the percentage change of the CSPI before and after quality adjustment (Chart 8). On interpreting this, it is necessary to keep in mind that the increase in productivity due to the recent streamlining

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here.

of distribution channels appears not in quality adjustment but in the nominal price decline. Detailed data show an aspect that the rate of productivity growth in labor-intensive services industries is small overall compared to that of the manufacturing industries. For instance, in the services area, the rate of productivity growth in labor-intensive services (information services, professional services, motor vehicle and machinery maintenance, etc.) is expected to be basically low. In fact, prices do not decline even from quality adjustment. On the contrary, there are some services in capital-intensive services (leasing and rental, communications and broadcasting, real estate services, etc.) in which technological innovation seems to be affecting quality adjustment. Take leasing services as an example. The productivity growth in electrical machinery and general machinery are expected to lower the indexes through exerting downward contribution to leasing (Chart 8 [reference]). Nevertheless, although it is highly possible that quality improvement due to technological innovation is occurring in telecommunications and broadcasting, it may be difficult to distinguish the price decline due to technological innovation because, in addition to the difficulties of measuring quality improvement, the decline in nominal prices due to deregulation is occurring simultaneously. In the future, the existing rents of the services sector may dissipate due mainly to deregulation, and quality improvement may occur simultaneously. In this case, the effects from an increase in productivity may appear not in quality adjustment but in nominal prices. Taking also into account that the effects of shifts in utility function caused by changes in the contents of services may not be fully incorporated into services prices, services prices need further examination.

7. *Conclusion*

This paper has discussed the importance of quality adjustment on compiling price indexes and our stance on this, along with various problems surrounding quality adjustment. Many issues must be solved in terms of quality adjustment; most of them are in fact quite hard to solve. However, we must adjust quality actively by selecting the most appropriate quality adjustment method. Otherwise a distortion in the price indexes will occur and this will make it more difficult to grasp economic activities in

real terms. Where there is no international consensus on quality adjustment, we have explained the Bank's efforts in selecting the most appropriate quality adjustment method according to the appropriateness of each item and the situation by case to solve problems surrounding quality adjustments to the greatest extent possible. As a result of quality adjustment for the purpose of increasing the accuracy of price statistics, we believe that features regarding the productivity of domestic firms, especially of the goods market, have become distinct. However, to make price developments as similar as possible to those of actual price movements, plenty of room remains for researching and improving quality adjustment methods, both conceptually and statistically. Furthermore, the Japanese economy is expected to continue changing drastically and price indexes will encounter new issues to be solved. The IT in progress today is probably only one of these issues. While the importance of quality adjustment is expected to continue increasing in the future, this paper was written to help stimulate domestic and international research on quality adjustment of price indexes.

[References]

Abraham, K.G., J.S. Greenlees, and B.R. Moulton, "Working to Improve the Consumer Price Index," *Journal of Economic Perspectives*, Volume 12, Number 1, Winter 1998, pp.27-36.

Advisory Commission to Study the Consumer Price Index, "Toward a More Accurate Measure of the Cost of Living," *Final Report to the Senate Finance Committee*, December 4, 1996.

Archibald, R., "On the Theory of Industrial Price Measurement: Output Price Indexes," BLS Working Paper #44, 1975.

Bank of Japan, Research and Statistics Department, "*Bukka shisu wo meguru shomondai* (Various Problems Surrounding Price Indexes; available in Japanese only)," *Bank of Japan Monthly Bulletin*, August 2000 issue, 2000a.

Bank of Japan, Research and Statistics Department, *FAQ on price indexes* (available in Japanese only), http://www.boj.or.jp., 2001.

Bank of Japan, Research and Statistics Department, "*Oroshiuribukkashisu no minaoshi ni kansuru nipponginkou no kongo no torikumihoushin—minaoshian ni taishi choudai shita goiken to sore e no kaitou* (Bank of Japan's Stance on the Revision of WPI—Public Comments on the Revision Plan and the Bank's Response; available in Japanese only)," *Bank of Japan Monthly Bulletin*, November 1999 issue, 1999c.

Bank of Japan, Research and Statistics Department, *Explanation of the Wholesale Price Indexes*, http://www.boj.or.jp.en, 1999b.

Bank of Japan, Research and Statistics Department, *Explanation of the 1995 Base Corporate Service Price indexes*, http://www.boj.or.jp.en, 1999d.

Bank of Japan, Research and Statistics Department, Explanation of the *Input-Output Price Index of Manufacturing Industry by Sector*, http://www.boj.or.jp.en, 2000b.

Bank of Japan, Research and Statistics Department, "*Oroshiuribukkashisu no genjou to minaoshian ni tsuite—goiken, goteian no onegai* (The Current Situation and Revision Plan of Wholesale Price Indexes—Inviting Public Comments; available in Japanese only)," *Bank of Japan Monthly Bulletin*, April 1999 issue, 1999a.

Bank of Japan, Research and Statistics Department, *Price Developments in Japan-A Review Focusing on the 1990s*-, October, 2000.

Boskin, M.J, E.R. Dulberger, R.J. Gordon, Z. Griliches, and D.W. Jorgenson, "Consumer Prices, the Consumer Price Index, and the Cost of Living," *Journal of Economic Perspectives*, Volume 12, Number 1, Winter 1998, pp.3-26.

Bureau of Labor Statistics, "The Consumer Price Index," chapter 17 of the *Handbook of Methods*, http:/www.bls.gov/opub/hom/homch17.pdf, 1997.

Bureau of Labor Statistics, "Consumer Price Indexes: Methods for Quality and Variety Change," Joint ECE/ILO Meeting on Consumer Price Indices, 3-5 November 1999.

Deaton, A, "Getting Prices Right: What Should Be Done?," *Journal of Economic Perspectives*, Volume 12, Number 1, Winter 1998, pp.37-46.

Diewert, W.E., “The Theory of the Output Price Index and the Measurement of Real Output Change,” in *Price Level Measurement: Proceedings from a Conference Sponsored by Statistics Canada*, 1983, pp.1049-1113.

Diewert, W.E., “Index Number Issues in the Consumer Price Index,” *Journal of Economic Perspectives*, Volume 12, Number 1, Winter 1998, pp.47-58.

Griliches, Z., “Hedonic Price Index for Automobiles: An Econometric Analysis of Quality Change,” in *The Price Statistics of the Federal Government*: Staff Report No.3, General Series No.71, National Bureau of Economic Research, 1961, pp.173-196.

Fisher, F.M., and K. Shell, *Economic Analysis of Production Price Indexes*, Cambridge University Press, 1998.

Hausman, J., “Cellular Telephone, New Products, and the CPI,” *Journal of Business & Economic Statistics*, Volume 17, Number 2, April 1999, pp.188-194.

Hayakawa, H. and T. Yoshida, “*Bukka shisu wo meguru gainentekishomondai* (Conceptual Problems Surrounding Price Indexes; available in Japanese only),” Research and Statistics Department, Bank of Japan, *Working Paper Series* 01-5, May 2001.

Morita, Y. *Bukka shisu riron no tenkai* (Developments of the Price Index Theory; available in Japanese only), Toyo Keizai Inc., 1989.

Nordhaus, W.D., “Quality Change in Price Indexes,” *Journal of Economic Perspectives*, Volume 12, Number 1, Winter 1998, pp.59-68/

Ohta, M., *Hinshitsu to kakaku* (Quality and Prices; available in Japanese only), Soubunsha, 1980.

Sen, A., *Choice, Welfare and Measurement*, Basil Blackwell, 1982.

Shiratsuka, S., *Bukka no keizaibunseki* (An Economic Analysis of Prices; available in Japanese only), Tokyo University Press, 1998.

Shiratuska. S, and S. Kuroda, *“Apparel seihin kakaku to hinshitsusa—CPI apparel no kakaeru mondaiten to hedonic regression approach ni yoru kaizen no kanousei* (Prices of Apparel Products and Quality Difference—Problems of Apparel in CPI and the Possibilities of an Improvement Using the Hedonic Regression Approach; available in Japanese only)”, *Kinyu Kenkyu*, 1996, Vol. 16, No. 2.

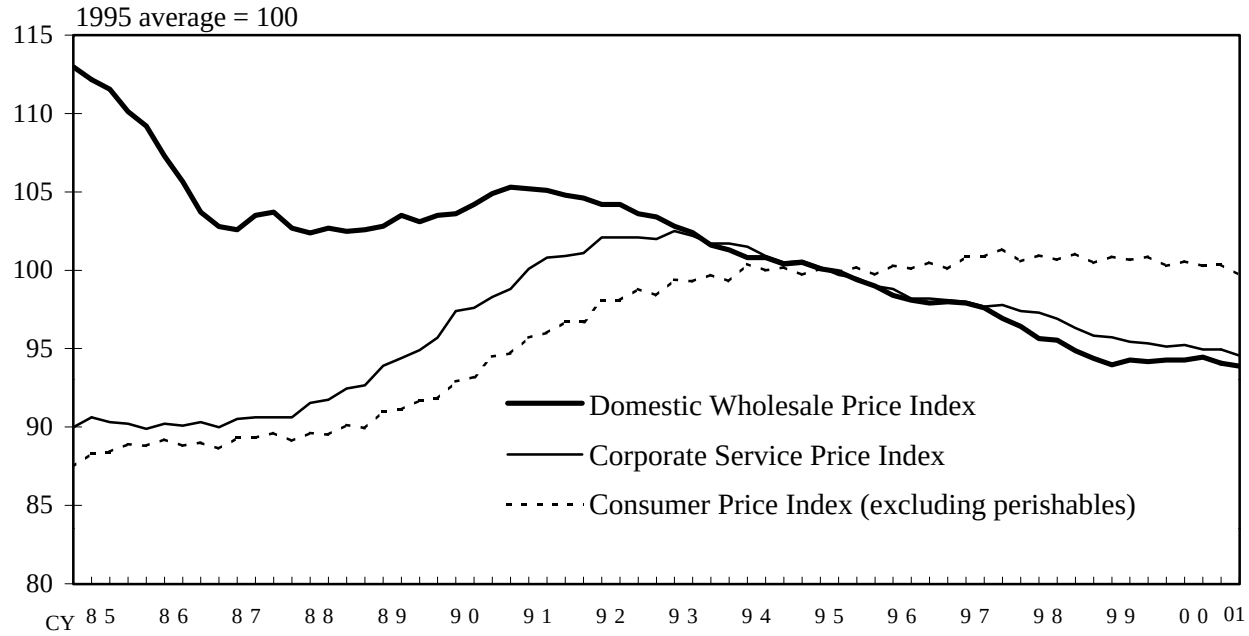
Triplett, J.E., “Concepts of Quality in Input and Output Price Measures: A Resolution of the User-Value Resource-Cost Debate,” M.F. Foss ed. *The U.S. National Income and Product Accounts*, University of Chicago Press, 1983.

Turvey, R., “Quality Differences and New Products,” http://www.turvey.demon.co.uk/, 2000.

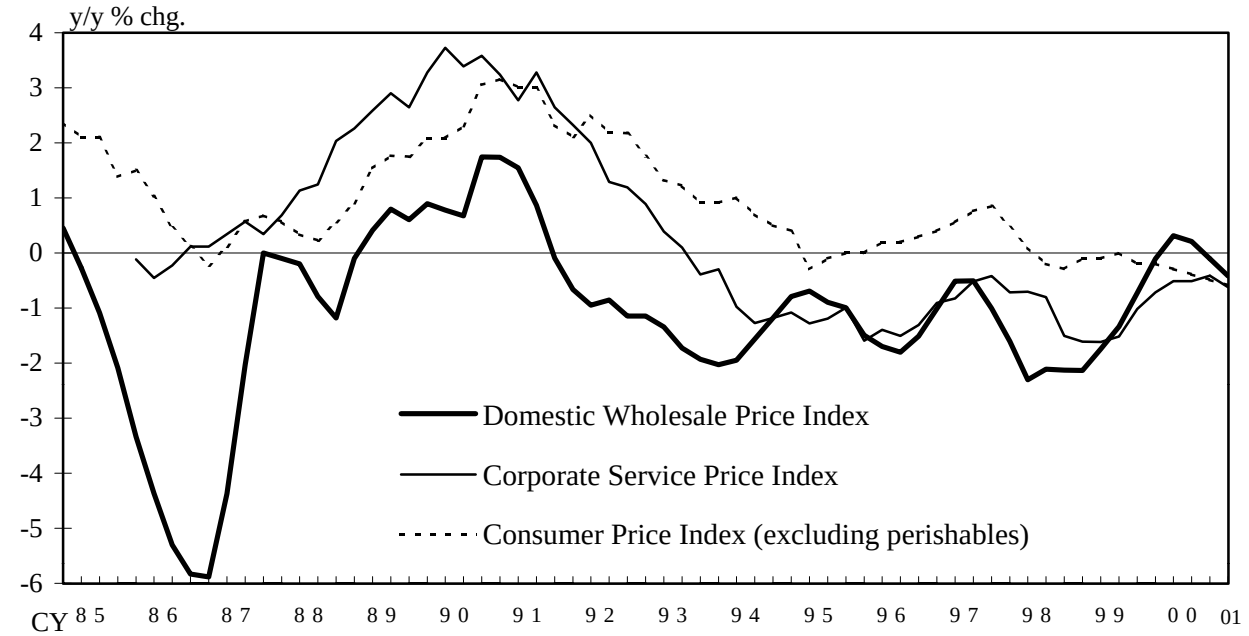
Chart 1

Developments of Price Indexes

(1) Index level



(2) Year-to-year percent changes



Notes: 1. Adjustments for the effects of the consumptiotn tax were made in the data.
2. As for the 2001/Q1, price indexes for domestic WPI and CSPI are those of the January-February average while CPI is that of January alone.

Sources: Bank of Japan, "Wholesale Price Indexes," "Corporate Service Price Indexes"; Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index."

Chart 2

Replacement of Price Data in WPI (During 2000)

(1) Number of replacements of price data

Group	No. of surveyed prices (A)	No. of cases (B)	(Ref). no. of cases in the previous year	Share of replacement (B)/(A)
Domestic Wholesale Prices	3375	641	447	19.0
Electrical machinery	412	193	115	46.8
Chemicals	356	54	49	15.2
Textile products	275	40	31	14.5
Transportation equipment	83	40	29	48.2
Processed foodstuffs	379	36	41	9.5
Other manufacturing industry products	292	36	45	12.3
Electric power, gas & water	77	30	1	39.0
Pulp, paper & related products	138	29	22	21.0
Export Prices	624	134	111	21.5
Electrical machinery	163	59	50	36.2
General machinery	101	19	4	18.8
Other manufacturing industry products	71	14	18	19.7
Import Prices	895	144	114	16.1
Machinery & equipment	197	63	38	32.0
Foodstuffs & feedstuff	202	31	29	15.3
Textiles	88	16	9	18.2
Total	4894	919	672	18.8

Notes: 1. Changes in surveyed prices indicate changes in the content of commodities, transaction conditions, and surveyed company.

2. Surveyed prices are those of December 2000.

(2) Quality adjustment methods used for old and new commodities

cases, figures in ( ) are those of the previous year

	Domestic Wholesale Prices	Export Prices	Import Prices	Total
Production cost meth.	221 (136)	47 (38)	29 (28)	297 (202)
Overlap meth.	73 (97)	9 (5)	21 (13)	103 (115)
Hedonic regression meth.	20 (8)	5 (6)	3 (2)	28 (16)
Direct comparison meth.	121 (78)	22 (16)	26 (25)	169 (119)
Unit comparison meth.	12 (13)	0 (0)	0 (0)	12 (13)
Difficult to compare	194 (115)	46 (29)	54 (35)	294 (179)
Others	0 (0)	5 (17)	11 (11)	16 (28)

Note: "Others" indicate changes in the contracted currencies.

(3) Measures taken in the index

cases, figures in ( ) are those of the previous year

	Domestic Wholesale Prices	Export Prices	Import Prices	Total
Price increase	3 (8)	3 (1)	1 (2)	7 (11)
Unchanged	464 (301)	85 (81)	113 (91)	662 (473)
Price decrease	174 (138)	46 (29)	30 (21)	250 (188)

Note: Even when the overlap method (a method that regards the price difference between old and new commodities as the quality difference in the two commodities and incorporates them as unchanged in real terms into the index) is applied, the decrease (increase) of the new surveyed price compared to that in the previous month is incorporated as price decrease (increase) into the index.

Chart 3

Replacement of Price Data in CSPI (During 2000)

(1) Number of replacements of price data

Major group	No. of surveyed prices (A)	No. of cases (B)	(Ref). no. of cases in the previous year	Ratio of change (B)/(A)
Miscellaneous services	849	113	23	13.3
Transportation	709	53	48	7.5
Finance and insurance	397	49	38	12.3
Communications and broadcasting	153	46	31	30.1
Leasing and rental	152	40	6	26.3
Total	2957	361	171	12.2

Notes: 1. Changes in surveyed prices indicate changes in the content of services, transaction conditions, and surveyed company.
2. Surveyed prices are those of December 2000.

(2) Quality adjustment methods used for old and new services

cases, figures in () are those of the previous year.

	No. of cases
Production cost meth.	47(51)
Overlap meth.	3 (9)
Hedonic regression meth.	--
Direct comparison meth.	155(48)
Unit comparison meth.	18 (3)
Difficult to compare	138(60)
Others	0 (0)

Note: "Others" indicate changes in the contracted currencies.

(3) Measures taken in the index

cases, figures in () are those of the previous year.

	No. of cases
Price increase	6 (2)
Unchanged	330(155)
Price decrease	25 (14)

Note: Even when the overlap method (a method that regards the price difference between old and new services as the quality difference in the two services and incorporates them as unchanged in real terms into the index) is applied, the decrease (increase) of the new surveyed price compared to that in the previous month is incorporated as price decrease (increase) into the index.

Chart 4

Quality Adjustment Methods

Name of method	Content	Actual use of method	Applied statistics
Direct comparison meth.	When the qualities of the old and new products are regarded as fundamentally the same, the prices of old and new products are compared directly based on the judgment that the quality change does not exist.	Incorporate prices of new products into the index directly.	Japan: CPI WPI CSPI U.S. : CPI PPI
Unit price comparison meth.	When the qualities of the old and new products are fundamentally the same, in cases when only the quantity differs (e.g., volume per product), the differences in the unit prices of old and new products are regarded as actual price differences. Then the prices of old and new products are connected.	(Old price/new price) * (surveyed price of new product) = (connected price)	Japan: CPI WPI CSPI U.S.: CPI PPI
Overlap meth.	When two products are sold at the same shop simultaneously, the price difference basically reflects the quality difference. This idea is applied when price data are replaced and the price difference between the old and new surveyed products at the same point of time is used as the link coefficient and connects the price indexes.	(Old price/new price) * (surveyed price of new product) = (connected price)	Japan: CPI WPI CSPI U.S.: CPI PPI
Production cost meth.	The difference in the production cost of old and new products (cost needed to enhance the quality) surveyed from producers is regarded as the price difference corresponding to the quality difference of both products. The rest of the price difference after adjusting the price difference corresponding to the quality difference is regarded as "price increase (decrease) in real terms."	(New product price) (cost difference of the old and new product) = (connected price)	Japan: WPI CSPI U.S.: CPI PPI
Hedonic regression meth.	Part of the price difference among products is due to the quality difference measured by various characteristics of these products. Based on this idea, this method objectively and quantitatively estimates the "price change corresponding to the quality change" from the changes in various characteristics of products using the regression equation and considers the residual of price difference as "price increase (decrease) in real terms."	(New product price) (difference in functions and degrees of performances of the old and new products converted into prices) = (connected price)	Japan: WPI U.S.: CPI PPI
Imputation meth.	When it is impossible to compare the quality of old and new products, this method connects the prices of old and new products based on the assumption that the price change occurring at the time of replacing price data is the same as the average price change of similar products.	(Old product prices) * (average percentage change of similar products) = (connected price)	U.S.: CPI

Example of Hedonic Regression Method

(1) Estimation of hedonic regression model

The following function is regressed using the characteristics and price data (here a logarithmic linear form is assumed).

$$\ln p_i = a + \sum_{j=1}^{n} b_j \ln x_{ij} + \sum_{k=1}^{K} d_k d_{ik} + u_i$$

p_i, x_{ij}, d_{ik}, u_i denote i th item at t period; p in price, x_j in j th characteristic, d_k in k th dummy variable, and u in error, respectively

Result of the hedonic regression model conducted on PCs

Box-Cox parameter regression form	Year 2000	
	Desktop	Portable
	0.200	
	Two-side Box-Cox	One-side logarithm
Constant	5.139 ***	4.637 ***
Main memory (MB)	0.294 ***	0.002 ***
HDD (GB)	0.280 ***	0.008 ***
Display size (inch)		0.035 ***
15 inches	0.250 ***	
15 inches and over - 17inches	0.688 ***	
17inches and over	2.345 ***	
TFT liquid panel display	1.304 ***	0.182 ***
CPU		
Pentium III	0.466 ***	0.120 ***
AMD K6-2	-0.496 ***	-0.107 ***
AMD Athlon	0.579 ***	--
Mac PowerPC G4	1.787 ***	--
Optical disk drive		
CD-R/W	--	0.092 ***
DVD-ROM	0.138 **	0.080 ***
DVD-RAM	0.520 ***	
OS		
Windows NT&2000	0.539 ***	--
Dummy's of manufacturers		
Company A	-0.224 **	-0.090 ***
Company B	0.399 ***	--
Company C	-0.440 ***	-0.304 ***
Company D	0.520 ***	--
Half-year dummy variables	-0.546 ***	-0.146 ***
Adj.R2	0.854	0.754
Standard error of estimation	0.494	0.118
Average of dependent variables	9.271	5.481
Number of samples	370	289

1. ***=1% **=5% *=10% respectively indicate the significance level.

(2) Calculation of quality adjusted prices

For example when PC-A is replaced by PC-B, the quality adjusted price of PC-B is obtained as follows:

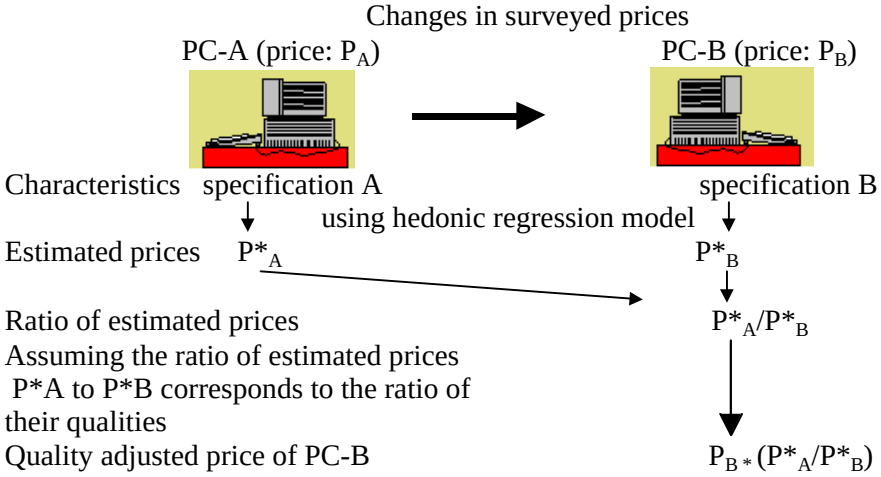


Chart 6

Quality Adjustment Effect in Domestic WPI

(1) Developments of quality adjustment effect

y/y % chg.

Surveyed period / Average y/y % change	First half of the 1990s (Ex. of 1993) <1990 base>	Middle of the 1990s (Ex. of 1995) <1990 base>	Second half of the 1990s (Ex. of 1998) <1995 base>	Recently (Ex. of 2000) <1995 base>
After quality adjustment (A)	-2.1	-0.7	-2.2	-0.1
Before quality adjustment (B)	-1.7	-0.4	-1.9	0.3
Quality adjustment effect (A)-(B)	***-0.4***	***-0.3***	***-0.3***	***-0.4***

(2) Details of the quality adjustment effect

y/y % chg.

	2000 (1995 base)			Reference: 1998 (1995 base)		
	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)
Total average	-0.1	0.3	***-0.4***	-2.2	-1.9	***-0.3***
Processed foodstuffs	-0.2	-0.1	***-0.1***	1.4	1.2	***0.2***
Textile products	-0.8	-1.3	***0.4***	-3.8	-4.0	***0.2***
Lumber & wood products	-0.7	-0.3	***-0.4***	-3.9	-3.8	***-0.1***
Pulp, paper & related products	2.7	2.6	***0.1***	-3.5	-3.6	***0.1***
Chemicals	2.3	2.5	***-0.1***	-2.6	-2.6	***0.1***
Plastic products	-0.6	-0.6	***0.0***	-1.7	-1.7	***0.0***
Petroleum and coal products	14.6	14.6	***0.0***	-8.3	-8.3	***0.0***
Ceramic, stone & clay products	-0.8	-1.0	***0.2***	-0.9	-1.4	***0.5***
Iron & steel	0.0	-0.1	***0.1***	-5.4	-5.4	***0.0***
Nonferrous metals	2.0	2.0	***0.1***	-7.1	-7.2	***0.0***
Metal products	-0.2	-0.2	***0.0***	-0.9	-1.0	***0.1***
General machinery	-0.6	-0.1	***-0.5***	-1.1	0.1	***-1.2***
Electrical machinery	-4.0	-3.4	***-0.5***	-3.7	-2.6	***-1.1***
Transportation equipment	-1.5	1.5	***-3.1***	-0.6	0.5	***-1.1***
Precision instruments	-1.3	1.2	***-2.5***	-0.5	-0.4	***-0.1***
Other manufacturing industry products	0.0	0.1	***-0.1***	-0.8	-0.7	***-0.1***
Edible agricultural, livestock & fishery products	-2.1	-2.0	***0.0***	0.3	0.3	***0.0***
Inedible agricultural & forestry products	-2.7	-2.6	***-0.1***	1.9	1.9	***0.0***
Mining products	-2.0	-2.0	***0.0***	-2.4	-2.4	***0.0***
Electric power, gas & water	-0.5	-0.5	***0.0***	-5.3	-5.3	***0.0***
Scrap & waste	1.0	1.1	***-0.1***	-35.1	-35.1	***0.0***

Note: To observe the quality adjustment effect of the relevant year, the year-to-year percent changes are calculated from the December index and the previous December index.

Quality Adjustment Effect in Consumer Goods (WPI)

(1) Quality adjustment effect in prices of consumer goods (by stage of demand and use; during 2000)

	Domestic products + Imported products	Domestic products
Consumer goods	-0.6	-0.8
Non-durable consumer goods	-0.1	-0.1
Durable consumer goods	-2.2	-2.5
Electrical machinery	-2.8	-3.2
Transportation equipment	-3.4	-3.4

(2) Quality adjustment effect in product prices of WPI corresponding to CPI (goods; during 2000)

	Domestic products + Imported products	Domestic products
Total	-0.4	-0.4
Clothes	-0.1	-0.1
Foodstuffs	-0.2	-0.2
Chemicals (medicine, etc.)	-0.5	-0.5
Electrical machinery	-1.8	-1.9
Transportation equipment	-3.4	-3.4

Note: Product prices of WPI corresponding to CPI (goods) are weighted averages of items included in the domestic demand goods of WPI corresponding to CPI by using CPI (Japan) weights.

Chart 8

Quality Adjustment Effect in CSPI

y/y % chg.

	2000 (1995 base)			[Ref.] 1998 (1990 base)		
	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)
All items	-0.3	-0.4	***0.1***	-0.9	-0.9	***0.0***
Finance and insurance	-1.2	-1.2	***0.1***	-2.3	-2.4	***0.0***
Real estate services	-1.7	-1.6	***0.0***	-0.7	-0.7	***0.0***
Transportation	2.7	2.7	***0.0***	-1.1	-1.2	***0.1***
Information services	0.0	-0.1	***0.1***	1.2	1.2	***0.0***
Communications and broadcasting	-2.1	-2.1	***0.0***	-1.7	-1.7	***0.0***
Advertising services	1.5	1.6	***-0.1***	-0.7	-0.6	***-0.1***
Leasing and rental	-5.8	-5.8	***0.0***	-2.3	-2.3	***0.0***
Industrial waste and sewage disposal	1.1	1.0	***0.0***	0.6	0.4	***0.2***
Motor vehicle and machinery maintenance	-1.2	-2.1	***0.9***	-0.2	-0.2	***0.0***
Other professional services	-0.8	-0.6	***-0.2***	--	--	--
Miscellaneous services	-0.7	-1.1	***0.4***	--	--	--
Civil engineering and architectural services	--	--	--	-1.0	-1.1	***0.1***
Legal and accounting services	--	--	--	0.2	0.1	***0.0***
Temporary employment services	--	--	--	1.2	1.2	***0.0***

Reference: calculated based on the assumption that the price declines in leasing and rental are totally regarded as quality change.

y/y % chg.

	2000 (1995 base)			[Ref.] 1998 (1990 base)		
	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)	After quality adjustment (A)	Before quality adjustment (B)	Quality adjustment effect (A)-(B)
Leasing and rental	-5.8	-1.5	***-4.3***	-2.3	-0.3	***-2.0***
contribution to CSPI	-0.4	-0.1	***-0.3***	-0.2	0.0	***-0.2***

Notes: 1. To observe the quality adjustment effect of the relevant year, the year-to-year percent changes are calculated by using the index as of December and that of the previous December.

2. As for civil engineering and architectural services, legal and accounting services, and temporary employment services, the categorization was revised at the time of switching to the 1995 base and has been rearranged into other professional services and miscellaneous services. In this chart, they are divided into three services for the 1990 base and divided into two services in the 1995 base.

3. The price decline in leasing includes not only quality changes but also the pure price decline of the item. Thus, this calculation is estimated as the upper limit value of quality adjustment. Changes in interest rates are not regarded as changes in prices of items but as changes in leasing rates.