Mismeasurement of CPI*

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Abstract

In this paper, we investigate several key problems in the Japanese economic statistics. We use CPI mismeasurements and biases as an example to explore the roots of the problems and also to offer guidelines for improvements. We emphasize 3 major shortcomings shared by many official statistics in Japan: (1) long delays in adjustments, (2) lack of proper coordination, and (3) insufficient information disclosure.

In the analysis of CPI bias, we limit our focus on potential bises due to aggregation, survey methodology and sample selection procedures. We estimate that, in recent years, the commodity CPI inflation rate is biased upward by at least .5% per year, even if we assume away the potential bias associated with the quality adjustment, delay in incorporating changes in consumption basket, and other important unresolved problems.

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1 Introduction

There are many good, even some wonderful, things to say about the economic statistics in Japan. To begin with, there are plenty of them, some quite exotic and probably not available anywhere else in the world. For example, former Tokai Bank (merged to form UFJ Bank as of January 2002), one of the major city banks in Japan, has been collecting the data and publishing the survey results on the amount of Otoshi-dama, money gifts given to children (by parents, relatives, guests, etc.) on New Year. Sumitomo-Shintaku (Sumitomo Trust) Bank, on the other hand, takes pride in being the first to estimate the economic impact of very popular Hanshin Tigers, a professional baseball team, winning the Japan Series in 1985, as many research sections of city banks followed the suits in estimating the economic impacts of other teams winning the series in subsequent years. It would indeed seem difficult to find any conceivable type of economic data with even remote interests for economists not collected in one way or the other in Japan, although many of them are collected by non-government institutions.

Another good thing to say about the statistics in Japan is its comprehensive coverage, geographically or otherwise. Although the country consists of many small islands, most of the government statistics cover virtually the entire population. Japanese economists are also lucky to have rather extensive and comprehensive data coverage on wide spectrum of topics, especially those collected on establishment basis.

There are problems, of course, and some are rather serious in nature and quantitatively important. In this paper, we focus on potential problems in Consumer Price Index (CPI). By so doing, we will point out several underlying factors responsible for the problems not only in CPI, but also in other official statistics in Japan.

The choice of CPI as our focus is partially dictated by the authors' own professional background, but also by the depth of the analysis that we can realistically hope to achieve[1]. CPI is an important and popular statistics and used for many different purposes. CPI inflation rate is one of the key indicators for cyclical fluctuations of the economy. CPI is also used as the benchmark in many wage setting and negotiations. Public pension annuity is also linked to CPI and periodic adjustments incorporate the past changes in CPI[2]. Recent macroeconomic developments in Japan also adds to the significance of studying potential mismeasurements in CPI in that the stagnant economy has been experiencing zero or negative inflation rate for prolonged periods, an experience rather unique which might shed some new lights to the issues of measurement biases in CPI.

Last, but not the least, as we indicated above already, we chose CPI because

[1] For example, GDP is by far the most popular and important statistics. Being a secondary statistics based upon large variety of primary statistics, however, potential sources of the biases and other problems are simply too many to make a through analysis in this paper.

[2] In recent years, however, public pension annuity has not been downward adjusted in spite of the sizable decline in the CPI.

CPI shares with other major official statistics the common underlying causes which lie beneath the problems in the Japanese official statistics system. We hope that the subsequent investigation of the CPI help elucidate the nature of the problems commonly found in many important official economic statistics of Japan.

The remainder of the paper is organized as follows. In section 2, we offer a bird eyes view of the official statistics in Japan and point out several important deficiencies in them. In section 3, we review key issues in CPI which leads to potential biases in the CPI. Section 4 is the main body of the paper. We investigate potential problems of CPI in three major facets; lower level data collection and aggregations, substitutions across brands, substitutions across stores. Although we are fully aware of the potential importance of the issue of quality change, we only review the recent studies in this area and make a few cautionary notes for the future, full fledged analysis. In 4.5, we offer our tentative assessment of the magnitude of the CPI inflation rate bias. In 4.6, we focus upon hitherto neglected aspects of the measurement problems in CPI; incorporating shopping and storage behaviors into COLI. Using simulations, we demonstrate that the failure to incorporate changing and cross sectionally diverse shopping behavior have important quantitative impact on the magnitude of the bias in CPI. In section 5, we summarize the major findings in sections 3 and 4 to offer tentative appraisal on the CPI and draw some observations on the underlying problems in official statistics in Japan. Section 6 concludes.

2 Japanese Official Statistics: A Bird-Eye View and Major Problems

2.1 Japanese Official Statistics

Japanese official statistics can be classified into three broad groups. The primary statistics are either chosa-tokei, statistics collected for specific statistical purposes, or, gyomu-tokei, those collected in conjunction with the regular tasks of governmental offices. Statistics in the third category are processed statistics and they derive from other primary data. Most of major official statistics in the first category are sitei-tokei (designated statistics) and they form the core of the official statistics in Japan. As of 2001, there are 62 designated statistics that are revised on periodic basis (there are many more that new data collection has been stopped)[3]. There exists many more approved statistics, so named because they are approved by the Minister of Somusyo. Table 1 lists these statistics. Not all the important primary data sets are found among these two categories of statistics. Instead, many of them are part of gyomu-tokei. For example, the primary data on exports and imports are in Custom Clearance Statistics compiled by Ministry of Finance. Equally importantly, some of the key economic

[3] Somusyo also reports the number of official statistics and statistical surveys conducted by central government and approved by Somusyo each year: in recent years, the number ranges between 400 and 500. See Table 1 for the details in the most recent years.

statistics are secondary statistics based upon other primary statistics. National Accounts statistics is by far the most well known in this category.

Designated statistics, and, to a certain extent also approved statistics, comprise special category among the official statistics because these are given special status in the law. Specifically, the law stipulates clearly that government bodies collecting these statistics are endowed with authority to enforce and request proper cooperation from the public chosen to be surveyed in the statistics. At the same time, the law sets rather rigid restrictions on the use and dissemination of information contained in these statistics. Such special status thus allows the data collecting agency to conduct surveys and census in the way that private data collecting bodies without such authorization cannot hope to accomplish.

Given the special nature of these statistics, it is hardly surprising that the list of statistics in Table 1 represents a small portion of the official statistics available to us in Japan. Be that as it may, the list gives us some idea on basic characteristics regarding Japanese official statistics. First of all, Japanese official statistics are compiled in a rather independent manner by each ministry, agency, or other bodies of government. Officially, Statistics Bureau of Ministry of Public Management, Home Affairs, Posts and Telecommunications (hereafter called Somusyo) is responsible for coordinating activities of statistics sections of different ministries. It is apparent, however, that the system is highly decentralized and each ministry seems to be acting in its own in creating, dismantling, collecting, and publishing variety of statistics[4].

One may be puzzled by associations of ministries with some of the statistics. For example, we may wonder why Somusyo conducts Survey of Research and Development, instead of, say, Ministry of Education, Culture, Sports, Science and Technology; or, we may ask: What is the rationale for National Tax Agency to collect data on salary in the private sectors;, or, Is the Bank of Japan (which is not even a part of government) the most appropriate institution to compile wholesale price index (WPI) and Corporate Service Price Index (CSPI), etc. etc. The point is that the association is often a historical accidence yet ministries seem unwilling to reshuffle their assignments.

Another striking characteristics of the official statistics system is the meager allocation of personnels and budget. According to Somusyo, the total number of central government full time staffs in statistics sections is 8,804. The size is a mere 2.2% of total central government administrative staffs, 398,000[5]. The budget allotted for statistics is also meager: In fiscal year 2000, central government allocated 93.6 billion yen, out of which 75.9 billion yen are allocated to statistics sections of Somusyo. Even this size is exceptionally large because 2000

[4] In most cases, it does not matter whether or not any particular official statistics is either primary or processed, or whether or not designated statistics. Neither does it seem important that statistics center of Somuyso is the coordinating agency. It matters greatly, however, if one tries to obtain the original data such as individual responses to some survey which is not available in published statistics. The center in this case is the decision making unit. It matters greatly whether or not the application for special usage is consistent with, among other things with the stated objective of each statistics.

[5] The number exclude those in national universities and stuffs primarily engaged in non-administrative activities (such as those in postal system).

was the year in which population census was conducted (once in every 5 year). In other years, such as shown for 1999 in Table 1, the budget has been around 40-50 billion and Somusyo's share is around 30%. The size is roughly 0.1% of the central government budget. The budget size can be also compared with 218 billion yen, the estimated sales of on-line data service industry in 1998.

Aside from the size, composition of staffs is also problematic. As far as we know, among 8,804 working in statistics sections of the central government, there is virtually no one with advanced education background in economics and only precious few with some professional background in statistics. Given all of these limitations, it is hardly surprising that the Japanese official statistics have large room for improvements. We briefly consider most important ones in the rest of this section.

2.2 Long Delays in Adjustments

Titles of the designated statistics indicate that the coverage of these statistics are far from being well balanced. For example, one of the statistics compile domestic production and usage of coal, even though only 1.9% of the total coal consumption is produced domestically and only 12% of the total energy consumptions is coal. There are three designated statistics on shipping and seamen, although the Japanese crew in the Japanese commercial ships has long been replaced almost completely by foreigners. Another designated statistics still duly collect production of silk and silk worms, even though the industry itself is all but extinct. The imbalance seems particularly noticeable in agriculture and fishery. In 1999, Ministry of Agriculture, Forestry and Fisheries spent 29% of the total budget and employed 67% of staffs of the personnels devoted to the statistics collection and compilation. We might compare the figure against the fact that the GDP share of all the primary industries combined is less than 2%.

On the other hand, surprisingly little resource seems to have been allocated for collecting data on tertiary industries, especially on services. There is only one designated statistics that covers the service industry offering basic data on production, employment, firm size, etc. Even this statistics rotate the choice of subsectors every 3 year to cover the entire spectrum of the industry. The coverage imbalance reflects long time-lag in adjusting the data collection to the secular changes in the country, industry, and people.

The problems due to the long delay in adjustment is not limited to the coverage imbalance. As we see more closely below, weights attached to individual items in CPI are based upon the FIES (Family Income and Expenditure Survey) and it is fixed for 5 year period, although the FIES is conducted on monthly basis[6]. The long lag is also a problem in GDP statistics: the first preliminary GDP figures are announced full 3 months after the end of each quarter. The first figures are then revised in 3months later in the second preliminary figure before the final figure is announced. This final figure is made available in December of

[6] To be fair, other countries also have similar delays in the adjustments of the coevrage and weights of the consumption basket. In the US CPI, BLS used 1982-1984 weights until 1996 and finally replaced by 1993-95 wieghts which is already 8 years old.

the next year. This can be compared against the GDP in the United States; the first preliminary figure is announced in 8 weeks and the second and final figure is made available by the end of the next quarter. In other words, by the time the Japanese first preliminary figures is announced, the US GDP final figure is announced.

2.3 Lack of Proper Coordination

The second problem is the lack of proper coordinations among different bodies of government. Needless to say, coordination with non-governmental institutions are pure exceptions, if there is any. As a result, different bodies of government collect many similar, if not duplicate, sets of data. Moreover, we find in many important areas the lack of proper official statistics, due, mainly, to the fact that the area belongs to more than one ministries responsibilities. Especially notable is areas under the general rubric of information and communication, as subsets of the areas are covered rather independently by sections of Somusyo and Ministry of Economy, Trade and Industry.

Another problem due to inadequate coordination is the difficultly in incorporating more than one sets of statistics. Each statistics often employs its own geographical grids, strata, or categories according to its own definitions so that cross referencing is often difficult and may lead to erroneous conclusions[7]. In some cases, it seems easy and straightforward to rectify the situation. For example, many statistics on private enterprises and establishments cover essentially the same universe of firms whereas each statistics employ its own coding method, sample selection methodology, etc., with the result that none of these statistics can be integrated to form a unified one[8].

Lack of coordination also places heavy burden on sample respondents, especially on large firms as they are included in most of enterprise based statistics. According to a survey by Somusyo in 1993, more than 25% of sample firms listed in Tokyo Stock Exchange responded that they have to reply to more than 100 different surveys per year by central and local governments.

2.4 Inadequate Information Disclosure

The third common problem is inadequate information disclosure. The problem is especially severe in two aspects. First of all, many published statistics are processed using one or more of the primary statistics but the details of the procedure leading to the published statistics is generally not available. The problem is extremely severe in most of National Accounts Statistics as they incorporate so many different statistics. Because of inadequate information disclosure, it is

[7] Among the most well known is the apparent inconsistency in personal saving rates in National Accounting and Household Saving and Expenditure Survey.

[8] The problem can be easily rectified by a simple code sharing in the case of the largest firms; most of these statistics take all the listed firms and firms with more than one billion yen of paid capital as samples.

often difficult for outsiders to disentangle the complicated procedures and identify and quantify the root cause[9]. In GDP statistics, corporate sector includes not only private incorporated enterprises, but also the portion of activities of central and regional governments conducted by specific agencies (such as postal system). There is no precise and reliable information upon which we can identify which part of the government activities are included. The problem is not limited to the secondary statistics. CPI is based upon the survey results of the prices at selected sample retail stores but the original survey results are not available with the result that we do not know (for example) how and how much of adjustments in quality change is made. The same problems exists on WPI as well.

For economists, an equally, if not more, important problem is the unwillingness on the side of government to make the original micro data available for outside researchers. As we indicated above, the restrictions are particularly severe among designated statistics. In order to obtain the original micro data from such statistics, we have to clear complicated, lengthy, and very time consuming application processes at statistics bureau of Somusyo. Even that by no means guarantee that the permission be granted[10].

The difficulty in obtaining the original data places severe constraints for outside economists even in pointing out with any reasonable accuracy where exactly the problem lies. The concern over the accuracy of CPI arose partly because many retail firms started publishing their own price data to argue that the CPI contains sizable upward bias[11]. The debate was ultimately not productive partly because Somusyo did no disclose original survey data comparable to those covered by retailers.

3 CPI Statistics - A Brief Review

3.1 CPI

Consumer Price Index (CPI) in Japan is collected and published by Somusyo Tokeikyoku (Statistics Bureau and Center, Ministry of Public Management, Home Affairs, Posts and Telecommunications). Japanese CPI is by and large very typical of CPIs collected in most of the countries. It is essentially a fixed weight Laspeyres index with the weights taken from Family Income and Expenditure Survey, or FIES, which is also collected by Somusyo. The weights in the index are revised every 5 year incorporating the latest survey results of FIES. Compared to the CPI in the United States, there are several notable differences in data collection procedures and lower level aggregations. Among others,

[9] See, Ando(2000) for the problems he faced in his exploration of the measurement errors in saving rate.

[10] The law explicitly and categorically prohibits use of official statistics for purposes other than the ones specified in the law establishing each statistics or corresponding ministerial orders. The application thus constitutes a petition for special exclusion of this general rule in making use of the original data. See Matsuda et al (2000) for the details.

[11] One such example is Sezon research Institute (2000).

Japanese CPI includes larger number of individual items (roughly 600 compared to about 200 in the US CPI); choose single representative brand for each item to survey prices; also choose single representative retail outlet within each designated area for each item (both outlets and items are rotated in the US); surveys actual price sample on specific days of each month rather than taking averages over period or brands as in the US CPI; arithmetic rather than geometric means (US CPI converted to use geometric means for lower level aggregation after Boskin Commission report) are used in every stage of aggregation.

In recent years, especially since the late 1990's when the deflationary pressure to the economy became apparent, CPI index has been criticized for its apparent failure to register the impacts of rapidly declining retail prices as they were reported by media as well as in the reports compiled by some of the largest national chain of GMSs. Some of the macro level official statistics also show lower inflation rates in recent years. Table 2 shows 3 most representative consumer inflation rates, CPI, GDP deflator for household final consumption[12], and WPI for final consumption demand. CPI shows substantially higher inflation rates than the other two. CPI statistics has met criticism also from more professional circle including some economists and statisticians[13].

3.2 CPI as COLI

From a viewpoint of standard microeconomic theory, the principal objective of CPI is to provide a benchmark for the cost of living index (COLI). Under a certain set of strict conditions, we can derive a group of price indices, called Superlative Price Indices[14], which approximate the true cost of living index up to the second order. One index among the group is Tornqvist price index and it is given by

$$\log P_{0t}^{TR} = \sum_{i=1}^{N} \frac{1}{2}(\omega_0^i + \omega_t^i)(\log p_0^i - \log p_t^i),$$

where 0 denotes the reference period, i is the index for the goods and services, and ω is the expenditure share. The Laspeyres index, on the other hand, is given by

$$P_{0t}^{L} = \sum_{i=1}^{N} \omega_0^i \frac{p_t^i}{p_0^i}$$

The major advantage of superlative price index, including the Tornqvist, is that the index properly incorporate the substitutions among goods and services

[12] The deflator for final consumption expenditure in GDP is constructed using CPI data and weights in FIES. The deflator is , however, (i) a Paasche index using the (ii) current weights from FIES. Both factors tend to generate lower inflation rate than the CPI.

[13] The most comprehensive study on Japanese CPI is in Shiratsuka (1997). Shiratsuka (1999) reviews this monograph as well as other major studies. Somusyo's homepage (http://www.stat.go.jp/data/cpi/8.htm) contains various documents prepared by the ministry on this issue.

[14] See Diewart (1976) and Caves, Christensen, and Diewert (1982).

in response to (among other things) changes in relative prices. As the above formula indicates, neither Lasperes (weights fixed as those in the reference period) nor Paashce index (weights fixed as those in the current period) incorporates substitutions. The most serious problem in Laspeyres formula as an approximation of COLI is that the index tends to over-represents prices which have risen from the reference period, thus over-stating the impact of price increases. By the same token, the index under-represents the impact of price declines. The magnitude of the bias thus depends crucially upon the two factors; i.e., the variability of relative prices and the degree of substitution across goods and services.

The practical difficulty using Tornqvist or Fischer (geometric mean of Laspeyres and Paasche) index is that they require the current data on expenditure shares. If the expenditure shares are continuously available, we can construct corresponding chained indices[15]:

$$\log P_{0t}^{TRC} = \sum_{s=0}^{t-1} \sum_{i=1} \frac{1}{2}(\omega_s^i + \omega_{s+1}^i)(\log p_s^i - \log p_t^i),$$

$$P_{0t}^{LC} = \prod_{s=0}^{t-1} \left(\sum_{i=1} \omega_s^i \frac{p_s^i}{p_0^i} \right)$$

3.3 Major Sources of the Bias

There are three fairly well known, if not well established, potential problems in the Japanese CPI. All of them are considered as sources of upward biases in CPI. In this subsection, we briefly review each of the problem.

3.3.1 Lower Level Data Collection Procedures

As we explained briefly above, in the current procedure of the price survey for CPI, prices for each item is collected, first by specifying the most representative brand for each item, and then selecting 'the most representative' sample store (usually the one with the largest sales volume of the item) within each precinct.

First of all, the brand selection procedure is problematic. Setting aside the problem of changes in the leading brand over time[16], fixing a particular brand by itself tends to create upward bias: people do substitute among different brands, especially when a particular brand is on temporary price discount. If

[15] The one important drawback of chained indices is path dependence, i.e., the same magnitude of total price changes result in different price index values, depending upon the course through which the changes take place. The problem is quantitatively important in high frequency data. See Feenstra and Shaprio (2001) for the bias due to this path dependence.

[16] Somusyo states that they check the selection of specific brands evry half year and replace brands whenever found appropriate. We do not know how many and how often brand substitutions occur. Shapiro and Wilcox (1996) cites Armknecht and Weyback (1989) and indicate that the item tunrover is closely related to the inflation in that the bulk of inflation rate is attributable to imputed price increase registered for newly surveyed brands and entry level items after the previos samples became unavailable.

a consumer is totally indifferent among different brands of a specific item, the relevant consumer price for such a consumer is the minimum of the retail prices of these brands. Fixing a particular brand gives us with the unbiased price data as COLI if and only if all the consumers are completely brand royal, or, all the retail prices of different brands move together.

By the same token, selection of single sample store within each sample precinct is also problematic as consumers do substitute and select shopping outlets. The neglect of store substitution tends also to introduce upward bias.

Another problem in data collection is the way discount prices are treated. The CPI survey collects prices on Wednesday, Thursday, or Friday of the week in every month that includes the 12th day of a month. If the price is discount price, such sample is void unless the price has been quoted for at least 8 days at the moment of the survey.

There are several problems with this procedure. First of all, it is not clear at all how regular and discount prices are defined. In most of the cases, the highest selling price seems to be the one defined as regular price. It is unclear if regular price ever changes at each store, and if so, how often. As we see below, actual prices do change quite frequently. The current procedure thus tend to ignore almost all the discount prices (whatever that means) of short durations, whereas in fact often the majority of sales are concentrated in short, discount sales. Moreover, the extent to which discount sales are used differ systematically across items, brands and types of retail outlets. Discount sales are widespread and routinely used in most of national brands, whereas most of generic commodities without strong brand recognition are rarely sold on discount. Discount sales is far more common at large scale supermarkets and speciality stores but very infrequent at small scale general stores and almost non-existent in some of convenience store chains.

Although we have no apriori reason to believe that these measurement errors per se generate systematic bias in measured inflation rate, in the context of the recent macroeonomic setting and secular changes in the retail industry in Japan, we do have reasons to suspect systematic upward bias in inflation rate created by these measurement errors and biases. First of all, the share of retail sales in Japan has been shifting away from traditional small scale stores towards large scale supermarket and discount stores in suburbia, and, also, towards inner city convenience store chains. This continuing shift may introduce systematic upward bias in the CPI to the extent that the current CPI procedures subsumes some of pure price differentials across different types of stores as those reflecting differentials in the retail services.

The biases created at lower level can be quantitatively large precisely because they occur as a result of substitutions over very close substitutes: substitution over time of the same brand, substitution among neighboring stores, and substitution among different brands of the same good.

3.3.2 Aggregation Biases

The second problem is the aggregation procedure. The Japanese CPI is fixed weight Laspeyres index. As indicated above, the biases created by using fixed weight and taking arithmetic means are well known. The aggregation bias arises in every stage in the Japanese CPI.

At the bottom level, one representative brand of each item is chosen for data collection. As we will have indicated above, this procedure assumes away the inter-brand substitutions within each item and thus tends to create sizable upward bias. Naturally, upward biases are introduced at higher levels as well due to the fixed weights procedure. As we saw above, fixed weighting problems appear also in the selection of sample stores. The problem became serious especially in the 1990's when the volume of retail sales shifted away from small independent stores to a larger chain stores as well as to discount outlets on roadsides (see Table 8). The FIES itself is not free from the sampling problem: Among others, the most conspicuous is that the single person household is not included in the sample strata. Given the large and increasing proportion of the population living alone, and the substantial deviations of consumption patters of those single household from the rest, the bias implicit in this procedure is also potentially important[17].

On the other hand, zero or negative inflation in recent years in Japan probably lessened the size of aggregation bias in comparison with economies with mild but positive inflation rate.

3.3.3 Quality Change, New Products, and Problems in Services

The last, but not the least of the problem is quality adjustment and treatments of new products.

In the current CPI, essentially nothing is done on incorporating the potential impact on COLI by introduction of new products into consumption basket. This is understandable given the fact that no established procedure to incorporate the impact exists at this moment. On the other hand, the long delay in incorporating the changes in the consumption basket by itself introduces large and rectifiable biases if price decline is highly concentrated in the early periods of market appearance before the product is included in CPI[18]. For example, it is only in the latest revision in 2000 that CPI included items such as personal computer, service charge for mobile telephone, etc. Even after the revision in 2000, the CPI does not include items such as printer and other computer peripherals, fax machine, internet provider service charge, etc.

[17] From October 2001, Somusyo started new consumption survey, covering 20,000 households including those with single member, focusing on high priced items purcahsed infrequently, which FIES is ill-suited to cover. The survey is completely delegated to semi-private research/survey organization. This survey is intended to complement FIES by surveying IT related items such as persnal computers, mobile phones, internet-provider services, consumer electronic appliances, and other selected items in services already covered in FIES. Starting later this year, FIES will also be expanded to conver single member households.

[18] This seems to be a regular pattern for many consumer durables, whereas it is conceivable that in other cases, prices rise fast during the early stage for other types of products.

Although many consider quality changes by far the most important source of the upward bias in CPI, very few systematic studies exists for Japanese CPI[19]. In the current procedure, whenever the sample item or brand is considered different in quality from the previous sample, overlap method is used to take account of quality changes. In 2000, CPI for the first time started using hedonic methods to estimate the quality change in personal computer, but, as of now, this is the only item utilizing the method.

Closely related to the issue of quality change is various measurement issues surrounding service prices. After the revision in 2000, services comprise almost half (48.4%) of the total CPI weights. There exist inherent difficulty in assessing the potential impacts of the major sources of the biases touched above on service prices. This is so because we often have no natural measure for quantity of the services purchased. This implies that expenditure data such as FIES are ill-suited to be used as the alternative data source for the prices. Objective measurement of quality of the services is even more difficult. Because of these reasons, we have little to offer on the biases in this group. On the other hand, there are reasons to believe raw price data are more accurate for some of the services in the CPI. Most of utility rates and public transportation service prices are uniform (and well documented[20]) without any major discount which is so common among food stuffs and clothing.

Setting aside the quality adjustment problems, the biggest problem in the service categories is the under-representation of the expenditure on medical and health care in the CPI as the weight is based upon the actual (out of pocket) expenditure in the FIES and it totally neglects payments for medical insurance. According to Survey on Medical Expenditure, the total medical expenditure in 1999 was 30.9 trillion yen, or, 8.08% of National Income of the same year. Of the total expenditure, patients' out of pocket expenses comprise only 14.6%, which is covered by FIES. In the current CPI, the weight on medical (2.4%) and health care (1.4%) is 3.8%. Because of the exclusion of medical and health insurance, the items selected in the category are limited to those not covered by typical health insurance. This explains why only OTC drugs, cost for physical check-ups, and hospitalization fee for normal delivery are included but most other medical services are excluded. Not surprisingly, available data indicates systematic differences in price indices, depending upon who pays the cost: consumers, insurance policy, public institutions, etc[21].

It should be also noted that CPI contains several conceptual flaws in some other service prices. Especially noteworthy is the imputed rent for houseowners.

[19] In series of papers, Shiratsuka and his associates estimated hedonic price indices for personal computer, automobile, camcoder, and apparels. According their results, quality adjusted personal computer price declined at 25% per year during 1990 to 1994, automobile also declined at .4% per year, video camera by -11% per year, during the same period. Quality unadjusted indices for these products, on the other hand, registered annual rate of changes -3%, +4%, and -6%, respectively (Shiratsuka 1997).

[20] This applies also for the price data on medical services. As the bulk of payments are covered by public health insurance, there exists readliy available and highly comprehensive price list for individual treatments, various fees, and prescription drugs.

[21] See Iwamoto (2000) for some representative medical price indices.

The actual rent data collected are those for rented houses; we know, however, that the rented houses and owner occupied houses differ greatly in capacity and quality. To the extent that the recent improvement in quality of owner-occupied houses are not properly incorporated, the measured rent is likely to include sizable upward bias. It should be born in mind, however, that given the sheer magnitude of the diversity of houses across regions, types, and vintage, it is a formidable task even to estimate the size of the bias, let alone correcting them.

4 Assessing the Magnitude of CPI Inflation Rate Biases

In the previous section, we gave a brief summary of the major problems in CPI. We found that most of the problems raised in Boskin commission for the US CPI are also found in Japanese CPI. In many areas, the potential ramifications seem even more important in Japanese CPI. In this section, we focus mainly on the problems arising from data collection procedure but spend some space for specific remarks on the nature of other problems. As we have stated already, our focus is dictated mainly by the data availability, not by our evaluation of relative importance of the problems listed above.

Before we start the main analysis, a cautionary note is due on the distinction between potential measurement errors in general and the bias in the inflation rate. The existence of measurement errors of course contaminate the CPI. They do not, however, imply systematic bias in the measured inflation rate, or changes in COLI. For example, consider the potential measurement errors in medical and health care services. Although we believe that there exists serious measurement errors and under-representation problems, it is unclear if and in which direction these problems are potential source of bias in measured inflation rate[22].

4.1 Higher Level Aggregation Bias

At the higher level of aggregation across items, it is well known that the current fixed weight Laspeyres using arithmetic means tend to produce some upward bias in the CPI. This issue is not unique to Japanese CPI and we only show the results in Table 3. Table 3 follows Shiratsuka (1997) and extends his results into 1995-2000 period. The procedure is simple and straight forward: we use annual expenditure weights in FIES for 85 lowest level categories to compute chained Fischer and Tornqvist indexes and compare to CPI which use the same but fixed at 1995 weights. The aggregation bias at this level is not large. Compared against chained Tornqvist or Fischer Indices, fixed weight Laspeyres generates roughly .05% upward bias per year in the last 5 years. The results by Shiratsuka shows that the same computation generates somewhat larger bias for the

[22] As a matter of fact, several indices shown in Iwamoto (2000) indicate some higher, and others lower rate of inflation in medical expenditure than the one in CPI.

earlier periods in the order of .1%. Aggregation bias arises due to the under-representation of the scope of substitution whenever the relative prices of goods and services change over time. Our results indicate that the bias is smaller in the most recent years primarily because of smaller variations in relative prices[23].

4.2 Intertemporal Substitutions

We move to the lower level of aggregation. Let us start with the bottom level of aggregation, biases created within each item. Essentially the problem are twofold: one due to the selection of a particular brand within each item, and the way that price observations are collected. In a sense the bias in this level are the easiest to deal with because, in principle, there is not much room for disagreements. The extent to which different brands of an item is substitutable is an empirical question which can be answered with reasonable accuracy if CPI collects sufficient amount of data. We deal with the substitutions across brands within each item in the next subsection.

Here we consider the substitution over time of the same brand. The extent to which consumers can exploit periodic discounts depends primarily on the knowledge and the ability to hold inventory at home[24]. Our finding suggests that the substitutions are quantitatively important in both accounts. In principle, the upward bias due to the survey procedure applies only to the level, not necessarily to the changes in the index. The problem is essentially that the procedure systematically truncate the low price observations. This truncation may or may not generate upward bias in the inflation rate. Circumstantial evidence indicates, however, that indeed the procedure brings about sizable upward bias in the measured inflation rate as retailers reduce average sales price by lowering further the discount price, and/or, increasing the frequency of price discounts.

The easiest way to visualize the inflation bias created by the inter-temporal, intra-brand substitution is to compare the actual average purchase price vis-a-vis the hypothetical price data, which CPI would collect, following the procedure of the data collection described in 3.2.1. We use POS-DEI [25] compiled by Distribution Economics Institute of Japan. Table 4 uses the POS-DEI for 6 selected items sold at sample large scale retail stores during the 24 months period starting from April 1995. The results are consistent across all of the 6 items. Namely, the current CPI procedure explained consistently overestimates the inflation rate as most of the special sales prices are dropped from the survey. Notice that the results indicate that the average purchase price decline occurred primarily as a result of the reduction in special discount price and/or the increased frequency of the periodic discounts. Moreover, as Shiratsuka (1997) pointed out,

[23] Notice that lower or negative inflation rate per se does not reduce the aggregation bias. What matters is changes in relative prices. Our results only confirm that the relative price variability at higher level of aggregation is positively correlated with inflation rate. See however out results for lower level of aggregation in 4.3.

[24] See Feenstra and Shapiro(2000) and our own [Ariga, Matui and Watanabe (2001)].

[25] See Appendix for the details of the data sets used in this paper.

the current procedure substantially increases the noise as the procedure only sporadically pick up sales discount from time to time. The standard deviations in the inflation rate under the current survey procedure is substantially higher in most of the items.

The next piece of evidence comes from the POS-SRI for 14 selected items. The average monthly price of each brand is given by

$$p_t = \alpha_t \cdot regp_t + (1 - \alpha_t) \cdot salesp_t$$

where $regp_t$ is the average regular price, $salesp_t$ is the average price at special sales, and α_t is the sales share at regular price during each period. We decompose the monthly price change of each brand into three components: take the time difference of the equation above, we get:

$$\Delta p = \Delta\alpha(regp - salesp) + \alpha\Delta regp + (1 - \alpha)\Delta salesp$$

Table 5 shows the decompositions for 14 items. First of all, we find that roughly 60% of the average price change is due to the changes in the special discount price, whereas the changes in the regular price comprise only about a quarter of the total price changes[26]. The finding is consistent with the result in Table 4 in that both point out that not only the current CPI procedure substantially lose high frequency information, but also in a very asymmetric manner. The procedure systematically lose information on price decline because the relative contributions of these components differs significantly, depending upon the direction of the average price change. Namely, more than 85% of the decrease in the average price is due to the increase in the share of discount sales and the decline in the sales price, as compared to 51% share in the case of price increase.

Unfortunately there is no unambiguous way to estimate the extent to which the bias due to the survey procedure applies to other items in the CPI. What we know is that the periodic price discount is quite widespread in most of medium to large scale retail stores. Most of processed food, toiletry goods, cosmetics, household appliances, and some of the clothing follow this type of pricing pattern. In other words, for most of those items sold at large scale retail stores, we expect periodic discounts similar to those given above have been taking place and the current CPI creates systematic upward biases for these items in the order of 2 to 3% per year.

4.3 Substitutions across Brands

As we explained in section 3, the CPI chooses single brand to represent the price movement of each item. In general, ignoring substitutions across different brands result in upward bias of the level of cost of living, whereas it is not certain if it

[26] We suspect that even this share is likely to be upward biased as most of the changes in regular price seem to have arisen due to the changes in the sales composition of different brands, rather than the changes in regular prices of respective brands..

results in any bias in the inflation rate. If the relative price of different brands is stable over time, the bias may well be negligible in computation of CPI index.

Figure 1 shows three price indices compiled from the POS-SRI data for liquid condiment, one of the 14 items included in 1997 National Survey of Prices Special Volume on Bargain Prices. Along with the Tornqvist index for the item, the Figure 1 shows indices for two brands which registered the lowest and the highest inflation rate during 1995 and 2000. Within item variations across different brands are indeed very large. Table 6 shows the intra item sample variances for the 14 items and monthly inflation rate for corresponding item level Tornqvist index. A simple panel regression of monthly item level price variances on inflation rate for 14 items yield

$$\begin{aligned} var_t^i &= \sum_{k=1}^{14} const^k - \underset{(1.54)}{.0363} ifr_t^i, \\ \overline{R}^2 &= .0874 \end{aligned}$$

The result indicates that the deflation coincides with increase in price variations across brands. These findings thus indicate that ,at least for these 14 items, consumers have ample opportunities to substitute one brand for others.

In Ariga, Matsui, and Watanabe (2000), we used the daily POS data for the two rival brands of curry paste sold at selected supermarket stores. Table 7 shows the impact of rival brand price discount on the sales volume. The average sales volume of Brand A at discount price is about 19% smaller if the rival Brand B is also sold at discount price. The impact of Brand A discount on the sales volume on Brand B at discount price is even larger, more than 30%. On the other hand, pricing of rival brand has much smaller impact on the sales volume at regular price, around 6-8%.

Given the large impact of periodic price discount on sales, these figures suggest the presence of heterogenous consumers as well as sizable inter-brand substitutions in response to changes in relative prices. Although these findings strongly indicate that price data of any particular brand can be highly misleading indicator for overall changes in prices of different brands of each item, we are unable to provide estimate on the magnitude of the inflation rate bias created by brand substitutions per se. Given the analysis above on the inter-temporal substitution, it is probably not very productive to try to estimate the brand substitution effects alone as the substitution in this aspect is so closely related to the inter-temporal substitution and periodic price discounts. We also note the difficulty due to extremely high rate of brand inflows and outflows, particularly among items in food, household appliances, toiletry, and clothing groups. Shifts in sales shares from one brand to another are not only highly frequent but also unpredictable. This makes it practically impossible to obtain reliable estimates of the substitution elasticities for wide ranges of goods in the CPI.

4.4 Substitutions across Stores

According to the current CPI procedure, the survey selects the most 'representative store' within each survey precinct for each item. The survey has roughly 700 such precincts to cover the country. Usually the stores with the largest sales volume are chosen for respective items. Sample stores within each precinct are revised on ad hoc basis.

Table 8 shows the changes in shopping points in National Survey of Family Income and Expenditure in the last 3 waves. As expected, regular stores lost shares across the board in the last 15 years. The decline is especially large in food. Somusyo's document [Somusyo (2000)] explains the selection procedure for precincts and sample stores. It is not entirely clear, however, to what extent the delay or failure in adjusting the sample retail stores contribute to the selection bias in the CPI. According to Somusyo, 'The latest store selection is fairly close to the 1999 distribution in the result shown in Table 6).'[27]

Although it is not clearly stated, the current CPI apparently attributes all the price differentials across retail stores to the differentials in the quality of services provided by outlets. This implies that whenever sample stores are changed and the surveyed price of a sample commodity differs from the one taken at the previous sample store, this price differentials are regarded as the underlying service quality differential, thus no effect appears on CPI. In short, even if the CPI has been constantly and correctly adjusting the sample store distribution to the changing shopping patterns, none of the within brand price differentials across different types of stores are incorporated in the CPI.

In principle, we agree that some of the existing price differentials do reflect the service quality of retail outlets. On the other hand, given the long history of entry regulations of large scale retail stores, and given the fact that consumers do indeed have shifted their purchase from general small scale retail store to supermarkets and mass marketing specialty stores whenever such stores are opened in the neighborhood, it seems clear that some of the price differentials are just that, pure price differentials reflecting the local monopolistic power of retail stores in pricing.

Table 9 and 10 offer some evidence. 1997 National Survey of Prices collects large cross section data on retail prices of 14 selected items at variety of retail stores across different locations. Table 9 shows the discrepancy in the actual retail prices of 14 selected items across different types of stores. The variation is large. At regular small retail stores, the average regular price is 4.8% higher than at supermarkets, 5.5% higher than mass-marketing speciality stores, and 5.9% higher compared to Coops. If we compare the special discount prices, the differences are much larger: average discount prices at regular stores is higher by 21.2%, 14.1%, and 14.4%, respectively, compared to those at supermarkets, mass-marketing speciality store, and coop. We suspect that even these com-

[27] Shiratsuka (1999) point out ' the shift from department stores and general small stores to discount outlets has largely subsided,' so that the price differentials 'has settled down to a level consistent with the difference in service quality ' (p.90). Table * shows clearly, however that the shift is still very much an ongoing process.

parisons are misleading because the relative frequency of discount sales differs across different types of stores[28]. Since we know of no established data, we use 70% sales share that we found for sample 18 supermarket stores in Ariga, Matsui and Watanabe (2000) for mass speciality stores and supermarkets. We also know in general that general small stores and coop offer price discounts much less frequently[29]. In case 1, we assume that 50% of sales volume are at price discount for these two types of stores, whereas in case 2 we assume the share is 20%. The average purchase price differences are large. Even in case 1, the differentials are around 15% for supermarkets and mass speciality stores and 20% or more in case 2[30].

To indicate that some of these price differentials reflect pure price differentials, we used this survey data to run simple cross section regressions on average regular and sales prices over a set of dummy variables including the one representing presence of nearby rival stores. The results in Table 10 show that both regular and discount prices are significantly lower among stores with nearby rival stores. Specifically, among regular small scale retail stores, the regular price is 8.2 % lower than comparable stores without nearby rivals. The impact of nearby rival stores on discount price is 15.5%. In other words, the result suggests that significant portion of the price differentials between large scale and small scale stores reflect the impact of local competition on pricing, rather than the differences in service quality. As a matter of fact, the same data shows that 26% of the small scale regular stores reported no nearby rival stores, whereas for large scale supermarkets, only 3.7% reported no nearby rival stores. Notice also that the impact of nearby rival stores on prices is far smaller in the case of supermarkets, mass-marketing speciality stores or coops.

We conclude from these results that indeed the sizable price differential exists between small scale general retailers and large stores, and that some of these differentials reflect the lack of local competition for some of small scale retailers. As indicated in Table 8, continuing shifts in sales share away from the former to the latter should have generated sizable pure pure decline for average consumers. During 1994 and 1999, the total share of small scale retailers declined by 6.5%. For the sake of argument, suppose that on average 10% pure price differentials exists between the two types of retailers. This implies that roughly .1% (i.e., 6.5% x .1 over 5 years) upward bias due to the shift of sales share and pure price differential.

Aside from the impact on potential bias in the overall CPI, the current store selection method poses different problems in measurements. These price differences shown in Table 9 are likely to generate sizable variations in average

[28] In Ariga, Matui and Watanabe (2000), we found that in the case of two competing brands of curry pastes solde at sample supermarkets, about 72% of total sales volume are solde at dsicount prices, although only 31% of daily price observations are at discout.

[29] One of the reasons is that supermarkets and other large scale retail outlets heavily use advertisements together with special discounts for sales promotion. Ariga, Matsui and Watanabe (2000) finds the significant impact on the number of shoppers on discount sales and advertisements.

[30] MacDonald and Nelson (1991) find 13.4% price differentials between warehouse food stores and more traditional outlets.

purchase prices across households, depending upon residence location, income, member composition, age, and other attributes. Choice of single 'representative' store in each precinct for each inevitably musks these variations. These considerations are important if CPI is used as COLI. More generally, the current CPI system is ill suited to incorporate cross sectional as well as inter-temporal variations in shopping behavior and its consequences on the COLI. This applies not only to the choice among different types of stores, but also to the extent to which consumers can take advantage of periodic price discounts, coupons, etc., which have become so common in recent years. In 4.6, we estimate such intertemporal and inter-brand and inter-store substitution behavior and simulate its consequences on COLI across different types of households.

4.5 Some Notes on Quality Changes

Although the issue is potentially the most important source of the bias in CPI, we do not attempt to investigate the problems in any depth in this paper. Instead we make two points. First, we argue that, in principle, CPI should benefit enormously from careful and systematic improvements in incorporation of impacts of quality change and introduction of new products.

4.5.1 Quality Changes and New Goods: What (little) We Know

As we already indicated, there exists few empirical studies in Japan which measure the quality changes and assess the impact of changes in CPI. Shiratuska (1997, 1999) is the only published results which we are aware of that provide the estimate of the impact of quality change on the CPI bias. He estimates that under-estimates of quality changes result in upward bias in CPI by .3 to .9% (.7 the point estimate) per year[31]. Given the fact that most of his studies are done using the data up to the first half of 1990's, it is not clear, however, that the same estimate applies to the current bias in CPI. As we see below, the CPI inflation rate for consumer electronics in the most recent years register lower (actually larger negative values) inflation rate than the comparable rate for WPI. The only point we stress here is the need for swift, systematic appraisal of CPI along the lines already suggested by many economists[32].

Somusyo (2000) itself also conducted preliminary estimation of hedonic price index for personal computer. Their estimated indicate that the price declined to 12.8 by mid-1999 from 1995 average, 100, which translates into 36.7% decline per year. In other words, if the personal computer were included in 1995, this alone would have reduce inflation rate by .2% for 1995-1999 (the weight on personal computer in current CPI is .54%). We also expect similar dramatic price decline for some of the items which now command sizable expenditure

[31] As he himself admits, the estimate is based only upon a few example studies on consumer electronics and passenger cars.

[32] Hausman (1999) estimaes the impact of the neglect of cellular phone services in CPI until 1998. He estimates .8-1.9% per year upward bais for telecommunication services as a result of the late inclusion. The ceullar phones in Japan is even more widespread and the number of users surpassed those of fixed telephone in 2001.

shares; mobile phones (.74%), internet provider services (not included), printers (not included), fax machines (not included), etc etc.

In most of the cases wherein important quality changes have taken place, items are also relatively new so that more often than not, the same list of goods and services appear in issues of both proper adjustments in quality and timely inclusion of new goods. In this sense, the timing is crucial. If the new item is introduced only after it has become a part of standard consumption basket, much of the impact of quality change and consumer surplus associated with (quality adjusted) price decline will be missed.

4.5.2 Curious Discrepancy between CPI and WPI

Although much of circumstantial evidence suggests significant upward bias due to quality changes in the longer run, for the most recent years, this may not be the case. In this subsection, we compare the CPI and WPI data to get some idea on the likely magnitude of the bias created by quality change.

Here we pick up items taken in both price indices from the two groups of commodities. The first group is processed food and the second is the consumer electric appliances. We choose processed food group primarily because we expect that the impact of quality change is relatively small[33]. Bank of Japan (2001) estimates that the likely magnitude of the quality improvement on this group of WPI is around .1% per year. Given the magnitude of the estimation error, we take it that the impact of quality change on the bias is essentially zero. The second group is taken because we know reasonably well that the among the items in CPI, the potential impact of the quality change on the bias is one of the largest[34].

Using the CPI weights, Table 11 shows the average inflation rates of the two indices for these two groups[35]. As expected, average inflation rate in the 1990's is somewhat lower for WPI in the case of processed food.

Surprisingly, the average inflation rate of CPI for consumer electronics is about 2.8% (per year) lower than the corresponding WPI. The result is surprising in that the longrun average inflation rate for overall CPI is substantially higher than the corresponding WPI. Our result for the consumer electronics shows the deviations in the opposite direction. To put it differently, the result implies that the retail prices of these products relative to the wholesale prices declined by as much as 25% during the 1990's. If we extend the sample period back to the beginning of 1980, the average annual difference in the last 20 years is 1.9%, which translates into the decline of relative retail price by as much as 66.4%. These figures cannot be taken literally because we know that the

[33] The other candidate is apparel. Unfortunately, we could not find many common items in this group and we opted for the processed food.

[34] Bank of Japan (2001) estimates the impact of quality change on WPI to be around -.5% per year. The same report indicates that the quality change in the automobile has the largest effect on corresponding WPI (-3.1% per year). We did not take this group because the CPI has only one item (passenger car) in this category and incompatible with WPI which has 3 indices for different types of passenger cars.

[35] These indices are computed using only individual items commonly found in CPI and WPI.

distributive margin is at most around 30% of the retail price and the available statistics suggest at most a modest decline of the retail margin during the period, perhaps a few percentages of the retail price. In other words, either CPI or WPI, or both indices must contain sizable biases.

One possibility is that WPI severely under-represents the price decline of these products. In 1990's, many consumer electronics firms relocated their plants to Asian developing economies and the import of these goods quickly replaced the domestic products. In 1995 revision of WPI, Bank of Japan started collecting the import price indices of these products. The bottom row of Table 11 shows the weighted inflation rate of consumer electronics between 1995-2000 in which we replaced the WPI by corresponding import price index. The result is essentially the same. Although the coverage of imported price indices is far from exhaustive, it seems unlikely that the deviation can be due solely to the rapid price decline of the imported consumer electronics[36].

The other possibility is that CPI over-estimates the quality change so that the CPI under-estimates the inflation rate for this group of products. There is reason to believe that the hypothesis has some merits for further investigations. The potential candidate for accounting the difference under this scenario is the difference in the quality adjustment methods. According to the Bank of Japan (2001), the most popular methods used for the quality change in WPI is cost comparison and used for about 30% of the items in the WPI. On the other hand, Somusyo (2000) states that CPI uses either overlap or direct comparison methods. Although Somusyo (2000) does not reveal how many of items are quality adjusted by which methods, it says explicitly that 'whenever the sample brand is replaced by a new one, and unless we have reasons to believe that the new and old brands are essentially of the same quality, overlap method is used'[translation by the authors]. Hence it is reasonable to say that virtually all the substantive quality adjustment in CPI is done using the overlap method. Bank of Japan also uses the overlap method, but the use is limited to about 10% of the items in the WPI. Overlap methods can generate sizable over-estimate of the quality change if the retail price of the existing brand declines substantially in anticipation of the forthcoming future brand. Suppose for an item i, CPI survey collects price quotation for brand b up until period t and replace the brand at $(t+1)$. Typically brand replacement occurs because of the decline in the sale share of the brand or disappearance of the brand from sample store. Overlap methods treat the price differential between the current and replacement brand b' as reflecting the underlying quality difference, so that the price index for the item i is computed as

[36] Yet another possibility is that the large difference in the price levels between the domestic and the imported is the root cause. The rapid decline of retail price could have occurred by rapid replacement of highly priced domestic ones by cheaper imports even if the imported goods prices did not decline faster than the domestic ones.

It is of course conceivable that the Bank of Japan could have severely underestimated the underlying quality changes of these products, more so than Somusyo did for the CPI. We consider this as highly unlikely given the recent developments in the debate between the Bank of Japan and Somusyo on the possible upward bias of CPI.

$$
\begin{aligned}
p_t^i &= rp_t^b, \\
p_{t+1}^i &= rp_{t+1}^{b^\theta} \frac{rp_t^b}{rp_t^{b^\theta}}
\end{aligned}
$$

wherein rp_t^b is the survey price of particular brand. Substantial over-estimate of the quality change can occur if the relative price $\frac{rp_t^b}{rp_t^{b^\theta}}$ does not properly represent the quality difference. In particular, the disappearing brand can be sold at heavy discount around the time of replacement. In that case, quality improvement is over-estimated and the method introduce downward bias of inflation rate.

Somusyo (2000), using color TV as an example, reports that chained index using overlap methods generates 46% decline in the index for the 3 year period between 1995 and 1998, which can be compared to declines of 27%, and 25% in the case of hedonic price index and published CPI index for the color TV.

On the other hand, as we introduced above, Shiratuka (1997) estimates hedonic price indices for passenger cars, video camera, and personal computer. His estimates indicate sizable upward bias in CPI during 1990 and 1994 for the first two cases[37], .5% and 5.6% per year, respectively. These results cast some doubt on the validity of the alleged upward bias due to the under estimation of the quality change.

All in all, for the most recent years, we cannot make any definitive statement on even the direction of the bias created by quality change. In either case, we are certain that the important inconsistency in quality adjustments exists between the CPI and WPI for at least this group of products[38].

4.6 Estimation of the commodity CPI biases

Inevitably, the estimation of a bias involves many arguably subjective judgements and likely to contain sizable errors in itself. The potential impacts of each of source of the biases differ across categories. Moreover, our ability to estimate the direction and the magnitude of the bias also differ greatly. For this reason, our analysis on the bias will be confined to the commodity CPI.

Excluding services, commodity CPI comprises 51% in weight of the overall CPI and our bias estimates below are limited to these commodity CPIs. We produce two results here. First, we compare the CPI with the COLI using the unit prices in FIES. The second result is the COLI for 14 selected items using POS-SRI. As we show below, two sets of results are consistent in suggesting sizable upward bias in the commodity CPI.

Table 12 compares 4 COLI indices for variety of CPI categories. For comparison, we use unit price indices in FIES. The advantage of using unit price data in FIES is they are directly comparable to individual item price indices in

[37] Personal computers were not included in CPI until 2000 revision.

[38] Except for the consumer electronics, for most of the items common in both indices, CPI inflation rate tends to be higher than the WPI inflation rate at least until mid 1990s.

CPI as CPI item selection is based upon FIES. FIES collects unit prices for about 200 items. We compare the 4 indices; (C,C) denotes the original CPI fixed weight Laspeyres, (C,K) uses CPI price data but uses FIES monthly expenditure share to compute Tronqvist index, (K,C) uses CPI fixed weights and FIES unit prices, and (K,K) is Tronqvist index using unit prices and expenditure shares both from FIES.

For the food group, Table 12 shows CPI inflation rate is .6% per year above that of unit price inflation rate in FIES. The deviation is substantially large for clothing and close to 2% per year. The large deviation between the two indices for clothing is consistent with the fact that consumers rapidly shifted their choice of clothing from domestic to imported, from small scale retailers and supermarkets to mass marketing speciality clothing stores[39].

For 6 of 14 items selected in 1997 National Survey of Prices special volume on Bargain Prices, FIES also report their unit prices. The difference for this group is about 1.5%-2% per year. The results in Table 13 for comparison of POS-SRI Data with CPI also comes ups with the upward bias of CPI in the order of 1.4% per year. These estimates are also very close to the size of bias we estimated in Table 4. Although the two baskets differ, index computed by aggregating all FIES registers 1.35% lower inflation rate than overall CPI.

We conclude from these findings that for at least food and clothing groups, the CPI in recent years has sizable upward bias, most likely in the range of 1.5-2% per year. We also believe the bias of similar magnitude exists for other items commonly sold at mass retail stores (miscellaneous household appliances, toiletry goods).

Roughly two thirds of the commodity CPI belongs to these groups which we believe that CPI is biased upward by 1.5-2% per year. To be conservative, let us assume that the bias arises only for the purchase of these groups of commodities purchased at large retailers. If we assume that two thirds of these purchase of goods are at mass retail stores and apply 1.5% per year bias for two third of those goods, the estimate of the bias is 1.5x(2/3)x(2/3)=.67%. If we use 2% per year as the bias for the group, the impact on CPI is roughly .9%. Therefore, even if we assume that the CPI bias is zero for the other commodities and also for samples taken at small scale regular retail stores, the impact of this bias on overall commodity CPI must be at around .5% to 1% per year[40]. In Table 12, we show that among comparable items excluding consumer electronics and services, the deviation between unit price inflation rate in FIES and CPI inflation rate is about .6% per year.

To sum up, we believe that .5-.6% per year is the conservative estimate of

[39] This shift started out with rapid expansions of several chain stores specializing in men's suits and other formal clothing. The department stores, traditionally the most popular choice for such items, lost its shares within a few years. In the most recent years, the shift has been concentrated in more casual clothing and underwear. Among others, UNIQLO chains registered explosive growth in sales and profits.

[40] If we assume that two thirds of these purchase of goods are at mass retail stores and apply 1.5% per year bias for two third of those goods, the estimate of the bias is 1.5x(2/3)x(2/3)=.67%. If we use 2% per year as the bias for the group , the impact on CPI is roughly .9%

the upward bias in CPI as the measure of COLI because we have not covered service prices which comprises roughly 50% of the overall CPI. It seems likely that upward biases exist in many important items in this category. On the other hand, the comparison of CPI with WPI above indicates a potential downward bias of CPI. As far as the bias is limited to this group, however, the impact on the overall CPI is relatively small; the consumer electronics (excluding personal computer) comprise roughly 2% of expenditure share in CPI so that even a 3% downward bias of this group results in .06% impact on CPI.

In conclusion, we find that at least .5% upward bias exists among commodity CPI.

4.7 Impact of Shopping Patterns on COLI

The current CPI almost totally ignores the impact on COLI by diverse shopping patterns of different types of consumers. This practice is common among CPIs in most of other countries[41].

In this subsection, we develop a simple model of cost minimization and demonstrate the impact of shopping and storage costs on the shopping and purchase decisions. We make two points. First, we demonstrate that pricing patterns of retail stores do influence significantly consumers' decisions on shopping timing and purchase. Second, we demonstrate that large variations in shopping and storage costs as well as average purchase price result from variations in pricing policy across different types of stores. Moreover, we show that variations in shopping and storage costs can give rise to diversity in the choice of stores. The optimal choice of the store that minimizes the overall cost is far from uniform.

4.7.1 Shopping-Storage Model

Consider a household who consumes at constant rate c per day. We assume that each household visits a retailer at every $1/s$ days. The price of the consumption good is randomly drawn from a known distribution, $F(p)$. We normalize this price such that the highest price is 1. The household incurs shopping cost δ per visit. They also bear storage cost ε per day per unit. For simplicity, we assume that each household purchase the same amount, q, of the consumption good per every visit if the price is below cutoff level, $\hat{p}$. Since the amount of the purchase per visit must be on average equal to the consumption[42], we have

$$sqF(\hat{p}) = c$$

Thus the amount of purchase per visit is given by

$$q = \frac{c}{sF(\hat{p})}$$

[41] CPI publishes supplementary indices incorporating differences in shopping patterns across different types of households. They do not incorporate the impact of shopping patterns on respective COLI.

[42] We ignore the cost associated with stock-out.

This amount is consumed at constant rate c per day. Hence the time needed to consume the stored good is equal to $\frac{q}{c}$ and on average the amount of storage is a half of the amount of purchase. Therefore the average storage cost per unit of time is given by

$$\frac{1}{2}\varepsilon q = \frac{c\varepsilon}{2sF(p)}$$

The household minimizes average (per unit of time) total cost by the choice of p and s taking δ, ε, and $F(p)$ as given. Viz,

$$\underset{\{p,s\}}{Min.}[c \int^{p} pdF(p) + s\delta + \frac{c\varepsilon}{2sF(p)}]$$

We use the POS-DEI data set to obtain empirical price distribution to be used in the simulation. The data includes the daily sales and price data for 6 selected items sold at 14 sample stores. Each item includes 20 to 30 different brands and we chose top 5 sales brands from each store for the simulation. The data spans two year period between April 7 1995 and April 7 1997. We used the daily price data to compute the empirical price density function for each brand, each item and each store.

The range of parameters we used in simulation are:

$$\begin{aligned} \varepsilon &: .001 \vee .01 \\ \delta &: .05 \vee .14 \\ c &: .2 \end{aligned}$$

All are measured in rates per day. For example, $\varepsilon = .001$ is equivalent to the depreciation at a rate .1% per day if the good is purchased at regular (high) price. Shopping cost per visit ranges between 5 to 14%, which translates into 500 yen to 1400 yen for a purchase of 10,000 yen worth grocery. 5% seems to be close to the minimum[43]. At $c = .2$, one unit of purchase is equal to 5 days' consumption.

Table 14 shows across store variations in the total shopping cost and average purchase price. The figures shown in each cell is the estimated coefficients of the dummy variable corresponding to each store (store #14 is treated as the default) in regressions of the total cost and average purchase price where the right hand side variables are dummy variables for brands and items, ε, δ, and δ^2[44]. The first two columns are for the average of the top 5 brands and the latter two columns correspond to the case where shoppers buy the brand with the heaviest discount in each item.

Across store variations in total shopping costs and average purchase prices are large: for example, total shopping cost varies among these 14 stores by as much as 8% from the lowest store #8 to the highest store #1, and average

[43] The minimum wage in Okinawa (the lowest) is around 600 yen per hour.

[44] Regressions on simulated results.

purchase prices by more than 11% (between store #9 and #1). If consumers choose to buy the heaviest discount (bargain hunter), the variations are even larger: more than 9% in total shopping costs, and over 13% in average purchase prices[45]. Notice in particular that the two coop stores tends to be more expensive side, especially for bargain hunters. This reflects the fact that periodic discounts are less common in those stores compared to supermarket chains.

One rather surprising result is large variations in optimal shopping and storage costs across stores even after controlling for the unit shopping and storage costs. For example, when $\varepsilon = .05, \delta = .001$,the shopping cost for the top sales brand for item #1 varies between .045 to .113 and the storage cost varies between .023 to .057. In other words, across store variations in pricing patterns alone can give rise to sizable variations in shopping frequency and storage. The other side of this fact is that consumers with different shopping and storage costs choose different stores even if all the stores are identical except for the pricing policy.

To demonstrate this, Table 15 shows the cost minimizing choice of store as we vary the unit shopping and storage costs for the case of item #1 , top selling brand. At lower shopping and storage costs, store #5 minimizes the total shopping cost. As we increase shopping costs, store #2 becomes the best choice with higher level of unit storage cost, reflecting the fact that the optimal shopping and storage policy for store #5 involves sizable purchase at deep discounts. At even higher the shopping cost, the optimal choice shifts from store #5, then to #2, and then further to #9 as we increase the unit storage cost. Moreover, this case is not an exception. Among the total of 3000 simulation cases (10x10 combinations of the two parameters, 6 items x 5 top sales brands=30 combinations), all 14 stores are the cost minimizing choice in at least one case[46].

The point is that shopping choice is an integral part of the consumption patterns and choices and they do have important quantitative impact on the cost of living. The availability of particular type of retail outlets in the neighborhood can have quantitatively important impacts not only on their choice of brand, average purchase price, but also on the total shopping cost and hence on their cost of living. Even setting aside the impact of different consumption baskets on cost of living, the results in Table 14 indicate that the total cost of living in our example case can vary as much as 9% depending upon the accessibility to particular type of retail stores.

5 Some Suggested Changes to Improve CPI

In this paper, we employed variety of alternative data and aggregation and estimation methods to correct the biases in the CPI. Our results suggest strongly the presence of sizable upward bias in the commodity CPI. Our best estimate

[45] Variations in total shopping costs are smaller than those in average purchase prices because volume shopping of the dsicounted items increases the invenotry holding costs.

[46] Store #10 actually had only one such case. Store #3 had the highest share of the best choice, 509 cases, roughly 1/6 of the all similaued cases.

is at least .5% per year excluding biases in services and those due to quality changes. The true bias is likely to be larger than our estimate but we need far more extensive research to obtain more reliable estimates. Here we spell out below proposals to improve CPI.

5.1 Beefing Up Statistics Sections of Government

Setting aside the precise size of the bias, we hope that the more enduring message of the paper is the need for fundamental changes in the way CPI is collected and compiled. First of all, as we indicated in section 2, like many other statistics sections of Japan central government, Statistics bureau of Somusyo is seriously under-manned, and it suffers from meager budget allocation. We suspect that the budget and man power limitations constrain severely the options available to improve CPI. For example, use of POS data is highly expensive if Somusyo has to purchase the data from outside. Systematic attempts to estimate hedonic price indices requires large resources for data collection and estimations.

Not only the size, but also the composition of the staffs is problematic. As far as we know, there is no single full time staff in the bureau with advanced degree in economics. Although they do have some staffs with some background in statistics, we doubt it very much that they are adequately manned. There seems to exists large room for improvement from extensive as well as intensive research activities on the issues raised above[47]. To conduct adequate economic analysis and estimation of quality change, the need for sizable professional economist stuffs seems obvious and compelling.

5.2 Improving Data Collection

The data collection methods need to be changed in many aspects, most of them fundamentally. First of all, the revision of the item selection and weights must be done on more frequent basis. In principle, this is simply a matter of automatic adjustments as far as CPI uses the FIES which is published on monthly basis. Given the importance of timely adjustments, we propose the shortest possible period, one year. The need for continuity can be met easily by keeping track of the CPI indices based upon weights and item selections in the past. The additional tasks created by the revision may not be large. Moreover, we expect large benefit from utilizing other official data sources in compiling CPI. For example, the benefit of coordinating data collection and compilations of CPI with those of WPI is obvious. CPI should seek for coordinating data collections with other agencies as well, especially in collecting service prices. In particular, we expect large gains in accuracy from utilizing other sources of data on medical and health cares, and also on housing expenses.

[47] In Schultz and Mackie (forthcoming) the comittee applauds swift and intensive researches condcuted by BLS to incorporate some of recommendations advanced in Baskin Commission report. Given the budget and staff size limitations, it seems very difficult for Somusyo to carry out similar researches with comparable speed.

The more fundamental change we propose is to seek for alternative data sources. Current data collection rely exclusively on surveying sample retail firms. Given the time and resource constraint, the margin of improving data quality in commodity CPI may be fairly narrow as far as the current method is retained. Instead, we propose two alternative (complementary) data collection method. The first is to use POS data. The merit of POS data is obvious. The data is available on daily basis for essentially all the brands sold in sample retail stores. Moreover, POS data contain quantity data which is totally missing in the current survey. The quantity data is important for several reasons. Even if Somusyo retains the current position that CPI should base its data on representative brand, the POS data provides more accurate and timely information on which brand is the most popular. Another merit of POS data is the data frequency. The data is available on daily basis so that the inference on special sales and other temporary price markdowns should be easy and straightforward[48].

The second candidate is to beef-up the current FIES to make it usable as a complementary data set for CPI retail price information. The advantages of using consumer side information are numerous. To begin with, the consistency between the CPI basket and actual consumption basket should be improved greatly. For the purpose of COLI index, actual mix of brands within each item and expenditure shares of items are the ideal set of information to be used for computation of COL. After all, to the extent that FIES accurately represents these choices, there should be no disagreement on how to best represent the consumption basket and relevant purchase prices. Even the proper selection of retail outlets for sample collection under the current survey will not be necessary as the consumers themselves make the choice and we can observe the outcome of these choices in the FIES. As we demonstrated above, even the current limited data on average purchase price seem to perform reasonably well as the basis to compute COL.

The adjustments necessary to incorporate quality change is the most difficult agenda and this paper has not covered the issue in any detail. Nevertheless, we are sure that the important inconsistency exists between CPI and other price data, especially WPI. The discrepancy is quantitatively large. Both statistics should benefit from proper coordination and joint work on this issue between Somusyo and Bank of Japan.

5.3 CPI as COLI, CPI as COGI

As is mostly the case in other countries, Statistics Bureau of Somusyo does not subscribe to the view that CPI should be the best estimate of cost of living index (COLI). Instead, the official position clearly states that the CPI should be viewed as the index of the specific basket of goods, or the cost of goods index, COGI[49]. We believe that CPI should serve both purposes. Whenever the

[48] Starting 2000, Somusyo use POS data for collecting price information on personal computer. Currently, this is the only item that POS data is used.

[49] See Schultz commission report (forthcoming) for the discussion of this issue incorporating Boskin report.

important difference arises between COLI and COGI, separate series of COLI and COGI should be compiled. We see no practical or theoretical difficulty in compiling both indices. As a matter of fact, additional cost of preparing separate COLI for different groups of household is relatively small and the current CPI does include such series as well. As we indicated above in 4.6, we suspect, however, that the relevant COLI for different groups of household may differ substantially, once proper attentions is paid to the shopping behavior of households. We saw above that not only the basket and quality of goods and services consumed differ across households, their shopping behavior also differ and it does matter greatly to: prices they pay, where and how frequently they shop. In order to incorporate shopping behavior into the COLI, it seems most important to collect information at household level, rather than from retail stores.

It is also fair to note that CPI should continue to provide information as COGI. Given the crucial role played by the private and social cost of changing nominal prices, COGI as an aggregate measure of nominal price changes is a key macro economic indicator in its own light[50]. In relation to other price indices such as WPI, CSPI, and variety of wage indices, COGI is also important in monitoring the dynamics of vertical price formation.

Having said that, even if Somusyo continues to retain the current position that CPI should be COGI, the statistics should perform better by incorporating substitutions at lower level more explicitly; as we argued above, there is strong case to believe that consumers do substitute one brand over the other, shop around different stores, and continue to shift towards mass retailers with lower prices. Unless one subscribes to an extremely narrow and rigid definition of fixed basket (fixed brand purchased at fixed set of retailers), CPI should move towards the direction of COLI at least in these dimensions.

In order to make explicit the distinction between COLI and COGI, it becomes crucial to disclose details of compilation processes, such as quality adjustments, brand and sample store replacements. Without full and timely disclosure of these details and the original survey results, the extent to which external monitoring can check the potential problems is limited.

6 Conclusion

After a journey into maze of price data, we come back where we started. As we argued at the beginning, Japanese government should allocate far more resources in collection, compilation, and timely disclosure of statistics. Although in recent years private data collection services grew rapidly, the need for official statistics is obvious and compelling. No private sector can realistically replace the statistics collection activities of central government.

The potential benefit from improvement in indices such as CPI can be enormous, given the fact that so many facets of economic transactions decision

[50] At a conference on price indices organized by the Bank of Japan in mid- 2001, in the context of short run macroeconomic policy formulations, some voiced concern over the potential noise created by use of hedonic pricing in incorporating quality changes into CPI.

making are linked explicitly or implicitly to CPI. Although many suggestions for improvements can be implemented within the current budget and staff allocations, we still believe that the more fundamental changes require sizable increase in the budget and staffs devoted to statistics sections in the government. Some of additional resources should be used to establish an independent body of to conduct researches for systematic appraisal of major statistics[51]. Given the current state of information disclosure, and inevitable information advantage of inside staffs, such research must be conducted within the government, rather than complete out-sourcing, although the research should benefit from hiring outside consultants. Such researches for appraisals are especially important for statistics compiled by using many primary statistics. Among others, National Account statistics is by far the most important.

We also pointed out several times the need for coordination within the governments. In primary data collection, statistics sections of government should coordinate their procedures as much as possible to make individual statistics comparable at least, and to the extent possible, they must be amenable for data mergers. The coordination needed is simple and straightforward. Whenever possible, statistics based upon the same population of samples should use the compatible data strata, the same method for coding, and the actual survey should be maximally merged to minimize the cost of respondents, especially large scale firms. The benefit from such coordination can be substantial. For example, most of employment and wage statistics and other firm or establishment based statistics are so different in the design that even cross referencing is rather hazardous.

As of early 2002, most of the official statistics are not provided in downloadable electronic files. Even among those downloadable, the data files are limited to the latest few waves of the surveys. In short, in spite of the efforts by staffs and some improvements in coordination in recent years, the official statistics in Japan are still plagued by the rigidity of the central government in many dimensions; rigid budget allocation, autonomy of individual ministries, delays in adopting latest information technology, etc, etc. We believe that compared to the size of benefit, the additional costs and efforts needed to implement these changes will be relatively small.

[51] The Statistics Council is a committee overseeing the statistics collection and compilation activities of the central government. Although the council had in the past made important policy recommendations to improve the official statistics, the council's abilities are limited in many dimensions. Like other government councils, the member consist of non-government officials and meet only a few times per year. Without the body of research staffs working on regular basis to monitor official statistics, their recommendations are necessarily abstract in nature and often too delayed. Given the autonomy of individual ministries, it is also unclear to what extent the council has influence on the changes in individual statistics produced in different ministries.

7 Appendix Data

We use the three sets of data in the following analysis of the potential mismeasurements of CPI.

(1) Family Income and Expenditure Survey

CPI uses this survey for the selection and weights of items. Aside from the expenditure records of sample households (roughly 8,000), the survey also reports average unit purchase prices for 200 items. We use these unit price data as the benchmark for the cost of living index estimates[52].

(2) 1997 National Survey of Prices volume on Bargain Prices (Statistics Bureau, Somusyo, as of the survey publication the bureau was a part of Management and Coordination Agency). The survey select 16 items and collects cross section data on regular and bargain (discount) prices across regions, types of stores, and variety of other attributes such as location characteristics and store sizes). We use data for 14 of these 16 items. We deleted 2 items, eggs and beef meet because of the potential large quality differences across samples.

(3) POS-SRI (compiled by Sezon Research Institute)

The data reports for 16 items monthly average prices and sales separately for regular price and discount sales. The data covers 72 months between January 1995 and December 2000 for 20 stores in Metropolitan Tokyo area belonging to a national chain of supermarket. We use the same 14 items selected in (2) for comparison purpose.

(4) POS-DEI (compiled by the Distribution Economics Institute of Japan)

The data includes 6 items among the 14 selected items above. The data consists of daily price and sales record for roughly 320 brand-store combinations for 24 months between April 1995 and March 1997.

[52] The major problem of using unit prices as the COLI are three holds. First of all, the data covers only some subsets of the consumption expenditure, and, in particular, the survey does not include any data on services. Second problem is that they are averages of nominal purchase prices without incorporating any changes in quality of products purchased. Another problem is the large monthly fluctuations in the data, partially reflecting measurement errors.

There are several advantages, however, over the current CPI as the benchmark of COLI. Among others, the unit price data reflects the average of the actual choice by sample households over items, brands, quality, and stores, thus incorporating substitutions by households across items, brands, quality and different types of stores. As far as quality changes not reflected in prices are not quantitatively important, the unit price and expenditure data provides us with the most natural measure of the COLI. another notable advantage is that the survey can be used to estimate the COLI across different types of households: although the current CPI supplements include CPI series for several different types of households, they incorporate only the differences in weights across households (they use the common average prices taken from Survey of Prices.)

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Table 1 Major Official Statistics, Staffs and Budget

Ministries	Designated Statistics(2000)	Approved Statistics (2000)	Statistics Budget (1999)	Statistics Staffs (2000)
Public Management	14	59	14,494	1,617
Finance	2	8	144	86
Education	4	50	256	102
Health and Labour	8	102	5,758	465
Agriculture	8	119	13,032	5,979
Trade and Industry	17	47	5,867	381
Land and Transport	7	68	4,169	124
Others	-	27	1,360	50
Total	62	480	45,080	8,804

Table 2 Recent Inflation Rates

	CPI	WPI*	GDP**
1990-2000	1.64%	-0.55%	0.49%
1995-2000	0.30%	-0.76%	-0.32%

*WPI for Final Consumption Goods; **Deflator for Household Final Consumption

Table 3 Aggregation Bias

	Fixed Weights			Chained	
	Laspeyrus		Tornqvist	Tornqvist	Fischer
	CPI Index	Annual Inflation Rate (%)			
1996	100.180	0.180	0.154[-.026]	0.154[-.026]	0.154[-.026]
1997	101.869	1.689	1.651[-.038]	1.657[-.032]	1.649[-.032]
1998	102.613	0.744	0.713[-.031]	0.716[-.028]	0.703[-.028]
1999	102.242	-0.371	-0.498[-.127]	-0.440[-.069]	-0.429[-.058]
2000	101.415	-0.827	-0.877[-.050]	-0.864[-.037]	-0.870[-.043]
95-00	-	0.283	0.229[-.054]	0.245[-.038]	0.241[-.042]
1970-95[53]	-	4.438	-	4.313[[-.125]	4.216[-.222]
1990-95	-	1.153	-	1.152[-.001]	1.272[.119]

Table 4 Bias due to CPI Data Collection Procedure

	Mean Inflation		Standard Deviation	
	Weighted Av.	CPI Procedure	Weighted Av.	CPI Procedure
Mayonnaise	-.0136	-.00383	.0148	.0208
Ketchup	-.0312	-.00414	.0195	.0305
Soy sauce	-.0225	.000923	.0343	.0434
Liquid soup base	-.0294	-.00304	.0238	.0429
Laundry Detergent	-.0273	-.000986	.0298	.0149
Instant Coffee	-.0544	-.0145	.0378	.0957

Numbers shown are average annual log differences.

[53] 1970-95 and 1990-95 figures are taken from Shiratsuka (1998).

Table 5 Decomposition of Individual Price Changes

	$\Delta\alpha(regp - salesp)$		$\alpha\Delta regp$		$(1-\alpha)\Delta salesp$	
price change	+	-	+	-	+	-
Grand Total	15.0		26.0		59.0	
Total	4.7	20.9	48.4	13.2	46.8	65.9
Item 1	21.4	42.2	36.2	8.7	42.2	49.1
Item 2	48.8	14.3	38.3	-6.4	12.9	92.1
Item 3	36.9	47.2	61.0	46.1	2.0	31.5
Item 4	na	na	na	-7.9	12.3	95.6
Item 5	-10.0	137.0	-27.0	-17.3	-24.1	141.4
Item 6	-9.4	63.7	70.3	14.8	39.1	21.5
Item 7	28.7	40.3	72.4	50.4	-1.1	9.4
Item 8	-158.5	18.6	156.9	30.4	101.7	51.0
Item 9	21.3	6.1	80.9	66.0	-2.2	28.0
Item 10	62.5	100.6	40.1	-180.8	-2.6	180.2
Item 11	-103.6	39.8	23.9	-0.6	179.6	60.8
Item 12	-25.3	9.3	-192.2	25.9	317.5	64.8
Item 13	4.2	-30.5	68.1	71.4	27.7	59.1
Item 14	17.1	-15.7	20.4	32.5	62.5	35.5

Table 6 Mean Inflation Rates and within item Variances[54]

	mean inflation rate (%)	variance
Instant Coffee	0.4477	.016
Facial tissue	0.1006	.0062
Mayonnaise	-0.2258	.0041
Yogurt	-0.1324	$.94\text{x}10^{-5}$
Liquid condiments	0.0781	.0080
Fruit juice	0.2465	.092
Fresh milk	-1.4649	.019
Sugar	-11.8878	.038
Wheat flour	0.2117	.0061
Soy sauce	-0.1937	.0043
Cooking Oil	0.2850	.0070
Sanitary Napkins	0.9755	.052
Laundry Detergent	-0.0627	.060
Kitchen Detergent	-0.0738	.0078

[54] Variance figure is monthly average for indices of brand specific index normalized to set the annual average for 2000 is equal to 1.

Table 7 Substitution across brands: a case of curry pastes

	Price of Brand B			
	Brand A Sales Volume		Brand B Sales Volume	
Price of Brand A	Regular price	Discount Price	Regular price	Discount Price
Regular price	5.4	5.0	3.1	42.4
Discount Price	70.7	57.4	2.9	29.2

Table 8 Expenditure Shares of Retail Outlets[55]

	year	Reg.(1)	Sup.(2)	Dept.(3)	Conv.(4)	Coop (5)	Disc.(6)
total	1984	50.8	28.9	10.0	-	4.6	-
	1994	40.5	30.3	9.3	1.1	6.3	4.0
	1999	34.0	35.3	9.1	1.7	5.9	5.4
Food	1984	40.6	44.9	3.5	–	7.0	–
	1994	25.2	49.2	4.1	1.9	10.4	2.3
	1999	16.7	57.5	4.5	2.6	9.8	2.7
Appliances	1984	46.3	24.1	15.1	–	4.3	–
	1994	37.1	22.7	10.8	3.1	5.8	12.5
	1999	32.3	26.6	9.4	3.0	5.3	16.7
Clothing	1984	36.9	18.1	37.6	–	1.8	–
	1994	33.7	17.7	34.0	1.3	2.1	11.2
	1999	28.7 .	20.5	36.5	1.4	2.3	10.6

[55] (1) Regular small scale stores, (2) Supermarket, (3) Department store, (4) Convenience store (5) Cooperatives stores, (6) Mass marketing speciality discount store. Source: National Survey of Family Income and Expenditure

Table 9 Average Across Store Price Differentials of 14 Items

	Small Stores	Supermarkets	Mass discount	Coop
Regular Price	100	95.4	95.0	94.4
Discount Price	78.7	64.9	68.9	68.7
Average Case 1	89.4	74.0 (16.7%)	76.8 (14.1%)	81.6 (8.7%)
Average Case 2	95.7	74.0 (22.7%)	76.8 (19.8%)	89.3 (6.7%)

Source: 1997 National Survey of Prices Special Volume on Bargain Prices.

Table 10 The Impact of Nearby Rival Store on Retail Prices[56]

	log (Regular Price)		log (Discount Price)	
Large Store	-.0401	(6.16)	-.0426	(4.50)
Supermarkets	-.0579	(2.84)	-.243	(8.18)
Mass-discount	-.170	(4.24)	-.315	(5.42)
Coop	-.116	(2.63)	-.180	(2.79)
Rival Store (RS)	-.082	(4.48)	-.155	(5.82)
RS*Supermarkets	.0659	(3.14)	.122	(3.98)
RS*Mass-discount	.0898	(2.17)	.139	(2.31)
RS*coop	.120	(2.62)	.123	(1.86)
Adjusted R^2	.995		.978	

[56] Data taken from 1997 National Survey of Prices Special Volume on Bargain Prices. The results shown are OLS cross section regressions. Numbers shown in parentheses are t-statistics.

Table 11 CPI-WPI Comparison

	1980-2000		1990-2000	
	(C,C[57])	(W,W)	(C,C)	(W,W)
Food	0.83	0.68	0.25	-0.35
Consumer Electronics	-3.33	-1.49	-6.12	-3.32
(Import Price Index)	-	-	-5.76	-2.49

Table 12 COLI Average Annual Inflation Rates in CPI and FIES

	1980-2000				
	(C,C)	(C,K)	(K,C)	(K,K)	CPI-FIES
Food	0.83	0.70	0.44	0.56	0.27
Clothing*	1.31	1.41	0.20	0.03	1.28
Consumer Electronics	-8.62	-6.05	-4.80	-3.41	-5.21
6 items in Survey of Prices	0.11	0.45	-0.55	-0.69	0.80
CPI excluding CE	0.57	0.67	0.32	0.45	0.12
CPI ex. services & CE	0.63	0.75	0.32	0.59	0.14
Overall CPI vs. overall FIES**	1.54	-	-	0.64	0.90

	1990-2000				
	(C,C)	(C,K)	(K,C)	(K,K)	CPI-FIES
Food	0.25	0.20	-0.54	-0.35	0.60
Clothing	0.72	0.73	-1.19	-1.39	2.09
Consumer Electronics	-6.12	-5.92	-2.89	-3.32	-2.80
6 items in Survey of Prices	0.03	0.38	-0.81	-1.43	1.46
CPI excluding CE	0.32	0.26	-0.46	-0.40	0.72
CPI ex. services & CE	0.11	0.20	-0.81	-0.51	0.62
Overall CPI vs. overall FIES**	0.89	-	-	-0.46	1.35

*1987-2000: **Baskets in two indices differ.

[57] (C,C) indicates index using both CPI price data and weights; (C,W) CPI prices and WPI weights; (W,C) WPI prices and CPI weights; (W,W) WPI prices and weights.

Table 13 COLI for 16 Selected Items

	1995	1996	1997	1998	1999	2000	1995-2000
POS-Laspeyres	-5.15	4.32	-7.66	0.72	-2.85	-6.47	-2.85
POS-Tornqvist	-5.05	3.17	-7.95	1.85	-2.80	-5.74	-2.75
CPI	-2.15	-2.07	-0.30	-1.00	-0.95	-2.28	-1.46

Table 14 Variations in Total Cost and Average Purchase Price across 14 Stores

	Total Cost		Average Purchase Price	
Sample Store	Top 5 Brands	Cheapest	Top 5 Brands	Cheapest
1 Coop #1	+3.42%	+8.75%	+2.46%	+10.33%
2 Coop #2	+3.51%	+8.17%	+2.65%	+7.83%
3 National Chain A #1	-2.731%	-0.33%	-6.15%	+1.51%
4 National Chain A #2	-0.58%	-3.03%	-2.83%	-2.56%
5 Unknown	-2.02%	+6.62%	-6.55%	+8.16%
6 Unknown	+0.26%	-1.10%	-2.33%	-0.85%
7 Unknown	-0.71%	+8.06%	-2.66%	+9.66%
8 Unknown	-4.74%	+0.92%	-6.63%	+1.36%
9 National Chain B #1	-2.53%	-3.38%	-3.49%	-1.11%
10 National Chain B #2	+.00%	+2.68%	-1.68%	+6.64%
11 Regional Chain C #1	-4.02%	+2.44%	-6.60%	+6.67%
12 Regional Chain C #2	+0.19%	+2.23%	-1.10%	+4.87%
13 National Chain D #1	+0.23%	+3.00%	-0.61%	+4.20%
14 National Chain D #2	0	0	0	0

Table 15 Optimal Store Choice for item #1, the top brand

	ε									
δ	.001	.002	.003	.004	.005	.006	.007	.008	.009	.010
.05	5	5	5	5	5	5	5	5	5	5
.06	5	5	5	5	5	5	5	5	5	5
.07	5	5	5	5	5	5	5	5	5	5
.08	5	5	5	5	5	5	5	5	5	2
.09	5	5	5	5	5	5	5	2	2	9
.10	5	5	5	5	5	5	2	9	9	9
.11	5	5	5	5	5	2	9	9	9	9
.12	5	5	5	5	2	9	9	9	9	9
.13	5	5	5	2	9	9	9	9	9	9
.14	5	2	9	9	9	9	9	9	9	9

Figure 1
Brand Specific Price Indices for Liquid Condiments