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Chapter Author: Paul A. Armknecht, Walter F. Lane, Kenneth J. Stewart

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9 New Products and the U.S. Consumer Price Index

Paul A. Armknecht, Walter F. Lane, and Kenneth J. Stewart

The U.S. Consumer Price Index (CPI), which the Bureau of Labor Statistics (BLS) publishes, measures the average change in the price of consumer goods and services from a base period to subsequent periods. BLS publishes a CPI for each month; consequently, the CPI is frequently used to measure price change between periods other than the base period; most commonly, the change in price level from one month to the previous month or to the same month one year earlier. By linking together historic CPIs (with earlier base periods), BLS has created a series of monthly price indexes that begins in January 1913. Although it is hoped that users recognize that this use is less precise, the CPI is also used to measure price change over longer periods that may span one or more of these linkings.

New items—items that did not exist in the CPI's base period—pose some distinct problems for the CPI. How well the CPI deals with the problems new consumer goods and services pose is critical to how well it measures consumer price change. Diewert notes that "ignoring new goods could lead to a substantial overestimation of price inflation and a corresponding underestimation of real growth rates, especially in advanced market economies where millions of new goods are introduced each year" (1987, 779).

The problem of new goods and services is potentially acute for the U.S. CPI because we at BLS revise it, and thereby reestablish its base period, so rarely.

Paul A. Armknecht is assistant commissioner for prices and price indexes at the Bureau of Labor Statistics and a member of the Conference on Research in Income and Wealth of the National Bureau of Economic Research. Walter F. Lane is chief of the Branch of Consumer Prices and Kenneth J. Stewart is chief of the Information and Analysis Section in the Division of Consumer Prices and Price Indexes of the Bureau of Labor Statistics.

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We set a new base period only once every ten years. To minimize the variance of the expenditures that form the basis of the base-period weights and to minimize any cyclical effects, we use a three-year period for the base. In addition, lags in obtaining the expenditure data mean that we cannot use a new base period until two years after it has ended. For example, the CPI for January 1987 was the first using the current base period, which is 1982–84; our current plans are for 1993–95 to be the next base period starting with the index for January 1998.

We compute and publish the CPI every month. As a result, a given base period is in effect for a very long time, perhaps as long as fourteen years after its midpoint—ample time for many new goods and services to come along. In addition, the base period is the reference point for many indexes, perhaps 120 months' worth, so there are many intermediate comparisons (month to month or year to year) which mishandled new products can affect.

In our dynamic economy new items come into the consumer marketplace virtually continuously. We distinguish three cases of new products according to our response to them:

- *Replacement items* are new models are previously available items that are or soon will be discontinued, such as the current year's automobile models.
- *Supplemental items* include newly added brands of currently available goods such as cereal and new ways to sell a service like airline travel.
- *Entirely new items* are those not closely tied to any previously available item. Although they may satisfy a long-standing consumer need in a novel way, they do not fit into any established CPI item category.

The examples of entirely new products that most readily come to mind are new technologies in home electronics or perhaps medicine. However, the new items that are likely to be much more important in their potential effect on the CPI are in the more mundane areas such as food, apparel, housing, and transportation, where the vast majority of consumption expenditures occur. These include new forms of outlets such as fast-food restaurants, new types of packaging such as microwave meals, apparel made of new fabrics, new housing features such as air-conditioning, and new transportation products such as minivans.

9.1 Problems New Products Pose for the CPI

The handling of replacement items gives rise to the first problem new products pose for the CPI. When manufacturers of old items discontinue them and replace them with new versions or models, the index must replace the old items with their new versions. However, such a replacement may differ from its predecessor in some respects and likely will sell for a different price. Consequently, it is important that the CPI capture any price change occurring simul-

taneously with the replacement while avoiding any changes attributable to change in quality. When, for example, automobile or apparel manufacturers introduce new models and thereby create new versions of their old items, they may change the style or add features to items. One reason for introducing new versions is to create novelty, and manufacturers often take this opportunity to raise prices. To the extent that it is possible, we in the U.S. CPI program decompose these price changes. We break each one into a "quality change" component and a "pure price change" component and then remove the change due to changes in item quality so as to reflect only the "pure" price change in the CPI. Since the CPI will reflect any subsequent price declines that occur as the new product versions age, it must show any initial price jump that occurred when they were born. As described below, BLS has methods to capture the price change that accompanies the introduction of new models and styles, and it is fairly successful in applying them. When we are not able to separate the price change from the quality change, we treat the observation as a special type of nonresponse and estimate the true price change by a sophisticated imputation process.

The second problem relates to supplemental goods. These are new goods or services that are similar to ones already available; however, unlike replacement goods, their arrival is not coincident with the discontinuation of previously available goods. Examples of these items include new types of discount airline fares and generic drugs. In the replacement case, the disappearance of the old version of an item forces us to find the best substitute; the disappearing item provides a point of comparison for the new item. In the case of supplemental items, lower prices and/or higher quality—often in the form of new features or other considerations—may cause many consumers to shift to the new version of the item. As long as the old item remains in the marketplace, there is no external factor forcing us to shift with them. Supplemental items usually enter the index as we refresh our samples through our sample rotation process. When extreme marketplace changes force us to act, we use our best judgment and direct a reinitiation of a proportion of the sample to the new versions. However we bring in a supplemental item, either through sample rotation or through directed reinitiation, we do not compare it to an old item and attempt to gauge the value of the quality differential with an old product; this can lead to the CPI missing a price decrease.

The third problem that new items pose for the CPI results from the arrival of entirely new products in the consumer marketplace. The U.S. CPI covers many time periods between base-period revisions. It must introduce new items and begin reflecting their price movements as soon as possible after their debuts. Since it is likely that the prices of new products move differently from those of established ones, not finding a way to bring new items promptly into the index will diminish its accuracy. Typically, new items, because of their initial scarcity or novelty, enter the marketplace at relatively high prices; then, as they become established and competing sources enter the marketplace and

increase their supply, their novelty diminishes and their prices fall. Again, as described below, the BLS has ways to bring new goods into the CPI market basket and to account for their price changes from that time forward.

The final and most intractable problem results from the fact that the arrival of new products allows consumers to satisfy their needs and desires more efficiently. New products displace the roles older ones played in consumers' consumption patterns. Consumers may cut back or even eliminate their consumption of some older items and still be as well-off as they were in the base period. They do this by purchasing, possibly at the same or lower cost, some of the new items-perhaps some that are quite different from the old ones—because the new items provide consumer satisfaction much more efficiently. In addition, the reality is that consumers combine the products they purchase to satisfy the basic needs and desires that result in their standard of living. For example, at one time a consumer may have combined a shirt and the services of a professional laundry to obtain a level of dress; the arrival of easy-care fabric shirts has for some consumers replaced the need for professional laundry services with the need for home laundry service at a lower marginal cost. Many consumers have shifted to the easy-care fabric shirts laundered at home and away from the older shirts laundered professionally. Arguably, just the presence of additional items, because they provide a greater range of consumer choice, is a form of price decrease. Unfortunately, the U.S. CPI has no way to show the price decreases that consumers experience as they take advantage of the new items to maintain or increase their living standards, and, consequently, the CPI fails to take account of the decline in the cost of living that new items bring.

9.2 CPI Sampling Frames and CPI Samples

To understand how these new products are introduced into the U.S. CPI, one needs to know a little more about how the CPI structures the consumer marketplace and selects items to represent it. The first sample we drew for the 1987 CPI revision was a geographic sample of eighty-five urban areas, which we call *primary sampling units* (PSUs). The BLS uses a 44-strata geographic sampling frame, which represents all urban consumers in the United States. We sometimes refer to these 44 geostrata as *market baskets*. We assigned each urban area in the United States to a unique geostrata.The geographic universe consists of all U.S. urban areas, both officially defined metropolitan areas and CPI-defined nonmetropolitan urban places. Thirty-two large metropolitan areas are *self-representing areas* because they are the only members of their strata, and consequently, they represent their entire geostrata. In the remaining 12 strata we probability-selected another fifty-six areas to represent medium- and smaller-sized metropolitan areas and nonmetropolitan urban places.

The item structure for the CPI consists of 207 item strata for commodity groups such as white bread, carbonated drinks, boys' apparel, and so forth. The cross of the 44 geostrata with the 207 item strata creates the 9,108 basic strata,

which is the level of index calculation at which the weights are fixed. Within each item strata we defined one or more substrata, called *entry-level items* (ELIs). There are 364 ELIs which are the first stage of item selection. ELIs are also the level of item definition at which BLS data collectors begin item sampling within each outlet.

9.2.1 Consumer Expenditure Survey

The CPI uses three surveys to conduct item/outlet sampling. The first is the Consumer Expenditure Survey (CES), which provides the weights for the basic strata and sample weights for ELI selection within the strata. The CES consists of an interview survey and a diary survey. The interview survey collects inventories of items held by the respondent and his or her expenditures for a full year on major consumer purchases (vehicles, durable goods, insurance policies). The diary survey records every purchase made during a two-week period to any member of the family. Each expenditure recorded is mapped to one of the 364 ELIs. Estimates of annual expenditures for each ELI and item strata by area are then produced. The average of these estimated annual expenditures for the 1982–84 period compose the expenditure weights used in the U.S. CPI.

To enable the CPI to reflect changes in the marketplace, item and outlet samples are reselected on a rotating basis. Each year, we select a new sample of ELIs and outlets for 20 percent of the areas (about seventeen cities). Each year, four regional universes are tabulated at the ELI level from the two most recent years of CES data. An independent sample of ELIs is selected for each items stratum with the probability of selection determined by the relative importance of the ELI within the strata. The sample-selection example (table 9.1) demonstrates the way this allows new items to enter in the information-processing item stratum. For the areas that had their samples rotated in 1984, the 1982–83 CES data were used. The "typewriters and calculators" ELI had the highest relative importance within the item stratum, followed by home computers. For the 1987 sample-rotation cities, these ELIs reversed positions, with home computers having the highest probability of selection, Thus, the ELIs selected for area samples will change based on their importance in the ongoing CESs.

9.2.2 Outlet Samples

The second survey used for the U.S. CPI is the Point-of-Purchase Survey (POPS), which determines the retail outlets from which consumers purchased goods and services. In the areas scheduled for sample rotation in the following year, the Census Bureau, under contract with BLS, conducts a POPS. The POPS is a household survey conducted over a four- to six-week period, usually beginning in April. It asks respondents whether or not cetain categories of items were purchased within a specified recall period. The recall period varies depending on the type of items purchased. ELIs are grouped into sampling categories (called *POPS categories*). Some POPS categories consist of only

Table 9.1 **Example of Sample Selection: Information-Processing Equipment for Southern Region**

ELI	Probability of Selection	
	1984	1987
Home computers	.25055	.34792[a]
Home computer software	.13491	.18734
Telephones	.13326	.19619
Typewriters, calculators	.27819[a]	.21018
Other processing equipment	.20308	.05825

Notes: Probability of selection is calculated as the ELI total expenditure divided by the item stratum total expenditure. The 1984 probabilities are computed from 1982–83 CES data; the 1987 probabilities are computed from 1984–85 CES data.

[a]Most important ELI in the item stratum

one ELI; other POPS categories contain several ELIs when certain types of commodities or services are generally sold in the same retail outlets. For example, the "meat and poultry" POPS category consists of eight beef ELIs, six pork ELIs, four ELIs for other meats, and three poultry ELIs. These are combined because an outlet that sells beef also tends to sell other meats. For each category the respondent in the household is asked about purchases made within the stated recall period, the names and locations of places of purchase, and the expenditure amounts. After this information is tabulated for the city, a sample of outlets is drawn for each selected ELI.

Since the item and outlet samples are selected in separate processes for each geographic area, they must be merged before data collection. A concordance maps each ELI to a POPS category. Each sample ELI is assigned for price collection to the outlet selected for the corresponding POPS category. The number of price quotes collected for an ELI in each outlet is equivalent to the number of times the ELI was selected for the area in the item-sampling process.

The number of price quotes assigned for collection in a sample outlet is determined through the item- and outlet-sample merge. In the outlet-sample process, an outlet may be selected more than once for a given POPS category, provided the expenditures reported for the outlet are large. The outlet may also be selected for more than one POPS category. If an outlet is selected multiple times for a given POPS category, the same multiple of price quotes will be assigned for collection for each sample ELI matching the category. If an outlet is selected for more than one POPS category, price quotes will be assigned for collection for all sample ELIs matching the categories.

9.2.3 Selection Procedures within Outlets

The third survey—the Commodities and Services (C&S) survey—is the main data-collection vehicle for the CPI program. It consists of the combined

sample from the item- and outlet-sample merge. For each ELI assigned for price collection in a sample outlet, a BLS field representative selects a specific store item using multistage probability-selection techniques. The field representative first identifies all of the items included in the ELI definition and offered for sale by the outlet. Items are grouped by common characteristics, such as brand, style, size, or type of packing. With the assistance of the respondent for the outlet, probabilities of selection are assigned to each group based on sales information.

After assigning probabilities of selection, the field representative uses a random-number table to select a group. All items included in the selected group are identified. Further groups are formed based on the common characteristics of the items. Probabilities are assigned to each group in the second stage, and a random-number table is used for selection. The process is repeated through successive stages until a unique item is identified. The field representative describes the selected item on a checklist which contains the descriptive characteristics necessary to identify the item and to determine or explain differences in characteristics that determine an item's price for all items defined within the ELI.

These procedures produce an objective, unbiased probability sampling of items throughout the CPI. They also allow broad definitions of ELIs so that the same tight specification need not be priced everywhere, as was the case prior to the 1978 revision of the CPI. An important benefit from the broader ELIs is a significantly higher probability of finding an item to price within the sample outlet that is included in the definition of the ELI and finding items that represent what the stores and other outlets often sell.

BLS agents complete the selection process at their initial visit to the outlet. Subsequently, either monthly or bimonthly, they revisit (or, less commonly, telephone) the outlet to obtain the price for the selected item.

9.3 Introducing New Items through Substitution

When a BLS field representative attempts to collect the price of an item in the CPI sample and discovers that the outlet no longer sells it, he or she follows our *substitution* procedures. Each month about 3 percent of the nonshelter observations in our sample are replacements of this kind, which we refer to as substitutions. Under the substitution procedures the field representative finds the item for sale in the outlet that is closest in quality to the discontinued item; this will be a new or updated version of it if one is there. The difference between the price of the old version of the item, observed the previous time, and the price of the substitute version this time, may represent

- pure price change that occurred during the time between the two observations,
- quality differences between the two versions, or
- some of both.

As a constant-quality price index, the CPI must isolate, measure, and remove any quality changes between the discontinued and replacement versions, while retaining any pure price change between the previous and current periods. Professional economists, called *commodity analysts,* make what are known as *comparability decisions* on how to handle substitute items. In the U.S. CPI, the treatment of substitutions can be broadly divided into three categories:

- those considered to be directly comparable to the discontinued variety,
- those where a direct quality adjustment is applied, and
- those where price-change imputation occurs.

In contrast to other ways of bringing in new items, all three categories of substitution compare, in some fashion, the price of a new item to that of the one it is replacing. We give a cursory review of the directly comparable and the direct quality-adjustment methods for treating substitutions; these have already been well documented elsewhere in Armknecht and Weyback (1989) and Kokoski (1993). We have recently improved the methods the CPI uses to impute price change for commodities and services, and these will be discussed in greater detail.

9.3.1 Direct Comparison

Long-in-place CPI procedures ensure that, when a specific item included in the CPI sample is no longer available, our field representatives select a replacement item that is as comparable in quality as possible to the discontinued variety. If the CPI commodity analyst deems the replacement version to be of the same or similar quality as its predecessor, we compare the price of the new item directly to the price of the discontinued variety—and we use that price change in index calculations. In this case we assume that there are no changes in quality between the two versions. To the extent that the replacement version of an item deemed to be of comparable quality is in fact of higher quality than the discontinued variety, the estimate of constant-quality price change for that item will be biased upward. For example, televisions often fall in price while they improve their features; in that case, we treat the replacement as comparable to show the decline in the market price of the television, but we miss the additional decline due to the improved quality, unless we can put a value on the improved features.

9.3.2 Direct Quality Adjustment

If a commodity analyst deems a replacement item to be qualitatively different from its predecessor, we attempt to isolate and remove the quality differences between the two versions. Direct quality adjustments are particularly common in the automobile and apparel components of the CPI.

Since the early 1960s, the new car and truck price indexes have used production-cost differences, marked up to retail, to adjust new vehicles for changes in quality between model years. Automobile manufacturers supply

BLS with production-cost data. We then adjust them upward by wholesale and retail markup rates to derive retail equivalent values for the quality changes. Quality changes for new vehicles in the CPI are made for changes which affect the performance and efficiency of the car. In addition, BLS treats all federally mandated safety and pollution requirements as quality changes.

Many new varieties of apparel are directly adjusted for changes in quality. Apparel analysts have developed regression models for specific apparel item strata (e.g., women's dresses). The model parameter estimates serve as implicit prices for the item characteristics. We use these implicit prices to isolate and remove the quality change that occurs with the introduction of replacement apparel items (Liegey 1993). We implemented this improvement into most CPI apparel categories in January 1991. Over time we hope to extend it to other goods and services.

9.3.3 Imputation of Price Change

If a new version of an item is of dissimilar quality to the discontinued version, and we cannot identify and factor out those quality differences either by the use of marked-up production costs or by hedonic regression techniques, we impute an estimate of constant-quality price change. In effect, we are assuming that in this case the price of the original version of the item would have gone up at that same rate as that for some other items. We are assuming further that the price difference between the old and the new version in excess of this assumed increase is due to quality differences between the versions.

Before 1993, when a version of an item in the CPI sample was discontinued, and the replacement item was of dissimilar quality and could not be directly compared or quality-adjusted, the price change imputed to that item was the change for its item stratum in its index area. Effectively, the price change between versions of dissimilar quality was imputed by the average price change of all other similar items in the same period and in the same geographic area. This method, which is known as *overall-mean imputation,* is the same method we use to impute a price change for a nonresponse; it is appropriate for imputing a price change when there is no reason to believe anything special is occurring. This is the case in most food and service CPI item strata.

However, we can see in many categories of items, when comparing the price change of comparable substitutes to the price change for nonsubstitutes, that there is a significant relationship between price change and the introduction of replacement lines or models. For other items, such as most types of nonfood commodities, price change is closely associated with the annual or periodic introduction of replacement lines or models. Typically, many replacement versions (e.g., new car models, new apparel lines) initially sell at relatively high prices. The prices of these new versions often fall over time, until they, in turn, are discontinued in favor of even newer and often higher-priced replacement versions. For these types of items, the imputation procedures within the CPI have recently been improved; these changes are detailed below.

The overall-mean imputation method estimates price change for replace-

ment versions from the price change of all other items in the same item stratum and index area. These include price changes for continuously priced (same) versions, as well as price changes for replacement versions of directly comparable quality (or those adjusted for changes in quality). Since price change for most types of nonfood commodities is associated with the introduction of new varieties, imputing price change for new varieties of dissimilar quality by price changes for both same and replacement versions was an improper estimate of price change (Armknecht and Weyback 1989). The continuously priced items showed little change and dampened the changes of the relatively few substitutes.

For example, automobile prices within a given model year often remain unchanged, or fall, as the model year progresses. On the other hand, price increases often accompany replacement new-model-year cars, even those of comparable quality to the discontinued models. Consequently, the average price change of comparable model changeover automobiles can be seen as a better approximation of price change for new models with dissimilar quality.

Since October 1989 we have imputed price changes for new-model-year cars and trucks using only the constant-quality price change of other model-year changeovers. In other words, price changes for cars and trucks *within* the same model year are no longer used to impute price changes *between* model years. This type of imputation, which is called *class-mean imputation* (Kalton and Kasprzyk 1986), is a more appropriate strategy for imputing price changes within the CPI.

Prior to its implementation, we tested class-mean imputation for the new car index for the twelve-month period ending February 1988. Over that study period, the test index (under the proposed new imputation strategy) rose 2.76 percent, compared to 2.42 percent for the published index. This occurred because, as expected, the average price change for model-year changeovers of comparable quality was usually higher than the average price change for automobiles within the same model year.

Subsequently, we simulated indexes using class-mean imputation for other types of nonfood commodities. Apparel items were obvious choices. Not only are apparel price changes associated with the introduction of new lines, but substitution is common for apparel items. While apparel represented only about 7 percent of all prices the CPI collected in 1993, over 31 percent of all replacement versions we encountered are in apparel (see table 9.2). Taken together, apparel and new vehicles make up around three-quarters of all direct quality adjustments in the CPI.

As with new vehicles, the price change associated with the introduction of new apparel lines, even after adjusting for changes in quality, was different from price changes for apparel lines within the same version. We began phasing in class-mean imputation for most other nonfood commodities in December 1992. Again, the sources of imputation of price change for replacement nonfood commodities of dissimilar quality are price changes for other, constant-quality replacement items.

Table 9.2 **Prices Collected for the Consumer Price Index for Replacement Versions, 1993**

CPI Major Groups and Selected Components	Total Prices Collected	Replacement Versions Priced	Replacement Versions Coded Directly Comparable	Replacement Versions Coded Directly Quality Adjusted	Replacement Versions Imputed by Overall Mean	Replacement Versions Imputed by Class Mean[a]
Food and beverages	467,396	7,854	3,200	41	4,299	314
Bananas	6,810	5	5	0	0	0
Housing (excluding shelter)[b]	123,876	4,164	2,479	149	1,008	528
Apparel and upkeep	58,739	8,558	6,307	912	775	564
Women's apparel	18,068	4,328	3,117	718	291	202
Transportation[c]	67,635	4,204	2,216	1,036	431	521
New cars and trucks	12,738	2,187	576	1,016	114	451
Medical care	50,490	876	254	317	281	24
Entertainment	27,403	1,196	673	68	356	99
Other goods and services	17,535	452	216	55	150	31
Total[d]	813,074	27,304	15,345	2,578	7,300	2,081

Source: Bureau of Labor Statistics.

[a]Includes some replacement versions of an imputation method that is being phased out.

[b]Treated here as a major group; "shelter" uses a different source of price data.

[c]Excludes used cars.

[d]Excludes selected components.

Table 9.2 shows the frequency of substitution within the various CPI major groups in 1993, that is, how many times during 1993 versions of items in our samples were discontinued and replaced by new varieties. The table also shows how the price change for those replacement versions was estimated.

9.4 Introducing New Items through Sample Rotation

The substitution and imputation procedures described above provide several ways for new products to join the CPI. A process we call *sample rotation* also provides several ways for the CPI to bring new products promptly into the index. Although the items entering through sample rotation do not get compared to those exiting at the same time, sample rotation enables the CPI to capture the movement of their prices soon after their arrival in the marketplace; this is important because the prices of new items are likely to move differently from the prices of established items.

Sample rotation is the annual reselection of the item and outlet samples for 20 percent of the geographic areas, which is about seventeen geographic areas. Consequently, all the samples turn over every five years. We link the new outlets and items that enter during rotation into the index by *overlap pricing*. This means that we price the old samples for the last time we use them in the CPI in the same month that we collect the new samples for the first time. In contrast to the situation in substitution, in sample rotation the prices of the two versions refer to the same time period. Consequently, we regard price differences between the old and new samples as quality differences. However, if the items in the new sample provide consumer satisfaction more efficiently, the index misses that effect, which is a form of price decrease. Since the items and outlets in the new sample are randomly selected, there is no way to compare the new items coming in during rotation to the old ones exiting.

As previously discussed, the Bureau of the Census conducts a new POPS for us in each CPI geographic area slated for rotation. This permits us to draw new outlet samples based on current information. As a result, the postrotation outlet samples contain new types of outlets, such as specialty boutiques or discount stores. Of course, we make no comparisons cross outlets or outlet types; again, if the new outlets in some way provide the items (or the consumer satisfaction embodied in them) more efficiently, we miss this form of price decline.

As mentioned earlier, for each of the 207 item strata in the CPI structure we select an independent sample of lower-level items (called entry-level items because they are defined at the level at which within-outlet sampling begins) with the probability of selection determined by the relative importance of the ELI within its stratum. At each rotation we reselect the ELIs in each stratum. Because the probabilities of selection come from the most recently available CES, ELIs with growing importance, which may contain emerging new items, have an opportunity to be selected based on recent consumer behavior. Recall

from table 9.1 that home computers now receive a higher probability of selection than typewriters and calculators. Thus, the ELIs in the CPI change following their changing importance in consumer spending patterns.

Some new items that appear in the market do not fit into existing ELI definitions but are close substitutes for products in an existing ELI. Such products emerge in the CES interviews and are coded separately so that expenditure data are available. For example, compact-disc players and compact discs are new substitute sound-equipment products for phonographs/tape players and records/tapes. The current ELI definition includes these items along with their expenditures, and the entire ELI could be initiated in all existing areas to reflect the current product mix. These situations occur infrequently, but CPI procedures can accommodate them. However, because of the time lapse associated with the CES and POPS surveys, unless special efforts are made to reinitiate an item stratum, it will be three to four years from the time the product appears in the marketplace to the time the product appears in the CPI.

At rotation, in addition to reselecting outlets and ELIs, we reinitiate all the ELI samples in the newly selected outlets. This gives supplementary new items (those that are similar to old items such as new brands or generics) a proper chance of selection and no doubt brings many into our samples in a fairly prompt manner. For the new products to enter through sample rotation they generally must fall within the definition of items eligible for price collection in an established ELI. Most new products in areas such as packaged foods, toys and hobbies, toilet goods and personal care products, new cars and trucks, and so forth, are eligible for pricing as their market penetration expands because of the broad ELI definition and/or their close similarity to existing products, and therefore they fall into established ELIs.

9.5 New Items That Cannot Be Introduced through Substitution or Rotation

In some instances, new products emerge that we cannot assimilate into any existing ELI, but that do fit within the item stratum definitions. In these cases we can define a new ELI and select sample items in accordance with the item's importance within the stratum. The product would then be introduced gradually through the five-year sample-rotation process. This process could take five to seven years for full implementation due to the lag in the CES and POPS surveys although samples would probably be somewhat representative after three to four years. The new series for midgrade unleaded gasoline is an example of this.

Finally, a new class of products may be introduced that cannot readily be defined within the existing item-strata structure. Such products would not be introduced until all item strata are redefined and the new stratum can be introduced within the CPI classification structure. This reclassification only occurs when major revisions of the CPI are introduced about every ten years. Ex-

amples of such products are videocassette recorders (VCRs) and home computers, which were introduced into the CPI classification with the 1987 revision.

For example VCRs first entered the consumer marketplace in significant volume in 1977 (see table 9.3). During the 1983–85 period the number of VCR manufacturers grew rapidly, resulting in rapidly falling prices and even more rapidly growing sales. In 1987, when the CPI began measuring the price changes of VCRs, they represented about 0.1 percent of consumer expenditures. During the ten years between their effective marketplace introduction in 1977 and their 1987 introduction into the CPI, their price had fallen by approximately 60 percent and their quality had increased considerably. Unfortunately, the CPI did not reflect these developments.

9.6 The U.S. CPI as a Cost-of-Living Index

We view the U.S. CPI as an approximation of a true cost-of-living (COL) index (Fixler 1993). A COL index measures the change in the minimum cost of the base-period standard of living, that is, the standard of living that consumers in aggregate experienced in the base period. The U.S. CPI is actually a Laspeyres index. A Laspeyres index measures the change in the prices of the set of goods and services actually purchased in the base period. We call this set the CPI market basket. Although the market basket in any period should always yield the same standard of living as in the base period, it is not likely always to be the cheapest way to get that standard of living.

The COL index, with its reference to consumer satisfaction grounded in the economic theory of consumer behavior, can indicate how to handle some difficult questions or suggest the theoretically correct if practically difficult approach. Diewert (1987, 779), following a path he attributes to Hicks, suggests that, for new products, we should impute to a new good a base-period price that is just high enough to make its base-period quantity of demand equal to zero. Of course, it would be quite an econometric challenge to estimate the demand equations for even a few new items, and realistically, such an approach is not feasible for us in the U.S. CPI.

The COL index can also guide us in determining what items to include in the CPI and how to stratify them. As a COL index approximation, the CPI should be an index of all—and limited to only—goods and services that contribute to consumers' well-being. Organizing the universe of consumer goods and services into item strata and higher-level groups provides both a means of sampling them and a way of analyzing changes in the CPI. In economic theory the consumer needs the requirements of life and desires the pleasures of life. His or her satisfaction increases continuously with the increasing of the quantity of the items that satisfy those needs and desires. These items are usually grouped into broad categories such as "food and beverages," "shelter," "apparel," "entertainment," "medical care," and so forth. In the United States we call these categories *major groups*. Presumably the consumer has some hierar-

Table 9.3 VCR Sales and Estimated Retail Prices, 1978–1987

Year	Unit Sales (thousands)	Value ($ millions)	Estimated Retail Price per Unit ($)
1978	402	299	1,240
1979	475	362	1,269
1980	805	498	1,032
1981	1,471	1,000	1,132
1982	1,599	1,300	1,355
1983	3,354	1,575	728
1984	6,731	2,898	717
1985	10,750	3,771	587
1986	11,810	3,893	549
1987	11,720	3,442	486

Source: Consumer Electronics Annual Review, Consumer Electronics Group, Electronic Industries Association, Washington, D.C., various issues.

Notes: Unit sales are total factory sales to dealers. Value is wholesale value of units sold to dealers. The estimated retail price is the wholesale value marked up to retail by estimated typical wholesale-to-retail markup ratios.

chy of needs and desires and seeks to satisfy them incrementally. For example, he or she will not consume greater and greater quantities and qualities of food before acquiring any shelter or clothing. In other words, at any standard of living—except perhaps the lowest—consumers will consume items in several categories. In this gross sense, we can view the categories as gross *complements.*

Similarly, the items within the categories are gross *substitutes.* Each category is the means to satisfy some broad need or desire. "Food" satisfies the need for nourishment; "shelter," the need for protection from the elements; "entertainment," the desire for mental stimulation; "medical care," the need for relief from an ailment. In this sense, virtually any new item that comes along should find a home in one of the categories and be at least a partial substitute for an older item. To cite some examples from the past few decades:

fast food has replaced some home cooking;
microwave meals, some lunches in restaurants;
margarine, butter;
trucks and vans, some automobiles;
television-watching, some movie-going or reading;
airline travel, most train travel;
polio vaccine, treatment in an iron lung;
word processors, paper and pencil;
dental sealants, oral surgery;
contact lenses, eye glasses;
high-tech athletic shoes, sneakers;
air-conditioning, fans;
drugs, ultrasound, and microsurgery, much more invasive procedures.

In all of these examples, and in many, many more, consumer choice increased as the new items provided new ways to achieve the same or a higher level of satisfaction. For some new items, such as flying as a potential replacement for train travel, it is not unequivocally clear that consumers could achieve the same level of satisfaction for the same or a lower price. For others, such as the polio vaccine, there really can be no question that the new product is superior as well as cheaper.

The principle of the COL index that only the items that contribute to consumer utility belong in a consumer price index implies that we should model consumers' utility functions. Some utility-function models imply that what yields utility are not the individual items that consumers buy but combinations of them that they create through household or consumer production. For example, Nordhaus's provocative thesis in chapter 1 in this volume implies that consumers get utility from light, which they produce by combining several consumer goods and services, such as candles, matches, whale oil, kerosene, lanterns, batteries, flashlights, electricity, lightbulbs, light fixtures, and so on. The CPI can follow the prices of consumer items such as these but, so far at least, it has not tried to price the cost of light, which consumers in various eras have produced by combining some of them. Yet it seems that it is light and not the lightbulbs or the electricity that directly yields utility or a level of living to consumers. Another example might be the cost of an evening at the movies: in one era, consumers obtained this by combining the services of a movie theater, an automobile, and perhaps a baby-sitter; now perhaps they obtain equivalent entertainment from a VCR, a television, and a video rental. The CPI tends to limit its efforts to following the cost of items sold in the marketplace. To measure accurately the change in the cost of a standard of living we perhaps should follow the change in the cost of obtaining or producing a level of light or entertainment or other immediate contributors to consumer satisfaction.

The CPI has ways to add new products to its market basket and it adds them in a reasonably prompt manner. Unfortunately, except for replacement items that are new versions of older goods, it has no way to show the price decreases that consumers experience as they take advantage of the new items to maintain or increase their living standards. Consequently, the CPI fails to measure the decline in the cost of living that new items and new technology bring. Of course, over short periods of a year or so, this effect is not likely to be significant. New products initially have limited importance in the market. In the long term, we incorporate new products into the CPI, but we will still face the problems of adjusting for quality change and reflecting how the new items replace quite different older ones in the satisfaction of human wants and needs.

9.7 Summary

From the preceding discussion it should be clear that most new products that emerge are gradually introduced into the CPI for measuring price move-

ment. In some cases we at the BLS are able to compare the new item to a previous item and make some form of quality adjustment. In other cases the new products are linked into the index and the CPI may miss any improvements to living standards associated with their arrival. Some items are introduced much more quickly than others depending on their rate of market penetration as measured in the CES and on research BLS economists perform to make sure the structure accommodates them easily. When a new genre of item appears in the marketplace and does not fit within the existing CPI structure, the new products can only be introduced when the classification structure is redefined during major revisions. To the extent that ELI and item-stratum definitions can be kept very broad, new products do get representation in the CPI. However, the broader questions—whether new products get sufficient representation, whether they are brought in soon enough, and perhaps most importantly, how they come in and get compared with older items—remain.

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Comment Frank C. Wykoff

The CPI, perhaps the most important single price statistic produced by the government, is used to calculate changes in many indexed public benefits and private contracts. It is a major indicator of economic and political performance;

Frank C. Wykoff is the Eldon Smith Professor of Economics at Pomona College.

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some analysts even argue that the CPI alone should guide Federal Reserve Board policy. For these reasons, design and construction of the CPI is important.

Nonetheless, many academic and business economists have shown remarkable neglect of the actual construction of the CPI by the BLS. An occasional call by a Simon Kuznets or a Zvi Griliches for "better data" tends to fall on deaf ears among those in the profession. This neglect may have been abetted by some institutional inertia, a (perfectly understandable) bureaucratic tendency to avoid clear explanations of actual practice and a possible reluctance to change. But the BLS does produce a detailed *BLS Handbook of Methods* that includes a chapter on the CPI, and much effort does go into correcting the various biases.

In fact, collection of raw price data, compilation of various subaggregates, and the final design of the CPI are quite complex, involving hundreds of individuals and thousands of observations drawn from a large and highly dynamic economic system over time. This measurement process requires theoretical and practical decisions at various levels by many different people. The CPI does not, and indeed cannot, reflect the design of a simple, fixed rule. The world presents the BLS with too many vagaries to allow this. Instead, field agents must make pragmatic decisions in implementing their instructions, and the instructions themselves must be simple enough to follow and yet complex enough to allow for the changing nature of the marketplace.

Paul Armknecht, Walter Lane, and Kenneth Stewart (ALS) have made a major contribution in this paper by explaining, as carefully as they can, the architecture and construction of the index. They explain the concepts that drive the equation structure and the pragmatic decisions that drive the sampling procedures. Finally, they point out some practical problems with implementation that result from changes in the nature of goods and in the mode of marketing. Some of these decisions are bound to be controversial; some are not exactly clear, and some are unresolved, but now, thanks to ALS, we know enough to start working on how best to allow, in designing price series, for the types of rapid changes that are taking place in today's markets, one of the most difficult of which is the introduction of entirely new goods, like VCRs and magnetic resonance imagers.

One can think of the CPI as an economic statistic, intended to summarize changes over time in prices of goods purchased by consumers, that is a compromise between two competing sets of influences. On the one hand, economic theory, reflecting which questions economists think the CPI is supposed to answer, drives the architecture. On the other hand, the actual object under study, the economy, confronts field agents who are collecting data with practical problems that are often difficult to anticipate and resolve—design changes, production changes, model changes, marketing changes, shopping pattern changes, and so forth. The index itself is a product of attempts to reconcile these two influences, one theoretical and the other practical. The CPI also is

complex because it is used to give a simple one-number description of so much that is going on.

In the BLS view, the CPI is designed as a "cost-of-living index," that is, an index that measures changes in the cost of living over time relative to a base period for which the index value is set to one. In principle, this means that if the period-t CPI equals 1.33, then the same standard of living costs a representative consumer 33 percent more than it did in the base period. Even within the confining framework of classical, representative-consumer economic theory, there are many different ways to measure changes in the cost of living, so more must be said about the theoretical underpinnings of the CPI than that it is a COL index.

The CPI is based on a Laspeyres price index model, which is to say that it is intended to be a measure of the period-t cost of a fixed bundle of goods relative to the cost of the exact same bundle in the base period. By construction the CPI value for period-t is supposed to be a weighted average of the period-t prices of the original bundle in which the weight assigned to each good in the bundle is the period-t quantity of the good consumed divided by the value spent on the good in the base period, which is the product of the base-period price and quantity. This formula yields one for the base period. If the original bundle costs 33 percent more in period-t, then the CPI will be 1.33.

Many other COL indexes, for instance Paasche, Fisher-Ideal, or Törnqvist, could be produced from similar data (though some collection aspects could be harder) but would be based on slightly different economic theories—different perspectives, specific utility functions, different mathematical bases, and so on. Why has BLS chosen the Laspeyres? Two obvious virtues of the Laspeyres formula are its simplicity and its familiarity. It is easy to explain a measure to compare the price of a fixed market basket of goods over time, and anyone who has studied a bit of economics has learned about a Laspeyres index, though perhaps without the title.

The Laspeyres also has the convenient and practical feature that once the weights are determined from the base year(s), only prices need to be collected in order to update the index monthly. Thus its ease of construction and its intuitive simplicity, that you simply multiply each good's price by the relative importance of that good in the basket and that the basket does not change, surely explain its popularity. Were BLS to abandon the Laspeyres formula, someone else would construct one, and everyone would probably use it instead of whatever newfangled index BLS produced in its place.

Nonetheless, two points need to be made. First, the Laspeyres price index comes from a very static, rigid, and limited economic model, and one certainly must question its effectiveness in describing the very complex, dynamic economy it is intended to reflect. Second, the CPI is not, in fact, a Laspeyres index: it only purports to be for ease of explanation. The actual numbers reflect a more subtle compromise with reality than Mr. Laspeyres's formula would sug-

gest. The exact nature of these compromises is what the ALS paper is all about, and it is a very constructive discussion of how BLS solves practical problems not anticipated by those of us who describe Laspeyres indexes to our students.

Briefly, the CPI is a Laspeyres index over 207 *strata* where a strata is not an actual individual good but a category of goods such as apparel, gasoline, or cereal. The weight associated with each strata is a constant determined by the average quantity of total expenditures devoted to this strata during a three-year interval centering on the base year. However, each strata price is itself an aggregate index of the prices of the many goods in that strata. It is not exactly clear to me from the paper how the price of a strata is compiled, however. Field agents do alter their sampling procedures from year to year in compiling the data that lead into these strata prices; thus, sample variations and therefore sampling error do take place within the price of each strata every year. Only in the crudest sense, then (i.e., at the most aggregated level), is the CPI a Laspeyres index. The sampling variations include changes in the geographical regions from which data is actually drawn each year. Of a total of eighty-five regions, 20 percent are rotated in or out each year. Again it is not exactly clear what goes on in these rotations.

To illustrate the nature of the difficulties faced by field agents who collect the actual raw data that lead to the price of each strata, let us consider the problems caused by the two facts that the vintage characteristics of products frequently change and that the nature of retail outlets frequently changes. Boutiques, mail order catalogues, department stores, discount houses, and specialty shops are all different retail modes of transaction. Thus, if we let v index the vintage style or model, o the outlet type, and t the date the price of a good is observed, then the difference between what price is reported from the field between period t and period $t + 1$ for a given good in any one strata is

$$p(v + 1, o + 1, t + 1) - p(v, o, t).$$

In period $t + 1$, a possibly new (in a characteristics sense) product, $v + 1$, is sold by a possibly new outlet type, $o + 1$. Just resampling this new price can overstate a pure price increase, in the sense of pricing a fixed bundle of goods within a strata, because either $v + 1$, $o + 1$, or both may differ, representing quality improvements. Here BLS has two options. One, they can either observe or estimate, with hedonics or cost estimates, $p(v, o, t + 1)$ or $p(v + 1, o + 1, t)$, which can then be used to strip out the percentage of price change attributable to quality change. Estimation of these new-old vintages or old-new vintages with hedonic techniques is well known. See Gordon (1990) for an extensive application to a variety of assets, and see Triplett (1990) for an analysis of hedonics in statistical agencies. For a subtle analysis of difficulties encountered in trying to observe new-old vintage or old-new vintage assets, see Berndt and Griliches (1993).

If one does not have these prices, due to either time or cost constraints, then the second option is to compute some average of the prices of stuff in the

strata that did not change. This latter procedure in effect amounts to excluding possible quality improvements embodied in new goods. This could bias the price index upward by excluding improvements in variety and quality that may have accompanied price increases of all products. It could also bias the index downward by excluding the very goods whose prices rose because they were better. To some extent the second option, leaving out new or improved goods, is driven by resource limitations at BLS. They simply do not have the resources to allow for every change that occurs. All they can do is try to correct for really big changes once they have clearly been a factor, but not until such evidence is obvious. Unfortunately, as Diewert (1987) has pointed out this will lead to substantial upward bias in price indexes; a bias that Triplett (1993) refers to as *new introductions bias.*

Of course, in some sense, if they are really trying to produce a Laspeyres index, then perhaps BLS should simply ignore such changes anyway. If one is trying to price the cost of a fixed bundle of goods purchased by a given consumer with the same utility function in each period, then perhaps new goods and new outlets should be left out altogether. On the other hand, though, perhaps economists, in and out of BLS, ought to study ways we could abandon this static framework altogether and build an index that reflects the very dynamic world in which we are trying to price the cost of what ever it is *contemporary* consumers are trying to buy compared to what they would have had to pay for this lifestyle years before. In other words, perhaps BLS should abandon the fiction that the world is simple enough to be captured by a Laspeyres formula at all.

It does seem evident to me that the CPI, as it is actually compiled by BLS, is not in fact a Laspeyres index. As a practical matter, BLS cannot construct a Laspeyres index because too many changes are occurring over time for such an index to reflect the economy after just a few years. Thus, BLS staff are trying to allow sensibly for some of these changes in demographics, shopping habits, quality change, new goods, and so forth, but all this work is still embedded in a Laspeyres framework. Perhaps the only solution to this conundrum is the ever fashionable 1990s warning-label solution to bring truth in advertising:

WARNING: The CPI is not a Laspeyres index*

*But we thought you would like to think it is. Have a nice day.

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