The Consumer Price Index*

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Almost everyone worries about the prices of all kinds of things. Perhaps the best way for an individual to find out how the price level changes is to follow in newspapers the Consumer Price Index (CPI) of the Bureau of Labor Statistics, a part of the U.S. Department of Labor. Consumers see the CPI as a good measure of price changes of the goods and services they purchase. They react to newspaper statements such as "In September of 1986, the average urban family spent $33.02 for the same amount of goods and services that could be obtained for $10.00 in 1967." They wonder whether income has increased sufficiently to compensate for this increase in prices.

Unions and management pay particular attention to the CPI because they know its value will play a critical role in wage agreements and that a 4% annual

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increase, for example, in the CPI will lead to a demand for at least a 4% increase in wages. Furthermore, in January 1986 there were 4.5 million workers whose wages were covered by contracts containing escalator provisions, that is, provisions calling for automatic changes in wage rates in accordance with specified changes in the CPI.

Americans who get Social Security benefits watch changes in the CPI because it is used to escalate their pensions. The CPI is also used to index payments in other government programs, such as food stamps. The CPI affects government revenue too because it is used to adjust taxable income brackets in our income tax law.

Finally, economists use the CPI as one of the principal indicators to judge the performance of the economy. As Figure 1 shows, the extent of inflation has varied considerably over time.

Although statistical studies of prices and living conditions in the United States were conducted in the late nineteenth and early twentieth centuries, the first complete "cost-of-living" indexes were published by the Bureau of Labor Statistics in 1919. They covered 32 large shipbuilding and industrial centers and arose through an agreement between the Shipbuilding Labor Adjustment Board and labor leaders that one of the factors to be considered in settling labor disputes was that of "adjusting wages to the higher cost of living resulting from the war."

Since that time, the CPI has been broadened in scope and increased in importance. This had led to many professional appraisals of the CPI, among them one by an advisory committee of the American Statistical Association in 1933–1934 and one by the National Bureau of Economic Research in 1959–1960. These appraisals have influenced major revisions in the CPI, made at approximately 10-year intervals since 1940, as well as many minor revisions.
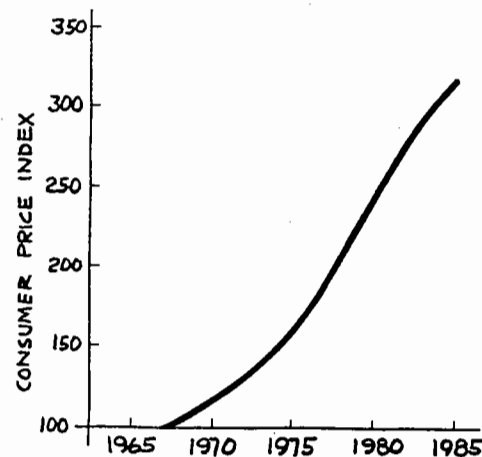

Figure 1 *Consumer Price Index for all urban consumers (CPI–U), annual averages (1967 = 100).*

PROBLEMS IN CONSTRUCTING THE CPI

Typical consumers are quite aware of changes that occur in the prices of goods and services purchased regularly. They know when the price of gasoline increases by one cent per gallon, or when the price of milk is increased by one cent per quart. Furthermore, they are able to predict with reasonable accuracy the impact of these price changes on monthly or yearly budgets and are therefore in a position to estimate the extra income (including an allowance for taxes) needed in order to compensate for these increases. Price changes relating to less frequent and more sporadic purchases—clothing, doctors' services, appliances, automobiles, and homes, for example—are not as visible to the individual consumer, and it is much more difficult to assess their effects on the budget. Thus one may well know that it costs more to live, or less to live, during the current year than in the preceding year, but would find it almost impossible to provide an exact value for this change in the cost of living. This problem would be further complicated by changes that might occur in such matters as family status (births and deaths, divorces), family desires (large cars versus small cars), and family purchasing patterns (chicken instead of steak). And yet it is exactly this evaluation—for the nation as a whole, for separate regions and cities of the nation, for different classes of expenditures (food, clothing, housing, transportation, and the like), and on a monthly basis—that the CPI provides. This essay deals primarily with the contribution of statistics to the construction of the CPI.

If consumers actually wished to keep sufficiently detailed records to measure the change in prices of the items purchased from, say, January 1986 to January 1987, they might proceed as follows. During January 1986, they would keep a record of every purchase and would then summarize these purchases in terms of quantities (number of quarts of milk, number of pairs of shoes, number of haircuts, and the like) and the unit price of each item. In effect, they would define a "market basket" of goods and services and obtain the cost of this market basket in January 1986. Suppose this cost is $750. In January 1987, exactly the same market basket of goods and services would be priced. Let us assume that the cost then was $800. Therefore this consumer's CPI for January 1987 with January 1986 weights (quantities) and with January 1986 as a base (= 100) is $100 \times 800/750 = 107$. The CPI is effectively computed in the same way, but the operation is much more complicated because it deals with a large population rather than a single consumer.

Even if we assume that the family status and desires of our consumer did not change from January 1986 to January 1987—an assumption that can seldom be exactly true—many practical problems and tantalizing questions would plague those responsible for the construction and interpretation of this index. In particular:

1. Even for a single consuming family, the number of different items purchased during a month or year is extremely large, and the continual pricing of such a list would be costly and time consuming. Preparation of a CPI for groups of families obviously magnifies this problem to a wholly impractical size.

2. The average family has available to it a host of vendors of goods and services, and prices vary from vendor to vendor. In January 1987 should one attempt to return to the same places where purchases were made in 1986? And what about stores that have gone out of business or stores that have come into existence in the interim?

3. Prices vary from day to day. Must our consuming family return to the same store at the same time to compute the cost of its market basket in January 1987? And how does one take into account the facts that some families take advantage of sales and others do not and that some families shop on a day-to-day basis while others shop less frequently?

4. Suppose that a major purchase, such as an automobile, was made by our family in January 1986. The fixed market basket still contained this item in January 1987, even though such a purchase was not made at that time. How should this be handled?

5. The goods and services available to the consumer change from time to time. Items contained in the original market basket may not exist in the stores when we return to price them at a later date, or they may exist only at an improved or lowered quality level. What do price changes mean under these circumstances?

6. We also observe that our consuming family—even though its composition, status, and desires are assumed not to have changed—may be able to "beat" a rise in prices by appropriately altering its purchasing patterns. Suppose, for example, that they notice that the price of steak has risen sharply and decide that the desires of the family are as well satisfied by chicken as by steak. If chicken is substituted for steak, the family's satisfaction level will not change, and yet the amount spent for food may actually decrease in spite of what may be a general increase in the price level. In effect, we can think of replacing the "fixed-contents" market basket with a "fixed-satisfaction" market basket.

The above problems relate to both measurement and concept. Thus we may find that a particular item of merchandise has changed in quality, and yet it may be a most difficult task to measure this change in quality and to translate it into a dollar value. The Bureau of Labor Statistics does attempt to account for these changes in quality in constructing the CPI.

Item 6 above is at a deeper conceptual level. Most economists would prefer a "constant-utility" or "constant-satisfaction" or "welfare" type of price index to the "fixed-market-basket" type of index currently produced by the Bureau of Labor Statistics. In other words, what change in expenditures must a consuming family make from one time to another in order to maintain a constant level of satisfaction, with the recognition that the contents of the market basket can be changed in order to accommodate changes in prices, changes in products, and the like? A number of researchers have constructed "constant-utility" indexes, but the practical and conceptual problems still prevent production of such a measure as an official monthly statistical series. As a matter of fact, in September 1945, the official title of the index was changed from

the Cost of Living Index to the Consumer Price Index in order to emphasize the distinction between these two approaches. In this essay I shall not treat these conceptual problems but rather focus on the role of statistics as it helps to solve CPI measurement problems.

SAMPLING AND THE CPI

Many of the above problems become more manageable if attention is shifted from the individual consuming family to a group, or *population,* of consuming families. Thus even though some members of the population did purchase automobiles in January 1986, other members of the population did not make such a purchase, and similarly for January 1987. An automobile can then be introduced into the market basket with a weight that will reflect the effects of changes in its average price, averaged over the population of families. This shift in emphasis from the individual consumer to a population of consumers, where differences among the members of this population are known to exist, means that the construction of the CPI requires statistical *sampling* (and analysis) from the population of consuming families.

Moving in this direction also forces one to think in terms of the *population of goods and services* available to all members of the population of consumers and in terms of the *population of outlets* at which all of these goods and services may be purchased. Furthermore, it is manifestly impossible to study every consuming family and to price each item of consumption in all the outlets where it can be purchased. Hence it becomes necessary to select samples from each of these populations and to draw inferences from the samples to the entire populations. The methods of statistics can assist and guide these steps.

The Consumer Price Index has never attempted to measure the changes in the prices of goods and services for all families and individuals living in the United States. Rather, because of the CPI's traditional use in collective bargaining between labor and management, its scope has been restricted to urban families. Until 1978, the population of consuming families covered by the index consisted of all urban families (including single workers) for which 50% or more of the family's income came from wages or from salaries earned in clerical occupations and for which at least one member of the family unit worked for at least 37 weeks during a year. Since 1978, the Bureau of Labor Statistics has produced a CPI for *all* urban consumers (CPI–U) as well as the continuation of the more limited CPI for urban wage earners and clerical workers (CPI–W).

In brief, a sample of urban communities is selected first, and then a sample of families is taken from each of the selected communities. In 1986, this was done in 91 areas. The 29 largest cities in the continental United States, plus 1 city from Alaska and 1 from Hawaii, were automatically included in this sample of cities. The remaining urban areas with populations of 2,500 or more were placed in homogeneous groups according to size and geographic location, and 60 cities were chosen from these groups in accordance with probability methods of selection. This sample of 91 cities serves not only as a basis

for studying the expenditure patterns of consuming families but also as a basis for the prices that must be used to determine the current cost of the CPI's market basket of goods and services. The CPI will continue to be based upon this sample of 91 cities until the next major revision takes place.

Within each of the 91 chosen cities, a sample of consuming units was selected and interviewed. These units were drawn in accordance with the tenets of statistical sampling theory; the goal was to choose samples in such a way that objective measures could be devised for assessing the likely size of deviations between averages from the sample and corresponding (unknown) averages from the whole population. This particular survey was called the Consumer Expenditure Survey (CES) because its primary purpose was to collect data relating to family expenditures for goods and services used in day-to-day living.

The CES is really two separate surveys. One is an interview survey conducted at quarterly intervals with each consumer unit in the sample. This survey collects comprehensive data on expenditures, assets, liabilities, and incomes and is most effective for measuring expenditures for large, infrequent purchases such as appliances and automobiles as well as for other household expenses. The second survey is a diary in which each consumer unit in another sample keeps a complete record of all expenses for a two-week period. This method is most effective for measuring small purchases such as hamburger, fish, toothpaste, and photographic film. Each year, 5,000 consumer units are surveyed in each of the two CES surveys. In January 1987, data from the CES for the years 1982–1984 were incorporated into the CPI.

DATA COLLECTION AND THE CPI

Data collected in the CES interviews are used for a variety of purposes in determining the structure of the current CPI. The data define the complete contents and total cost of each family's market basket in the survey years. The items are classified into five major groups: food and beverages; housing; apparel and upkeep; transportation; and medical care, entertainment, and other items. Each of these groups is further subdivided to a final classification scheme consisting of 69 expenditure classes. Some examples of these expenditure classes are: beef and veal, eggs, piped gas and electricity, housekeeping services, footwear, auto repairs and maintenance, hospital and related services, and reading materials. The expenditure classes are further divided into 207 item strata. That is, the consumer's market basket is divided into 207 compartments. The total cost of each compartment is then determined for all sample consumers selected from within a particular city, and these total costs are expressed in relative terms; for example, at December 1986 prices, beef and veal are estimated to account for 1.013% of the total cost of the nationwide market basket. Different market baskets are used in different cities to allow for differences in such characteristics as climate and the availability of different foods. Thus we use many average market baskets rather than a market basket that applies to a single consuming unit.

As noted earlier, the CES interviews define a market basket filled with all the items that consumers purchase. It would be impossible to price all of these items in their almost infinite variety each month, even recognizing that this pricing need be carried out only in the 91 index cities. Hence another sampling problem arises. Again the theory of statistical sampling was used to select a sample of items from each of the 207 item classes. The sampling approach allows the contents of the market basket to change. For example, if one item disappears from the market, replacements may be made by further sampling. The 207 compartments and their original weights, however, remain fixed through time until a new market basket is put in place.

Selecting the specific 120,000 items and identifying the outlets from which prices will be collected is a complex process of several steps. First, many of the 207 item strata or compartments (the fixed building blocks of the index) are further divided into "entry-level items" or ELIs. For example, the item stratum for home laundry equipment is divided into two ELIs: washers and dryers. For each of the urban areas where prices are collected, a sample of ELIs is selected within each item stratum. At least one ELI from each item stratum is priced in each urban area. And over all urban areas, each ELI is priced somewhere, the frequency of its pricing being proportional to its importance within the item stratum. For example, washing machines may be priced in Poughkeepsie and dryers in Grand Island, but nationwide, the proportions of washers and dryers in the CPI are approximately equal to the relative proportions bought by all urban consumers.

With the sample of ELIs in hand for each urban area, we pick a scientific sample of stores or other outlets for pricing each of the ELIs. To do this, the Bureau of Labor Statistics uses a Point of Purchase Survey (POPS) in each urban area. This survey is like the CES in that it determines how much consumer units spend for different classes of items, but it also finds out how much they spend at each of the places from which the items were bought. From this survey, the Bureau constructs what statisticians call a *sampling frame*. For each item category, the sampling frame contains a list of the outlets from which the item category was purchased and of the amounts spent by all sampled consumer units in that outlet. A probability sample of outlets is then selected for each item category, with the result that the sample is representative of all the various types and locations of outlets from which consumers in that urban area purchase items in a category.

Now the Bureau's field staff can visit each of the selected outlets; but which washing machine will be priced? There may be *dozens* of different brands and models. For the CPI the sample must be representative of all different kinds of washing machines. To meet that objective, Bureau staff and store personnel review the dollar volume of sales for each type of machine and then select a probability sample from the ones sold in that store. The greater the sales of a particular variety, the greater the probability that it will be included in the sample, but every variety—no matter how obscure—has some chance for selection. The final result is that the national sample for each item stratum in the CPI is composed of many different varieties of an item. The varieties

on which consumers, on average, spend more, appear more frequently in the sample list while those for which less is spent appear proportionately less frequently.

The field operations of monthly pricing are intricate. Not only must a large field staff be trained and supervised, but the staff must get the cooperation of store managers and provide for businesses that cease operations or come into existence during the 10-year period that ordinarily elapses between major revisions. To appreciate the magnitude of these endeavors, note that prices are collected at 21,000 outlets each month.

The CPI has a final sampling problem, not always recognized as such. Although the CPI is published monthly, it does not refer to any definite date during the month. The pricing operation has to be almost continual, and it is therefore necessary to choose a sample of times when prices are obtained. This sampling is not carried out in as formal a manner as are the other sampling operations. Nevertheless, every attempt is made to ensure, for example, that sale and nonsale days for food are represented in their proper proportions and that a similar balance is maintained for other items, such as newspapers and theater admissions, whose prices may change periodically.

One important goal in statistical design and analysis is to have an objective measure of the precision of sample analyses. Although this goal has not yet been fully realized in the complex setting of the CPI, substantial progress has been made. All indications are that the sampling operations are reasonably well under control and that uncertainty in the value of the index due to sampling is relatively small compared to the uncertainties arising from other aspects of the process, for example, the effects of quality changes on the index.

SUMMARY

The production of monthly values for the Consumer Price Index by the Bureau of Labor Statistics is a highly complex undertaking that involves problems of *basic economic theory* (for example, the choice between a price index or a constant-satisfaction index), *measurement and quantification* (for example, of changes in the quality of items purchased by consumers), *sampling statistics* (definition and selection of samples from a wide variety of populations), and *operations* (for example, training and supervision of price reporters).

The CPI is concerned with a population of consuming families and with the population of cities in which these families live. A sample of cities serves two purposes. First, from within the selected cities a sample of consumers is chosen from which it is possible to determine average expenditure patterns. Second, prices are collected in the selected cities to determine the value of the current CPI. The Consumer Expenditure Surveys also define a population of goods and services for which consuming families spend their income. From this population a sample must be taken for current pricing purposes. Within each of the index cities there exist populations of outlets at which items can be purchased, and samples must be chosen to represent these populations.

Finally, there is a population of times within a month at which price quotations can be obtained, and this population also must be sampled.

It is certainly true that everyone may not be completely satisfied with the CPI in its present form. Improvements can and probably will be made in many parts of the index, for example, in the basic data on consumer expenditure patterns, in the sampling of outlets, and in the collection of price data from these outlets, in the preparation of indexes for a wider variety of subpopulations, and in techniques for handling quality change problems. It may even happen that some completely new approach to the construction of the index may be developed, possibly through the use of newer mathematical techniques. No matter what its form, however, the CPI undoubtedly will remain one of the main indicators of the state of the U.S. economy.

PROBLEMS

1. Refer to Figure 1. In 1980 how much would the average urban family have paid for the same amount of goods and services that it could have obtained for $10 in 1967?

2. Explain the difference between a "constant-utility" and a "fixed-market-basket" type of index. Which type would you prefer the Bureau of Labor Statistics to use? Why?

3. What is the purpose of dividing up cities into homogeneous groups before choosing the cities to be included in the price survey?

4. Why are all of the largest cities automatically included in the price survey?

5. Suppose a group of rural members of Congress push through a bill requiring the Department of Agriculture to find out the cost of living for farm families.
   a. Could the department refer them to the CPI? Why or why not?
   b. If not, what steps would the department have to take to implement this law?

6. Suppose an anthropologist studying a remote community of Northern Albertan gold prospectors decides to construct a CPI for the community. A survey in January 1975 finds that the prospectors spent on the average:
   a. 100 ounces of gold for flour, which costs 4 ounces a sack;
   b. 20 ounces of gold for burros, which cost 100 ounces on the average;
   c. 40 ounces of gold for whiskey, which costs 5 ounces per pint.

In January 1976, the anthropologist finds that flour has gone up to 6 ounces of gold per sack; burros sell for only 80 ounces on the average; and whiskey costs 10 ounces a pint. What is the CPI for January 1976 (January 1975 = 100)?

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