as prior data unaffected by these revisions. Estimates reflecting the new benchmarks appear in the "Current Labor Statistics" section of the *Monthly Labor Review*, beginning with September data in the November issue. □

Footnotes

[1] As defined in the *1987 Standard Industrial Classification Manual*, issued by the Executive Office of the President, Office of Management and Budget.

[2] All ratios are based on first-quarter 1988 universe employment data. For additional information, see *Employment Data under the New Standard Industrial Classification, First Quarter 1988*, Report 772, October 1989.

[3] A detailed description of the procedure appears in *The X-11 ARIMA Seasonal Adjustment Method*, by Estella Bee Dagum, Statistics Canada Catalogue No. 12-564E, January 1983.

Quality adjustments for structural changes in the CPI housing sample

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The Consumer Price Index (CPI) estimates the average change in prices paid by the American public for a fixed set of consumer goods and services. When a characteristic of a good or service used in the index changes, the change may include a measurable difference in the quality of the item or service being priced from one time period to the next. If so, an adjustment reflecting this difference will be made.

Quality adjustments can be direct or implicit. If the value of the change in quality can be measured, the measured amount is removed from the observed price difference. If the value cannot be measured, an implicit adjustment is made for the item or service based on the change of all other items in the same estimating cell. As an example, for the Rent Index, when a price comparison is canceled because the dollar amount of the change in quality is not known, there is no direct imputed price used for the given housing unit. Instead, the proportional weight for the unit is spread out among the other housing units in the same cell—or groups of similar cells if the impact on one cell would be too large—in a process known as *noninterview adjustment*.

This noninterview technique of indirect quality adjustment performs well as long as the price movements for the items that change in quality are similar to the price movement of all other items in the cell. If they are different—for example, if the items that change in quality always are experiencing significant price changes while the rest of the sample is not—then we would be better off trying to estimate the value of the change in quality directly.[1]

Prior to February 1989, the CPI used the noninterview indirect adjustment technique for observations in the rent sample that had a change in any of four structural characteristics: central air conditioning, the number of bedrooms, the number of bathrooms, and the number of other rooms.[2] The rent sample from the CPI housing survey is the source of information on price changes for the Residential Rent Index and the Owners' Equivalent Rent Index. Quite frequently, changes in rent accompany structural changes, and the indirect adjustment process underestimates the former, thus overestimating changes in quality. Accordingly, starting with the data used in the February 1989 indexes, the Bureau of Labor Statistics has made direct quality adjustments in the CPI for rental units with verified changes in structural quality.

This note describes the process of adjusting for quality changes in structural characteristics. CPI analysts now make direct dollar adjustments for changes in the four structural characteristics mentioned above, in addition to adjusting for changes in parking accommodations, amount of furniture, number and types of appliances, and utility billing, a practice that already existed in previous housing surveys.

Table 1. **1990 structural change factors, by census region**

[Percentage of rent]

Structural element	Northeast	North Central	South	West
Central air conditioning	6.29	8.56	18.00	5.86
Number of bedrooms	16.51	16.34	20.55	14.97
Number of bathrooms	15.55	9.54	9.25	8.52
Number of other rooms	8.69	1.90	2.05	3.05

Source of adjustments

The adjustment values for the changes in structural characteristics are based on hedonic regressions, which show the relationship between the logarithm of rent and various structural and locational variables that affect rent. These regressions provide a set of factors (regression coefficients) for the different housing characteristics. As a result of the semilogarithmic form of the regressions, the factors give estimates of the value of the structural characteristics that are percentages of the rent. The BLS housing team then estimates the dollar adjustment for each change by multiplying the appropriate factor by the rent. Table 1 shows the 1990 structural change factors, broken down by census region, for the four characteristics of central air conditioning, number of bedrooms, number of bathrooms, and number of other rooms mentioned above.

Hedonic regressions are run annually for the four U.S. census regions, shown in table 1. The primary purpose of the regressions is to estimate the effects of age bias on the housing indexes.[3] Using them for quality adjustments is a spinoff benefit.

Using the adjustments

Rental units in the CPI housing sample are contacted twice a year, at which times BLS agents obtain the rents for the current and previous month. The CPI estimates the average change in rent over a 1-month period and over a 6-month period. The movement of the CPI Rent Index is a composite of these two

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independently calculated estimates. The new adjustments are made to correct for structural changes both when comparing the current rent to the previous month's rent and when comparing the current rent to the rent from 6 months ago.

BLS makes the adjustments when (1) there has been a change in the unit's description and (2) the followup verification question "Has this changed in the past year?" is answered "Yes." The verification question is used to screen out random differences in the reported description due to miscounts and misinterpretations of the questions. A direct price comparison is made without any quality adjustment if the description is different and the difference is not a verified change.

The movement of the Residential Rent Index is based on changes in *contract rent*—that is, the amount that tenants pay or owners receive for rental housing units. Contract rent includes all services, facilities, and utilities paid for by the rent payment. Contract rent is adjusted to create what is called *normalized rent*, which is what the CPI housing estimation program actually uses to calculate the Rent Index. Normalized rent is the rent paid by the tenant, plus any other payments or payments-in-kind paid to the landlord in the form of subsidies or services, all put on a monthly basis if paid otherwise. By contrast, the Owners' Equivalent Rent Index, which measures the change in the cost of shelter for people who live in their own homes, uses the concept of *pure rent*, which is derived by deducting estimates of the charges for utilities and furnishings (paid separately by homeowners) from the normalized rent.[4]

Calculating the adjustments

The quality adjustment used in the Residential Rent Index is a percentage of the current rent, subtracted or added to the normalized rent for the current time period, depending on whether the unit's quality has improved or declined. The adjusted rent is then compared with the previous rent.

The adjustment process for the rental units used in matching for the Owners' Equivalent Rent Index is different because that index uses pure rents, whose utility costs have been removed, as opposed to contract rents, in which utility costs are included if included in the lease. The quality adjustment factors for structural change are subtracted or added to each previous pure rental amount used in the rental equivalence calculation.[5] Although applied to the pure rent, the adjustment is calculated on the basis of the normalized rent.

For residential rent, the dollar adjustment for the 6-month comparison period is given by

(1) ADJ = [(Normalized $rent_T$) / (1 + Calculated factor)] – Normalized $rent_T$.

For Owners' Equivalent Rent, the dollar adjustment for the 6-month comparison is

(2) ADJ = [(Normalized $rent_{T-6}$) x (1 + Calculated factor)] – Normalized $rent_{T-6}$.

The adjustment for the 1-month comparison is based on whether or not a new tenant has moved into the unit. If there is a new tenant in the unit at the time the adjustment is contemplated, the structural change likely occurred with the occupancy by the new tenant. If the tenant moved in during the current month, then the 1-month quality change is for the full amount. If the tenant moved in between 2 and 6 months earlier, it is assumed that the change in quality occurred when the tenant moved in and that there has been no further change in quality since then. In that case, there is no 1-month quality adjustment.

If the same tenant is living in the unit as was present during the previous collection period 6 months earlier, the change in quality has an equal probability of occurring at any time in the last 6 months, so an adjustment of one-sixth of the quality change factor is made. On the individual unit level, the 1-month adjustment will be too high or too low under these circumstances, but the overall aggregate adjustment will be accurate.[6]

For residential rent, the dollar adjustment for the 1-month comparison is

(3a) ADJ = [(Normalized $rent_T$) / (1 + Calculated factor)] – Normalized $rent_T$

when the length of occupancy is 1 month; when the length of occupancy is 2 to fewer than 6 full months,

(3b) ADJ = 0.00,

and when the length of occupancy is 6 full months or more,

(3c) ADJ = [(Normalized $rent_T$) / (1 + (1/6 x Calculated factor))] – Normalized $Rent_T$.

For owners' equivalent rent, the dollar adjustment for the 1-month comparison is given by

(4a) ADJ = [(Normalized $rent_{T-1}$) x (1 + Calculated factor)] – Normalized $rent_{T-1}$

when the length of occupancy is 1 month; when the length of occupancy is 2 to fewer than 6 full months,

(4b) ADJ = 0.00.

and when the length of occupancy is 6 full months or more,

(4c) ADJ = [(Normalized $rent_{T-1}$) x (1 + (1/6 x Calculated factor))] – Normalized $rent_{T-1}$.

Examples

The factors derived from the semilogarithmic regression function are additive; that is, when there are multiple structural changes to a housing unit, the regression factors are summed. Thus, the final factor for the change is the total of the separate factors for the different changes.

To demonstrate the adjustment process, suppose that a rental housing unit in the Western census region has added an extra bedroom and bathroom, but has dropped central air conditioning for the same tenant. Suppose also that the normalized rent 6 months ago was $400, last month's rent was $500, this month's rent is $600, and there are no utilities or furnishings included in the rent. Then, using equations (1), (2), (3c), and (4c), we arrive at the following quality adjustments:

(a) The 6-month adjustment for the Residential Rent Index equals

$[\$600/(1+.1497+.0852-.0586)] - \$600$

= ($600 / 1.1763) – $600
= –$89.926,

where .1497 is the increased value of the bedroom, .0852 is the increased value of the bathroom, and .0586 is the decreased value of the removed central air conditioning.

(b) The 6-month adjustment for the Owners' Equivalent Rent Index equals

[$400 x (1 + .1497 + .0852 - .0586)] – $400
= ($400 x 1.1763) – $400
= + $70.52,

where .1497, .0852, and .0586 are as before.

(c) The 1-month adjustment for the Residential Rent Index equals

[$600 / (1 + (1/6) x (.1497 + .0852 – .0586))] – $600
= ($600 / 1.029) – $600
= –$16.910,

where, again, the same three numbers as before constitute the calculated factor.

(d) The 1-month adjustment for the Owners' Equivalent Rent Index equals

[$500 x (1 + (1/6) x (.1497 + .0852 – .0586))] – $500
= ($500 x 1.029) – $500
= + $14.50,

with the calculated factor the same again.

Note that the relatives of change for contract rent used in the Residential Rent Index and for pure rent used in the Owners' Equivalent Rent Index after quality adjustments are the same:

(a) The 6-month contract rent comparison becomes

($600 – $89.926) / $400
= $510.074 / $400
= 1.2752.

(b) The 6-month pure rent comparison becomes

$600 / ($400 + $70.52)
= $600 / $470.52
= 1.2752.

(c) The 1-month contract rent comparison becomes

($600 – $16.910) / $500
= $583.090 / $500
= 1.1662.

(d) The 1-month pure rent comparison becomes

$600 / ($500 + $14.50)
= $600 / $514.50
= 1.1662.

Summary

The use of hedonic regression factors represents a new improvement and a major change in calculating quality adjustments in the housing indexes, even though the impact of these factors is limited. Verified structural changes for rental housing were reported seven times per month, on average, in 1988, and verified changes to or from central air conditioning were reported an average of six times per month. Together, the two kinds of change made up approximately 0.3 percent of the number of usable 6-month comparisons.

The percentage factors for structural changes are updated with each recalculation of age bias adjustments. □

Footnotes

[1] For a more detailed discussion of quality adjustments, see Paul A. Armknecht and Donald Weyback, "Adjustments for Quality Change in the U.S. Consumer Price Index," *Journal of Official Statistics* (Statistics Sweden), vol. 5, no. 2, 1989, pp. 107–23.

[2] Chapter 19, "The Consumer Price Index," *BLS Handbook of Methods*, Bulletin 2285 (Bureau of Labor Statistics, April 1988), p. 175, describes the earlier, original process of canceling comparisons when structural changes occurred.

[3] See Walter F. Lane, William C. Randolph, and Stephen A. Berenson, "Adjusting the CPI shelter index to compensate for effect of depreciation," *Monthly Labor Review*, October 1988, pp. 34–37. The regression results for structural changes used variables for location, services, neighborhood, structural characteristics, and depreciation.

[4] The basic concepts of contract rent used in the Residential Rent Index and pure rent used in the Owners' Equivalent Rent Index are described in the *BLS Handbook of Methods*, pp. 174–76.

[5] For reasons of complexity, the system was designed to adjust each time period separately, rather than adjusting the current normalized rent for comparisons with previous time periods, as the Residential Rent Index does. The calculations for pure rent are as follows:

$$\text{Pure rent}_T = \text{Contract rent}_T - (\text{Cost of utilities}_T + \text{Cost of furniture}) + \text{Quality adjustment}_T;$$

$$\text{Pure rent}_{T-1} = \text{Contract rent}_{T-1} - (\text{Cost of utilities}_{T-1} + \text{Cost of furniture}) + \text{Quality adjustment}_{T-1};$$

$$\text{Pure rent}_{T-6} = \text{Contract rent}_{T-6} - (\text{Cost of utilities}_{T-6} + \text{Cost of furniture}) + \text{Quality adjustment}_{T-6}.$$

[6] The following equations for 1-month quality adjustments are based on the assumption that new tenants have occupied the unit and, hence, changes in quality have occurred. For major utilities, the housing form verifies 6-month changes and 1-month changes separately. The system makes 1-month quality adjustments for changes in regard to the inclusion of electricity, natural gas, and heating oil in the rent only when there is a "Yes" response to "Has [the item in question] changed since the first of last month?" Changes in these utilities occur frequently enough, and the difference in quality is significant enough, to determine precisely when the 1-month and 6-month adjustments should be made.