ANALYSIS OF CENSUS BUREAU NATIONAL HOUSING INVENTORY ESTIMATES

David V. Bateman, U. S. Bureau of the Census

I. Introduction

The purpose of this paper is to analyze the differences in housing unit inventory estimates that have been discovered through a comparison of the Annual Housing National Surveys conducted in the fall of 1973, 1974, 1975, and 1976, with other estimates of the housing inventory. These surveys were conducted by the Census Bureau for the Department of Housing and Urban Development.

Analysis of the inventory estimates indicates that the published Annual Housing Survey's inventory estimate (current independent housing unit estimate) appears to be "too high" when compared with the independently derived 1970 census inventory count adjusted for new construction and units lost from the inventory and an alternative estimator of the inventory derived from the Annual Housing Survey (AHS) itself.

The above differences, and the resulting analysis, will be described in detail along with suggestions for future research and action.

Readers should keep in mind that data presented in this paper are intended for analysis of potential biases in the inventory estimates, and as such may differ from published data.

II. Background

Some background information is needed as a basis for discussing the differences.

A. Purpose of the Survey

The Annual Housing Survey - National Sample estimates described in this paper result from data collected in the fall of 1973, 1974, 1975, and 1976. These surveys were designed to provide a current series of information on the size and composition of the housing inventory, the characteristics of its occupants, the changes in the inventory resulting from new construction and from losses, indicators of housing and neighborhood quality, selected financial characteristics, and the characteristics of recent movers.

B. Annual Housing Survey Inventory Estimation Procedure

The sample design for this survey utilizes the basic Current Population Survey (CPS) design (461 primary sampling unit design) in that virtually the same primary sampling units (PSU's) and enumeration districts (ED's) are used; of course, different households within the ED's are designated for Annual Housing Survey interviewing.

The Annual Housing Survey inventory estimates are derived basically by means of a three-stage ratio estimation procedure. The first and second stages of ratio estimation are only incidental to the problem addressed in this paper. The first-stage adjustment was employed for sample housing units from non-self-representing primary sampling units (NSR PSU's) only and its purpose was to reduce the contribution to the variance arising from the sampling of NSR PSU's. This procedure adjusts for the differences that existed at the time of the 1970 census in the distribution by census region, tenure, and geographic residence of the total housing unit inventory as estimated from the sample NSR PSU's.

The second-stage ratio estimation procedure was only employed for AHS new construction sample units (i.e., sample units built after April 1, 1970). This procedure was designed to adjust the AHS estimates of new construction units to independently derived current estimates for selected categories of new construction units for each of the four regions. These independent estimates were considered to be the best estimates available for the number of new construction units. This adjustment was needed to correct for known deficiencies in the AHS sample with regard to representation of new construction units as well as reducing sampling variation in the sample estimate.

The third-stage ratio estimation procedure is of critical importance for this paper. This ratio estimation procedure was employed for all AHS sample units. The procedure was designed to adjust the AHS sample estimates (i.e., the estimates employing a basic inverse of probability weight, noninterview adjustment factors, and first- and second-stage adjustment factors) to independently derived current housing estimates for four types of vacant housing units, and for 24 residence-tenure-race and sex of head categories for occupied housing units.

The second- and third-stage ratio estimation procedures were repeated in an iterative process in order to bring the AHS estimates into close agreement with both sets of independent estimates (i.e., the independent estimates employed for both the second- and third-stage ratio estimation processes).

C. Current Independent Housing Unit Inventory Estimation Procedure

1. New Construction Inventory Estimates -- The second-stage ratio estimation procedure utilizes independently derived estimates of the new construction housing unit inventory. For conventional new construction housing units, the independent estimate was derived from the Survey of Construction (SOC), a survey of housing unit completions conducted monthly by the Bureau of the Census. For new construction mobile homes, an estimate of mobile home shipments was obtained from The Survey of Housing Starts.[1] This estimate was then adjusted to account for mobile homes shipped and actually occupied as primary residences. (A ratio between mobile homes shipped and put in place for residential purposes was established from the 1970 census for the years 1965-1970.) These independent estimates were used in the 1973, 1974, and 1975 surveys. They were not used in the 1976 survey for most categories, as a coverage improvement program was implemented that theoretically provided complete coverage for new construction units.

2. Total Housing Unit Inventory Estimates -- The third-stage ratio estimation procedure

utilizes independently derived current housing estimates. These estimates are obtained separately for occupied and vacant housing units. The independent estimate of occupied housing units was derived from data based on the Current Population Survey (CPS), a household survey conducted monthly by the Bureau of the Census. The independent estimate of vacant housing units was derived from data based on the Housing Vacancy Survey (HVS), a quarterly vacancy survey conducted as part of the CPS by the Bureau of the Census for the Bureau of Labor Statistics.

a. Occupied housing unit independent estimates obtained from CPS -- These estimates were obtained by the following procedure: (Note reference [1] for a history of changes to this method.)

(1) A weight, which is made up of four components, is associated with every person in the CPS sample. These components are:

(a) A basic weight that is the inverse of the probability of selection.

(b) A weight to reflect an adjustment made for interviews that should have been conducted but were not due to a variety of reasons.

(c) A weight that reflects an adjustment to sample persons located in non-self-representing PSU's only, for the purpose of reducing the contribution to the variance arising from the sampling of these PSU's (first-stage adjustment).

(d) A weight that brings the distribution of the sample persons into closer agreement with independent post-census estimates of the distribution of the population by various age-sex-color categories (second-stage adjustment).

An estimate of occupied housing units is then obtained by summing the principal person's weight for all households. The principal person's weight for a household is defined to be the wife's weight in a husband-wife household or the weight of the head of the household for all other types of households.

(2) The CPS estimates of occupied housing units were obtained for the 35 months preceding the survey date.

(3) A 12-month moving average of the above 35 estimates is then obtained. Twenty-four averages result from this computation.

(4) A least squares regression line is then fitted to these twenty-four 12-month moving averages.

(5) The least squares line is then used to predict what the occupied HU estimates will be for the survey date. The third-stage AHS adjustment, as explained above, is made for 24 different categories of residence-tenure-race and sex of head. The estimate of total occupied housing units, as estimated from the regression line, was allocated to these categories by the following method:

(a) The distribution of occupied HU's from CPS in each of the categories for the four quarters of year of the appropriate survey was obtained.

(b) An average percentage distribution of the occupied HU's was then obtained over the 24 categories for the four quarters.

(c) The percentages obtained in (b) were used to allocate the estimate of total occupied HU's obtained from the regression equation to the 24 categories.

For the most part, this paper will not analyze CPS occupied HU inventory estimates that include the steps described in (3), (4), and (5) above. The purpose of this paper is to study the occupied housing unit estimates coming from CPS, and the regression estimation procedure confounds the analysis.

b. Vacant housing unit independent estimates from HVS -- This independent estimate was obtained by averaging the vacancy estimates from the Housing Vacancy Survey (HVS) for the quarters centered around October of the appropriate survey year. The HVS estimate of total vacants was allocated to the four vacancy status categories by again calculating percentage distributions for the four categories from preceding quarter(s) of HVS for the appropriate survey year.

c. Coverage improvement currently in CPS -- The current independent estimate of occupied HU's is derived from the Current Population Survey, which is supplemented by a sample of units in structures that were missed in the census (E6 Bank), as are most current demographic surveys conducted by the Census Bureau such as AHS, Health Interview Survey, etc. In addition, missed census units and units created since 1970 at addresses listed in the census are picked up by a relisting procedure. The second-stage ratio estimation procedure in CPS, ratios the sample estimates of population to an "independent" estimate of population which has not been adjusted for the undercoverage of persons in the census. Therefore, the coverage improvement in CPS (E6 Bank) has very little effect on the estimate of the number of occupied HU's due to the CPS second-stage ratio adjustment procedure, although it may have an effect on the characteristics. The coverage improvement (E6 Bank) in CPS could affect the housing unit inventory estimate to the extent that these households may be smaller than the average household.

The coverage improvement program conducted as part of the October 1976 Annual Housing Survey attempted to represent the following kinds of units previously not represented in the sample from those areas in permit-issuing jurisdictions where an address sample was taken [4]. These units are presently missing from CPS:

1. Mobile homes put in place as a new address after the 1970 census outside of mobile home parks.

2. Mobile homes put in place after the 1970 census in mobile home parks built after the 1970 census.

3. Mobile homes that were vacant in the 1970 census that have since become occupied.

4. Housing units in structures that have been converted from entirely nonresidential use to residential use since the 1970 census.

5. Housing units that have been physically moved

to a new location since the 1970 census.

6. Housing units for which a permit was issued prior to January 1970, but the units were not completed until after the 1970 census.

7. Mobile homes in parks built before the census but missed by the census.

III. Estimators of the Current Occupied Housing Unit Inventory

Alternative estimators, that are currently available, of the occupied housing unit inventory are the following:

1. The estimator that is used currently to estimate the occupied HU inventory is obtained by creating a smooth monthly time series from CPS. This involves the fitting of a regression line to the monthly CPS estimates. These estimates are presented in column (1) of table A and the methodology is described in detail in section II.C.

2. An estimator of the occupied HU inventory could be obtained by eliminating the regression estimation procedure. This procedure would probably provide poor estimates of change due to monthly variation not attributable to actual inventory changes. Data using this method are presented in column (2) of table A.

3. An estimator of the occupied HU inventory can be obtained from CPS before the second stage of ratio estimation and the regression procedure. These data are presented in column (3) of table A, and include census missed units as well as allocating units picked up in the October 1976 coverage improvement program that was instituted to eliminate known biases in the sampling frame. These data do not have the benefit of a regression procedure and, as such, would probably produce poor estimates of change over time. These estimates are probably somewhat "low" because of two reasons:

(a) Undercoverage in area segments -- Approximately 25 percent of the CPS sample are located in areas of the country where listing procedures are used to obtain a sampling frame. The October 1966 Intensive Coverage Check conducted by the Census Bureau indicated that approximately 1.74 percent of all housing units in area segments were missed by CPS [2]. Thus, approximately 350,000 total housing units could be missed currently in area segments if this result is still reliable. There are indications that this may be an underestimate of the number of HU's missed, as this check was done dependently. For example, the 1970 census evaluation program indicated that over 4 percent of all housing units in rural areas were missed in the census (listing techniques, similar to those used in area segments, were used in rural areas in the census) [3].

(b) The coverage improvement program instituted in the October 1976 AHS survey may have had difficulty in picking up structures that were used for nonresidential purposes at the time of the 1970 census but have since been converted to residential use. The Survey of Components of Change and Residential Finance (SCARF) conducted in 1957-59 and the Components of Inventory Change Survey (CINCH) conducted in the 1960's indicate that we may be missing more units than the 16,000 units picked up in the coverage improvement program.

Table A

	AHS PUBLICATION FIGURE (1) CPS & HVS based inventory est. Includes second-stage adj. and regression estimation (000)	(2) CPS & HVS inventory est. without regression estimation (000)	(3) CPS & HVS inventory without second stage and regression estimation* (000)	(4) AHS "unbiased estimates"* (000)	(5) (2)-(3) (000) CPS	(6) (2)-(4) (000) AHS
October 1973						
Occupied	69,337	69,465	68,173	67,212	1,292	2,253
Vacant	6,632	6,632	6,740	6,608	- 108	24
	75,969	76,097	74,913	73,820	1,184	2,277
October 1974						
Occupied	70,830	71,246	70,060	69,403	1,186	1,843
Vacant	6,771	6,771	6,834	6,730	- 63	41
	77,601	78,017	76,894	76,133	1,123	1,884
October 1975						
Occupied	72,523	72,621	71,653	71,038	968	1,583
Vacant	6,564	6,564	6,627	6,733	-63	- 169
	79,087	79,185	78,280	77,771	905	1,414
October 1976						
Occupied	74,009	73,836	72,423	72,161	1,413	1,675
Vacant	6,528	6,528	6,591	6,828	- 63	- 300
	80,537	80,364	79,014	78,989	1,350	1,375

*Missed HU's have been added back in by means of the coverage improvement program established in the October 1976 Annual Housing Survey, National sample.

4. An estimator of the occupied HU inventory can be obtained from the Annual Housing Survey itself (column (4) in table A). Again census missed units as well as missed housing units obtained from the coverage improvement program are included in these data. These estimates are also probably underestimates for the same reasons cited in 3. above. Theoretically columns (3) and (4) in table A should have the same expected values; however, except for a relatively small problem with 1973 and 1974 AHS estimates, these differences in 1973 and 1974 are unexplainable. In addition to the sources of undercoverage mentioned in 3. above, the AHS in 1973 and 1974 is missing some units that were classified as a loss from the inventory in the regular survey but were found to be legitimate units from the reinterview of lost units.

Again the AHS data do not have the benefit of a regression estimation procedure and, as such, would probably produce poor estimates of change.

5. Another estimator of the inventory that is not included in table A is one constructed from a components of change. Basically, a components of change estimator for a given time period is constructed by adding to the census HU inventory estimate an estimate of the number of new construction units and units added through other means, and subtracting an estimate of the number of units lost from the inventory. At the present time, we are unable to create a good components of change estimator due to the inability of picking up certain kinds of units, namely:

(a) Units that come into the inventory as a result of structures that were used for nonresidential use in the census but have since been converted to residential use and units moved to the present site since 1970.

(b) Units that are going in and out of the inventory over time (flip-flops). For example, you could have a unit that is in the inventory in 1973, a loss in the 1974 survey, and it comes back into the inventory again for the 1976 survey.

(c) Units lost by means of merging units and units added by conversions.

Differences between columns (3) and (4) and column (2) are presented in columns (5) and (6). Note that one cannot interpret these numbers as bias in the CPS estimation procedure, because of the undercoverage problems in area segments, and the inability to obtain certain types of units from converted structures.

IV. Analysis of Current Independent Estimates and "Components" of Inventory Change Estimates from AHS and CPS

Conceptually it seems as though the current independent estimates may be too high for occupied housing units,[2] whereas the independent estimate for vacant housing units may be slightly too low. In addition, a potential problem in estimating the occupied HU inventory could arise from the first-stage adjustment used in CPS; it is unclear at the present time whether this would result in an upward or downward bias.

A. Potential Problem in Occupied HU Inventory

The independent estimate used in the third-stage ratio estimation process for AHS is derived from the CPS estimate of occupied HU's as described previously. The second-stage adjustment procedure in CPS weights up the sample cases without regard to household membership. Thus, the principal person's weight has an additional component that is due to nonprincipal person undercoverage in the survey. In other words, the second-stage adjustment in CPS accounts for both persons in missed HU's as well as persons missed from enumerated HU's. If more persons are missed within enumerated HU's than in missed HU's, the principal person's weight will be biased upward; that is, the CPS might adjust for more undercoverage of principal persons than there actually exists for purposes of estimating the occupied housing inventory.

Model for Potential Bias of CPS Estimates of Occupied Housing Units:

Let the ratio estimate factor used for the second-stage ratio estimation procedure in CPS for a particular age-race-sex cell be represented by

$$f = \frac{P + W}{p' + w'} = \frac{Z}{z'}$$

where:

- Z is an independent demographic estimate of the population for the cell in question
- z' is an estimate of Z derived from the CPS through the first stage of ratio estimation
- P is an independent estimate of principal persons which is unknown
- W is an independent estimate of nonprincipal persons which also is unknown
- p' is the sample estimate of P through the first stage of ratio estimation. This can be obtained from the sample.
- w' is the sample estimate of W through the first stage of ratio estimation. This also can be obtained from the sample.

It is apparent that the second-stage factor that should be applied to the principal person's weight for the purpose of estimating the occupied housing inventory is

$$f' = \frac{P}{p'}$$

1. Note that if $\frac{W}{w'} = \frac{P}{p'} = K$

then $f' = \frac{P + W}{p' + w'} = \frac{Kp' + Kw'}{p' + w'} = K$

and the current estimation procedure is "unbiased" in estimating the occupied housing unit inventory.

2. If $\frac{P}{p'} < \frac{W}{w'}$ which might be the case currently, then $Pw' < p'W$

$$Pw' + p'P < p'W + p'P$$

$$P(w' + p') < p'(W + P)$$

$$\frac{P}{p'} < \frac{W + P}{w' + p'}$$

and the current estimation procedure overestimates

the housing unit inventory. Note table B below for estimates of these factors for the indicated surveys.

Table B

	$\left(\frac{W + P}{w' + p'}\right)$ Average CPS second-stage factors	$\left(\frac{P}{p'}\right)$ * Estimate obtained from coverage improvement program
October 1973	1.03791	1.01968
October 1974	1.02924	1.01229
October 1975	1.02608	1.01252
October 1976	1.03228	1.01311

*Based on October 1976 coverage improvement program in AHS National. Note that the true $\frac{P}{p'}$ probably lies somewhere between these two sets of numbers because of undercoverage in area segments and possible weaknesses in the ability to pick up certain kinds of units such as units in structures converted from nonresidential to residential use.

3. If $\frac{P}{p'} > \frac{W}{w'}$ then it can be shown as in 2. above that $\frac{P}{p'} > \frac{W + P}{w' + p'}$

and the current estimation procedure underestimates the occupied housing unit inventory.

B. Potential Problems in Estimation of Vacant HU Inventory

The independent estimate, of the vacant HU inventory, used in the third-stage ratio adjustment process in AHS is derived from the HVS estimate of vacant HU's. The HVS estimation procedure does not have a second-stage ratio estimation procedure. Therefore, the coverage improvement in CPS (E6) as well as the units picked up in the relisting procedure would appear to adjust for the undercoverage of vacants in the census. One should also note that current surveys have a better coverage rate of vacant units than does the census. Therefore, the independent estimate of vacant HU's would appear to be conceptually correct except for undercoverage due to frame deficiencies [4] explained in section III, and due to undercoverage in area segments.

C. Comparison of April 1970 CPS Estimate of the Occupied HU Inventory and the 1970 Census Count of the Occupied Inventory

Up until the present time, the only validation of the CPS occupied HU inventory estimate has come from the 1970 census inventory count. The inventory estimates for the CPS and the census were relatively close:

1970 census occupied HU inventory count adjusted for undercoverage ---------- 64,338,000

1970 census occupied HU inventory count unadjusted for undercoverage ---------- 63,450,000

April 1970 CPS occupied HU estimate[3] - 62,971,000

This evidence would seem to indicate that there are no problems with the present procedure in estimating the occupied inventory. Certainly there is no evidence here of a tendency to "overestimate" the inventory. Nevertheless, one has to be careful in interpreting these numbers; the CPS procedure could have "overestimated" the occupied inventory for April 1970 and possible "offsetting biases" eliminated a potential bias. Possible "offsetting biases" are:

1. Because of certain kinds of frame deficiencies in the CPS sample, the missed rate of principal persons could have increased over the decade approaching the missed rate of nonprincipal persons.

2. During the sixties and early seventies, an additional step was employed after the least squares method to obtain an occupied HU inventory estimate. The incremental change in the occupied housing unit inventory from the previous census to the most current month represented on the least squares line was calculated using the following formula:

$$I = \frac{Y-H}{N}$$

where:

Y = the number of occupied housing units as estimated from the regression line for the most current month that was used as input to the calculation of the regression line

H = the number of occupied housing units in the 1960 (1970) census

N = the number of months that have elapsed between April 1, 1960 (1970) and the most current month that was used as input to the calculation of the regression line

In order to project the regression line to the current quarter of interest, the value (4.5) times (I) was added to the occupied housing unit inventory estimate that was read off the least squares regression line, for the most current month that was used as input to the calculation of the regression line. The overall effect of this procedure is to dampen the projected inventory estimates.

3. The 1970 census had less undercoverage of occupied housing units than the 1960 census. A conservative estimate is that the 1960 census missed an additional 250,000 occupied housing units over the 1970 census. Therefore, one would expect the inventory estimate built up from the 1960 census to fall short of the 1970 census by this amount if this was the only problem occurring.

D. First-Stage Ratio Adjustment Used in CPS and Its Potential Effect on Estimating the Occupied HU Inventory

The CPS first-stage ratio adjustment procedure may have some effect on the housing inventory estimate. This procedure was employed for sample persons from non-self-representing (NSR) PSU's only. The procedure was designed to reduce the contribution to the variance arising from the sampling of NSR PSU's. This ratio adjustment takes into account the differences that existed at the time of the 1970 census in the distribution by region (four regions), SMSA's (Central Cities, balance urban and balance rural), outside

SMSA's (urban, rural nonfarm and rural farm), and race (white and all other races). The first-stage ratio estimate for each specified category was as follows:

$$\frac{\text{The 1970 census population in the particular category for all NSR strata}}{\text{Estimate of the population in the particular category using 1970 census counts for sample NSR PSU's}}$$

The numerators of the ratios were calculated by obtaining the 1970 census population counts for each of the categories for each NSR stratum and summing these counts in a particular category across the NSR strata in each region. The denominators were calculated by obtaining the 1970 census population counts for each of the categories for each NSR sample PSU, weighting these counts by the inverse of the probability of selecting that PSU and summing these weighted counts in a particular category across the NSR PSU's in each census region. The computed first-stage ratio estimate factor was then applied to the existing weight for each NSR sample person in each first-stage ratio estimation category.

A problem could exist if these sample PSU's are characterized by unusually large or small households. If the PSU's are characterized by large households, the first-stage ratio adjustment process would yield underestimates of the occupied housing unit inventory and in the case of small households it would yield overestimates. It seems intuitively probable that these biases could cancel out over the 220 NSR strata used in CPS. At the present time it is felt that this problem is not a "major one" and thus research as to the extent of error is not designated as a major project although consideration is being given to revising this adjustment for the purpose of obtaining HU inventory estimates.

E. Analysis of "Components of Inventory Change" Estimates for October 1973, 1974, 1975, and 1976

Estimates of change in the total housing inventory are published for two time periods; one period uses the 1973 survey as the base, and the other uses the 1970 census estimate.[4] A key element in these tables are unspecified units. Unspecified units are the difference between

(1) the present year survey estimate and

(2) the base year estimate adjusted for new construction HU's and HU's lost from the inventory.

These units reflect additions to the inventory which are not specifically sampled for the survey, offset by certain losses. Such additions include conversions, changes from nonresidential use, housing units moved to site, units returned to the inventory in a particular survey year, etc., which were definitional losses in a prior year (for example, mobile homes which were vacant in 1973 but became occupied in the particular survey year). Examples of certain losses are mergers and mobile homes occupied in a particular year and vacant in succeeding years, etc.

Table C shows unspecified unit counts for the present published housing unit inventory, and for alternative estimators of the inventory obtained from the Current Population Survey (CPS) and the Annual Housing Survey (AHS). Examination of this table shows that the alternative estimators overall yield slightly smaller counts of unspecified units for comparisons using the 1970 census as a base. However, there is no apparent reduction when the 1973 survey is used as a base.

Table C

UNSPECIFIED UNITS (000's)

Time period	Final CPS based est. (published)	Revised CPS based est.*	AHS unbiased est.*
1970-73	195	-861	-1,954
1970-74	944	237	524
1970-75	1,820	1,013	504
1970-76	1,808	285	260
1973-74	749	1,098	1,430
1973-75	1,527	1,776	2,360
1973-76	1,613	1,146	2,214

*CPS and AHS occupied HU's are calculated by eliminating the second-stage ratio estimation stage and restoring missed housing units obtained in the October 1976 AHS coverage improvement program.

V. Conclusions

Associated with a national sample survey that is conducted to estimate the occupied housing unit inventory are a "target" population and a "survey" population. The target population comprises the total set of occupied housing units in the country and the survey population comprises the entire group of occupied housing units included in, or associated with, the frame and the estimation procedure. One of the purposes of the Annual Housing Survey is to produce an estimate of the number of occupied housing units in the target population. Because of the nature of the second-stage ratio adjustment procedure used in CPS, in which no adjustment is made to the independent estimates of population for undercoverage of persons in the census, the survey population does not account for occupied housing units missed in the census. However, due to a conceptual bias in the CPS estimation procedure, explained in section IV, that overestimates the number of units in the survey population, this procedure may inadvertently provide good estimates of the number of units in the target population. In fact, the present procedure may be producing "better" estimates of the number of units in the target population than presently available alternative estimates described in section III.

Nonetheless, in any survey operation errors of methodology should be corrected when they are discovered. At the present time we are unable to prove conclusively that any of the available estimators are better than the estimator currently being used. However, we believe a better estimator of the occupied housing inventory might be obtained from the CPS by eliminating the second-stage adjustment (in CPS), introducing a coverage improvement program similar to the program introduced in the AHS, improving the coverage of

housing units in area segments, and introducing a more sophisticated regression model to produce better estimates of change.

VI. Possibilities For Future Research and Potential Action

It is generally felt that the present procedure of ratio adjusting the Annual Housing Survey inventory estimates to the independent estimates generated by CPS and HVS is a desirable one if the CPS and HVS estimates can be refined. A refined CPS (monthly estimates) and HVS (quarterly estimates) could provide a smooth series of inventory estimates over time yielding good estimates of change. Since estimates of change are deemed extremely important for the Annual Housing Survey, and since it seems advisable to therefore continue ratio adjusting the AHS to the CPS and HVS inventory estimates, a future revision in the methodology used to estimate the CPS occupied HU inventory may also need a historical revision in the series back to the 1970 census. This revision could include the following research and actions:

1. A re-running of all CPS monthly tapes back to the 1970 census to reconstruct occupied housing unit inventory estimates that are not conceptually biased by the second-stage factors. This would involve the installment of a coverage improvement program in the Current Population Survey. Both month and year built information would have to be collected in order to allocate these units to the proper month CPS would have initially picked them up.

2. The installment of a new modeling technique to predict the occupied inventory for a given month. At the present time a simple regression line of the form $y = a + bt$, where t is a time index and y represents the 12-term moving average (explained in section II.C.2.a.) is used. The effect of the current form of regression is to project forth a linear trend where the objective should be to project a trend cycle. The effect of this adjustment on an inventory that we know has a strong cyclical movement could distort the estimate depending upon where the current inventory is in the business cycle. A new regression technique might allow for curvilinear movements in the occupied inventory estimates.

3. If we shift to a revised CPS estimate of the occupied HU inventory, the only theoretical undercoverage would exist in areas where area sampling procedures are employed. Therefore, coverage procedures could be "firmed" up by testing alternative listing procedures, etc. The present procedure of listing is primarily an "observational" one in that listers are instructed to inquire at the unit only if they are unable to obtain an address from readily visible outside sources. Inquiry at all units would pick up additional units at an additional cost.

Another source of possible undercoverage could be structures in address segments that were classified as nonresidential in the census but have since been converted to residential use. The coverage improvement program instituted in the October 1976 AHS survey picked up relatively few of this type of unit. It is generally felt that the successor method that was used may be ineffective in picking up this kind of unit. Note Montie's and Schwanz's paper for more information on the coverage improvement program [4].

4. Revised first-stage ratio estimate factors for CPS could be calculated for purposes of estimating occupied housing unit inventories. These factors would be based upon 1970 census housing unit distributions. The present procedure is acceptable for measuring population characteristics.

5. Research might be conducted into the possibility of developing a new system of principal persons and nonprincipal persons population controls. If this could be done, undercoverage in area segments and undercoverage due to conversions would not be so critical for inventory counts.

6. The Components of Change Inventory Estimator may be a good source of future inventory estimates if techniques can be devised to estimate certain troublesome components that were elaborated on in section III.

FOOTNOTES

[1] Construction Reports, Housing Starts. C20-76-11.

[2] Morton Boisen, formerly of the Census Bureau, suggested this may be the source of a bias in the estimation procedure.

[3] Based on aged 1960 population controls.

[4] Current Annual Housing Reports. Series H-150-75A.

REFERENCES

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[2] U.S. Bureau of the Census. The Current Population Survey Reinterview Program, January 1961 through December 1966. Technical Paper No. 19.

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[4] Montie, Irene and Dennis Schwanz. Coverage Improvement in the Annual Housing Survey. 1977 American Statistical Association Proceedings, Social Statistics section.