Background

Current Population Survey (CPS)

The Current Population Survey (CPS) is a national survey of approximately 60,000 households which provides a monthly picture of the nation's labor force characteristics. The CPS began in 1940, and the questionnaire has remained essentially unchanged since the last redesign in 1967. The current redesign takes into account changes which have taken place in the workforce and structure of American society, and takes advantage of improvements in survey methodology, such as computer-assisted data collection and questionnaire methods based on the theories of cognitive psychology. Further discussion of the changes in CPS can be found in the September 1993 issue of the *Monthly Labor Review*.

In addition to the questionnaire and mode of collection changes, new weights will be used to derive estimates from the sample. Starting in January 1994, the 1990-undercount-adjusted census population counts will be used. We will refer to this as *90 weighting*. The data used in this report are all based upon *90 weighting* unless otherwise stated. (The old weights were based on the 1980 Census of Population.)

Parallel Survey

In order to better understand the effects of the CPS redesign changes upon published estimates, BLS sponsored a Parallel Survey conducted from July 1992 to December 1993 by the Census Bureau. Using a monthly sample of approximately 12,000 households, the design of the Parallel Survey sample was a national stratified multistage probability sample which yields unbiased estimates for the nation as a whole. In contrast, the CPS sample has a State-based design which yields unbiased estimates for States and the Nation. In this report, we will utilize data for September 1992 through December 1993. The data collected during the initial two months, July and August of 1992, were not used due to startup effects in the Parallel Survey.

Polivka (1994) provides annual average estimates from the Parallel Survey. Annual averages give our best overall understanding about the differences between the redesigned CPS and the CPS prior to January 1994. These have been used as the basis of comparison because their sampling errors are much lower than those of the monthly Parallel Survey estimates, and their use eliminates the need for seasonally adjusting the data. However, to interpret 1994 monthly estimates in comparison to 1993, analysts need comparable monthly estimates, both on a seasonally adjusted and unadjusted basis. Providing these estimates is a formidable task because of the many design differences between the CPS and the Parallel Survey. In this report, we present a set of estimates which attempt to account for some, but not all, of these differences. The major design differences are summarized in table 1.

Table 1. Design Features of CPS and the Parallel Survey (PS) from Sep. 92 - Dec. 93.

	CPS	PS
SAMPLING DESIGN		
Type of Design	State-Based	National
Number of sample primary sampling units (PSU)	729	283
Number of geographic areas in sample PSU's	1,973	579
Monthly sample size (occupied housing units)	58,900	12,000
Post-stratification	600 cells	559 cells
	Plus States	NO States
Composite estimation	Yes	No
Standard Error of Monthly Unemployment Rate	0.11	0.25
Standard Error of Annual Avg. Unemployment Rate	0.07	0.16
COLLECTION PROCEDURES		
Mode of collection	PAPI, CATI	CAPI, CATI
% Centralized CATI	9%	18%
% True Month-in-Sample in September 1992	100%	50%
% True Month-in-Sample in October 1992	100%	50%
% True Month-in-Sample in November 1992	100%	50%
% True Month-in-Sample in December 1992	100%	50%
% True Month-in-Sample in January 1993	100%	54%
% True Month-in-Sample in February 1993	100%	58%
% True Month-in-Sample in March 1993	100%	64%
% True Month-in-Sample in April 1993	100%	76%
% True Month-in-Sample in May 1993	100%	78%
% True Month-in-Sample in June 1993	100%	86%
% True Month-in-Sample in July 1993	100%	93%
% True Month-in-Sample in August 1993	100%	97%
% True Month-in-Sample in September 1993	100%	100%
% True Month-in-Sample in October 1993	100%	100%
% True Month-in-Sample in November 1993	100%	100%
% True Month-in-Sample in December 1993	100%	100%

The model-based estimates presented in this report take into account differences between the CPS and Parallel Survey in sampling error and population controls but do not account for differences in post-stratification procedures, sample rotation, rotation group bias patterns, composite estimation, percent CATI, and seasonal patterns in monthly estimates. A brief discussion of the implications for the model-based estimates of these latter differences follows. For an in-depth discussion of the differences in sampling design between CPS and the Parallel Survey, see Kostanich and Cahoon (1994).

Poststratification

Poststratification is a statistical procedure used to ensure, among other things, that estimates aggregate to known population totals. In the CPS, estimates are controlled to match State totals. Estimates from the Parallel Survey were not controlled to match State totals. In addition, because of the small sample size of the Parallel Survey, more collapsing of race and ethnicity cells had to be done than is the case under regular CPS.

Sample rotation

The CPS uses a 4-8-4 rotation sampling scheme which means that households are interviewed for 4 consecutive months, not interviewed for 8 months, and then interviewed for 4 additional months before being permanently dropped from the sample. Each month, a new panel or rotation group is introduced, replacing the panel which received its 8th interview the previous month. Thus, each month 1/8 of the total sample is being interviewed for the 1st, 2nd, ..., and 8th time. This particular sampling scheme attempts to balance respondent burden with improved estimates of month-to-month and year-to-year change. (In any given month, 75 percent of the interviewed households were interviewed in the previous month and 50 percent were interviewed in the same month in the previous year.) Historically, it has been shown that, for a given month, the expected value of the estimated unemployment rate from each of the 8 rotation groups is different. For example, the estimated unemployment rate for the month-in-sample 1 (MIS1) panel is, on average, 7.4 percent higher than the estimated rate based on the month-in-sample 2 (MIS2) panel and 8.8 percent higher than the estimated rate based on the month-in-sample 8 panel. The estimated unemployment rate from the CPS for MIS1 through MIS4 combined is, on average, 4.3 percent higher than for MIS5 through MIS8. Although this basic 4-8-4 rotation scheme was used in the Parallel Survey, it takes 16 months to completely phase in this type of design, and the first month in which 1/8 of the sample received its 8th interview was September 1993. Thus, if the rotation group bias pattern under the old methodology were to hold true under the new methodology, we might expect estimates from the Parallel Survey to be higher than they would have been if the sample had been fully phased in before September 1992.

Rotation Group Bias Patterns

A major change in the redesigned CPS questionnaire is the inclusion of questions each month to determine if persons not in the labor force are discouraged workers. In the "old" CPS, from January 1970 through December 1993, questions for determining discouraged-worker status were asked only of MIS4 and MIS8 households. Between January 1967 and December 1969, these questions had been asked of MIS1 and MIS5 households. When the discouraged worker questions were moved from MIS1 and MIS5 to MIS4 and MIS8, the rotation group bias patterns changed dramatically. Thus, we expect the rotation group bias pattern for the new CPS to be different from the old. Because of the small sample sizes in the Parallel Survey and the incomplete rotation phase-in, we cannot estimate what the new pattern is. On the other hand, for the parallel testing period, monthly estimates based only on true MIS1 households were 4 percent higher than for true MIS2 to MIS4 combined, as compared to a 3 percent difference in CPS, providing some evidence that there was a change.

Composite Estimation

The CPS estimates are computed each month using a composite estimator to increase the accuracy of both the monthly estimates and the estimates of month-to-month changes. The composite estimator is a weighted linear combination of two estimates for the current month. One is based on data from the entire sample for the current month; the other derives from the previous month's composite estimate plus an estimate of over-the-month change from the 75% of the sample interviewed in both months. The particular form of the composite estimator was chosen based upon the rotation group bias patterns found under the old CPS methodology. Since, as mentioned earlier, we do not have accurate estimates of the rotation group bias pattern for the new methodology, we cannot modify the form of the composite estimator. To avoid mixing January 1994 estimates based on the new methodology by using December 1993 estimates based on the old methodology, the estimate for January will not be composited. The composite estimator will be restarted in early 1994. There will be an effect due to starting up the composite estimator, but we are unable to predict the exact effect. Because of the problems inherent in the sample rotation pattern for the Parallel Survey mentioned above, the model estimates reported in the present paper were developed based upon noncomposited Parallel Survey data.

Centralized CATI Percentage

The percentage of centralized computer-assisted telephone interviewing (CATI) was 18 percent in the Parallel Survey and 9 percent in the CPS. The redesigned CPS will have approximately 13 percent centralized CATI in January 1994, and this will increase to 18 percent sometime in 1994. For information on the implications of these differences on estimates see Kostanich and Cahoon (1994).

Seasonal Adjustment

The method used by BLS for seasonal adjustment is X-11 ARIMA, with seasonal factors reestimated every 6 months. The most recent set of factors was estimated in December 1993. For the seasonally adjusted estimates in this report, we used these most recent seasonal factors computed using data from the CPS through December 1993 based upon 1980 weighting. It was not possible to compute accurate seasonal factors from the Parallel Survey, since it usually requires at least 5 years of data to produce good monthly factors. The factors obtained from CPS data through December 1993 are the factors that will be used starting in January 1994 to adjust the redesigned CPS. BLS will monitor the seasonally adjusted estimates from the redesigned CPS to look for possible changes in seasonal patterns.

Summary of Statistical Methodology

The modeling effort reported here looked at the 12 basic series that, when aggregated, comprise the civilian labor force. These are listed in table 2.

Table 2. The 12 modeled series

1	Agricultural employment, women 16-19
2	Agricultural employment, men 16-19
3	Agricultural employment, women 20+
4	Agricultural employment, men 20+
5	Nonagricultural employment, women 16-19
6	Nonagricultural employment, men 16-19
7	Nonagricultural employment, women 20+
8	Nonagricultural employment, men 20+
9	Unemployment, women 16-19
10	Unemployment, men 16-19
11	Unemployment, women 20+
12	Unemployment, men 20+

Since the civilian noninstitutional population is known, having estimates of these 12 series makes it possible to compute estimates of those not in the labor force by subtraction. A large number of rate series then can be computed. Our approach was to produce modeled monthly unadjusted estimates for each of the 12 series and then use the standard seasonal adjustment procedure for each of the 12 series individually. Once the model estimates were computed, estimates for those not in the labor force were obtained by subtraction. The remaining series were then used to produce seasonally adjusted unemployment rates, employment-to-population ratios, and labor force participation rates.

The importance of decreasing the variability of the monthly estimates from the Parallel Survey can be seen from table 3. The first column represents the average over the 16-month period, September 1992 to December 1993, of the ratios of the variance of the monthly Parallel Survey estimates to the variance of the monthly CPS estimates. The column labeled Model gives the average, over the same 16 months, of the ratios of the variance of the monthly model estimates to the variance of the monthly CPS estimates.

Table 3. Ratio of Parallel Survey and Model variance to CPS variance

	PS	Model
Agricultural Employment		
Women 16-19	5.1	1.4
Men 16-19	5.8	1.7
Women 20+	6.4	3.8
Men 20+	3.8	2.3
Nonagricultural Employment		
Women 16-19	3.5	1.5
Men 16-19	3.7	1.3
Women 20+	5.1	2.5
Men 20+	4.4	2.2
Unemployment		
Women 16-19	4.3	1.2
Men 16-19	4.1	2.0
Women 20+	4.6	2.5
Men 20+	4.3	1.5

The average of the ratios in the first column is about 4.5, which is close to the ratio of the sample size of CPS to the Parallel Survey. In order to improve the monthly estimates of each of these 12 series, modeling was done for each series separately.

There are many different methods that could have been used to improve the monthly Parallel Survey estimates. Our approach, which may be improved upon at a later time, is described below. All of the modeling was done on non-seasonally adjusted data. Let

(1) $Y_t =$ Observed monthly CPS estimate under the old method
$y_t =$ True monthly CPS value under the old method

and let

(2) $$Y_t = y_t + e_t$$

where e_t is the CPS sampling error, and $t = 1, \ldots, T$, where $T = 16$. Also, let

(3) X_t = Observed monthly Parallel Survey estimate under the new method
x_t = True monthly Parallel Survey value under the new method

and let

$$X_t = x_t + u_t \tag{4}$$

where u_t is the Parallel Survey sampling error. We will make the assumption that

$$y_t = \beta_0 + \beta_1 x_t \tag{5}$$

which says that the true values have a linear structural relationship. Our goal is to estimate the true value x_t for each of the 16 months. The estimates of the x_t are what we refer to as the *model estimates*. The model parameters β_0 and β_1 allow the CPS observation to contribute to the monthly estimate. In effect, the model uses both the CPS and Parallel Survey estimate to give an improved monthly estimate. By using information from both the CPS and the Parallel survey, the model is able to reduce the variance of the monthly estimate as defined under the Parallel Survey. The reduction in variance can be seen in the column labeled Model in table 3. On average, over all 12 characteristics, the models produced a 57 percent decrease in the variance relative to the variance of the monthly Parallel Survey estimates. It should be noted, however, that the variance of the model is still greater than the variance of the monthly CPS estimate by about a factor of two.

In addition to estimating the model parameters and the monthly estimates x_t for each of the 16 months, we computed two test statistics. The first was a
statistic $^{2}_{G}$ χ^2_G tests the hypothesis that the model, as given in equation
χ^2_G suggest that the model is deficient,

χ^2_G measures how much unexplained variability remains in the data apart from that

The construction and properties of χ^2_G are discussed more fully in the appendix, but under the null hypothesis that the model specified in equation (5) is adequate, χ^2_G approximately distributed as a chi-square random variable on 14 degrees of freedom.

The second test statistic was a *structural relation test* statistic χ_S^2. This statistic tests the null hypothesis $H_0\!: \beta_0 = 0, \beta_1 = 1$, which implies that there is no difference between the true values as measured under CPS and the Parallel Survey. Large values of the test statistic χ_S^2

Survey are measuring different true values. There are other structural relationship tests one might also consider, but that selected seems a natural one. The construction and

χ_S^2 are discussed more fully in the appendix, but under the null hypothesis χ_S^2 is approximately distributed as a chi-square random variable on 2 degrees of freedom.

4 in terms of the two tests just discussed. Table 4 lists the actual test statistics along with

p

underlying hypotheses. For example, a small *p*

hypothesis, while a large *p*

hypothesis. Values of 0.05 and 0.10 are often used as references when judging the sizes of -values; when a *p*

to be significant at the 0.05 level of significance. Small *p*

of-fit statistics $^{2}_{G}$ indicate that the model is inadequate, i.e., that the relationship in equation (5) does not adequately explain the observed variation in the data apart from sampling variability. Small *p*-values for the structural relationship test indicate that the model cannot be further simplified to one where CPS and the Parallel Survey are estimating the same underlying true value.

Table 4. Summary of model fitting for the 12 labor force characteristics.

	Model goodness-of-fit		Structural relationship test	
	c_G^2	*p*-value	c_S^2	-value
Agricultural Employment				
	10.60	0.72		0.27
Men 16-19		0.27	2.21	
Women 20+	7.72		18.22	0.00
	23.28	0.06		0.10
Nonagricultural Employment				
	19.32	0.15		0.08
Men 16-19		0.83	1.32	
Women 20+	19.48		1.95	0.38
	12.88	0.54		0.26
Unemployment				
	8.96	0.83		0.00
Men 16-19		0.64	8.17	
Women 20+	10.31		64.99	0.00
	11.95	0.61		0.19

None of the goodness-of-fit statistics in table 4 indicate substantial model failure. On the

the underlying true values between CPS and the Parallel Survey, in particular those for the unemployed adult women, unemployed teenage women and adult women employed in

groups, except adult men, are significantly different.

Appendix 1 presents detailed graphs of the model estimates for each of the 12 series, in

data and the model estimates over time. The modeled estimates produce a smoother monthly series than the Parallel Survey, but one aspect of the model estimates needs to be

average of the Parallel Survey estimates over the same 16 months. The model estimates seem to underestimate employment in agriculture, in particular, and slightly underestimate total employment. Because total unemployment also was slightly underestimated, this did not have a noticeable effect on the reported unemployment rate estimate, but may have had a slight effect on the employment-to-population ratios and labor force participation rates presented in the next section. These last two rates may be slightly underestimated, on average. Since our main concern in this report was with producing unemployment rate estimates, estimation procedures that would have produced higher levels of employment were not investigated. Other estimation procedures may be studied in the future.

Table 5. Ratio of 16 Month Averages of Model Estimates to Parallel Survey Estimates

	Ratio of Averages
Agricultural Employment	
Women 16-19	0.794
Men 16-19	0.889
Women 20+	0.979
Men 20+	0.932
Nonagricultural Employment	
Women 16-19	0.993
Men 16-19	1.003
Women 20+	0.999
Men 20+	1.000
Unemployment	
Women 16-19	0.996
Men 16-19	1.004
Women 20+	0.999
Men 20+	0.997

In this section, we present graphs and tables portraying seasonally adjusted and unadjusted model estimates, along with estimates from the CPS. The first two graphs show total

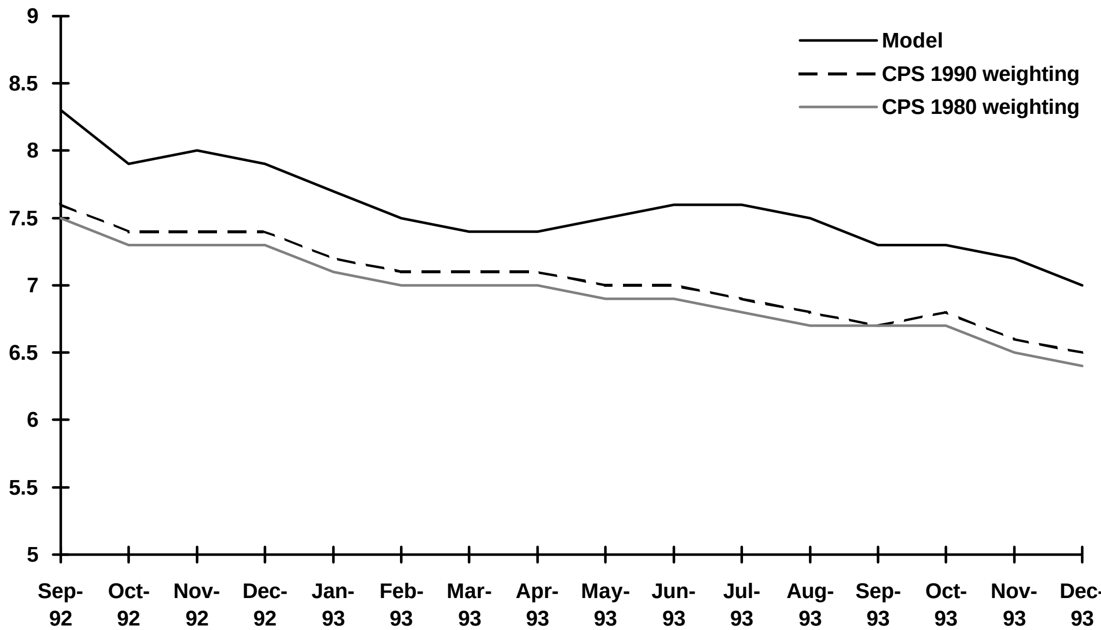
from the model and from the CPS under both *90 weighting* *80 weighting*. The next

are followed by six tables, each formatted similarly to table A-33 from the monthly *Employment and Earnings*
seasonally adjusted model estimates, and table 6, the unadjusted estimates. Table 7 gives the seasonally adjusted composited CPS estimates based upon , with compositing beginning in October 1992, and table 8 gives the unadjusted estimates. Table
80 weighted data,

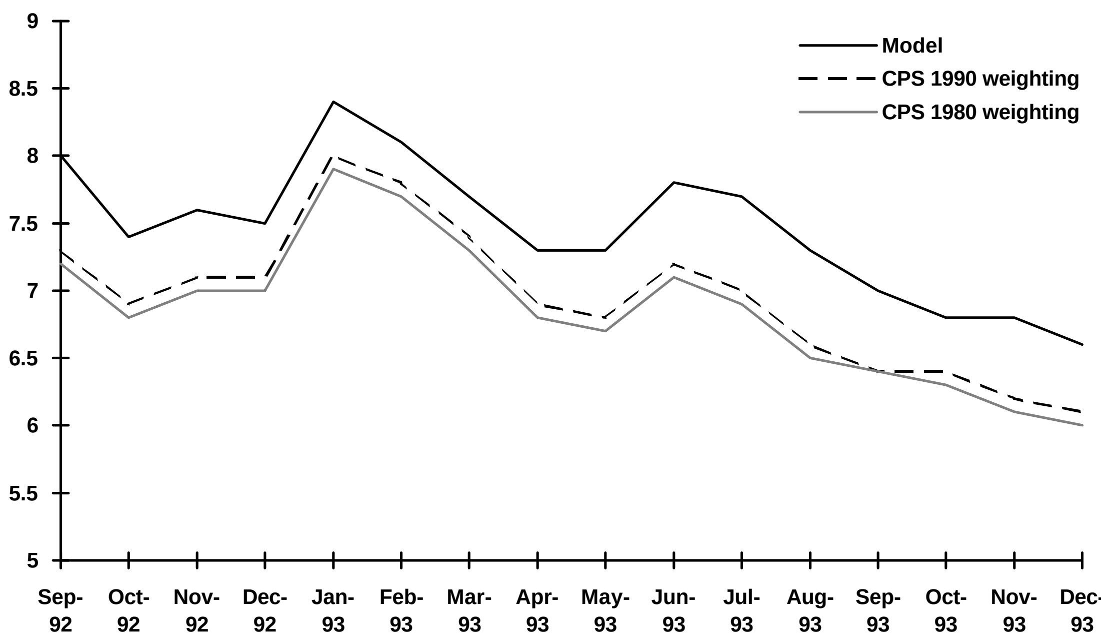
The following abbreviations are used in all of the tables:

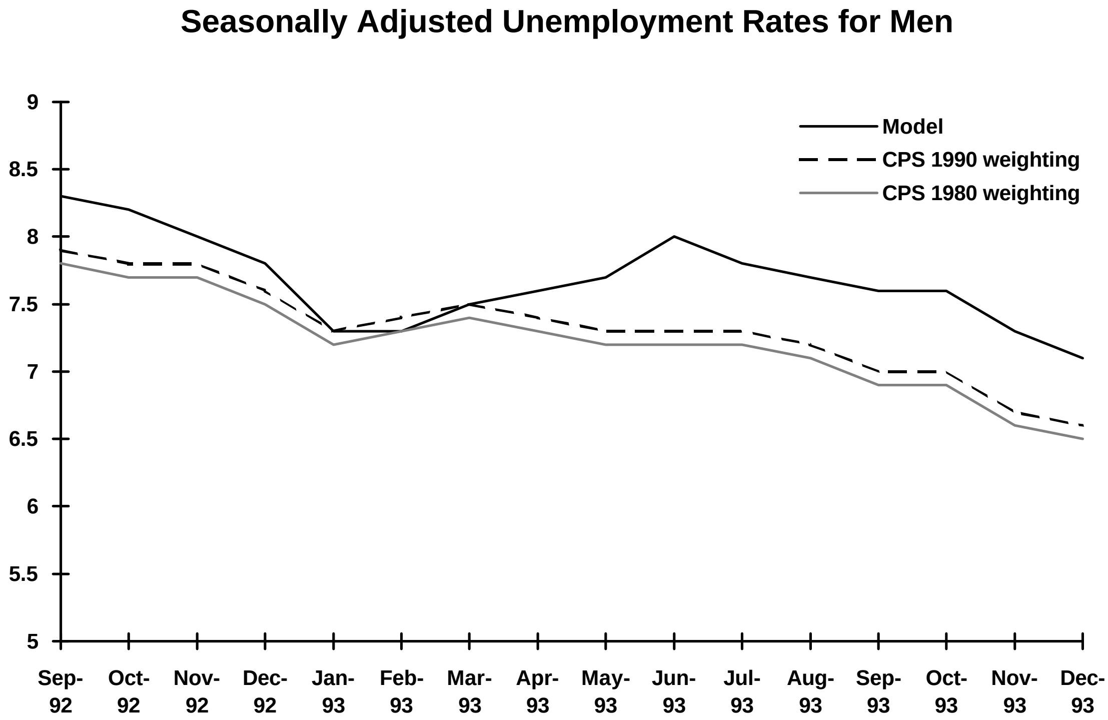
LFPR	
EPR	Employment to population ratio
	Unemployment rate

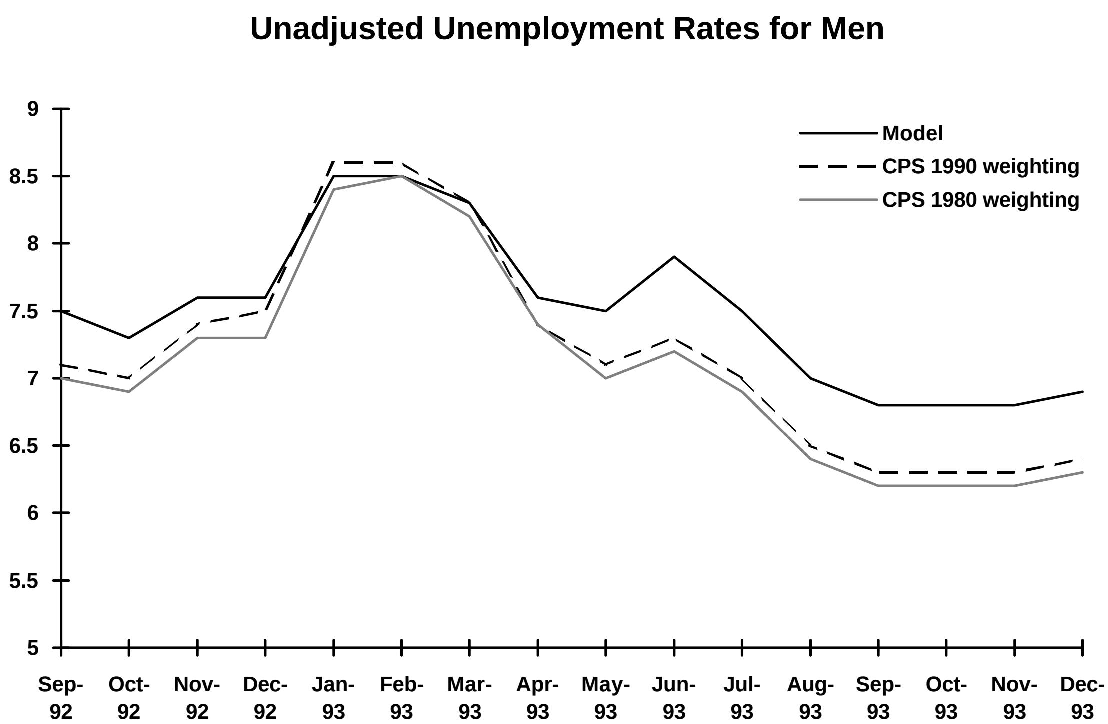
Seasonally Adjusted Unemployment Rates



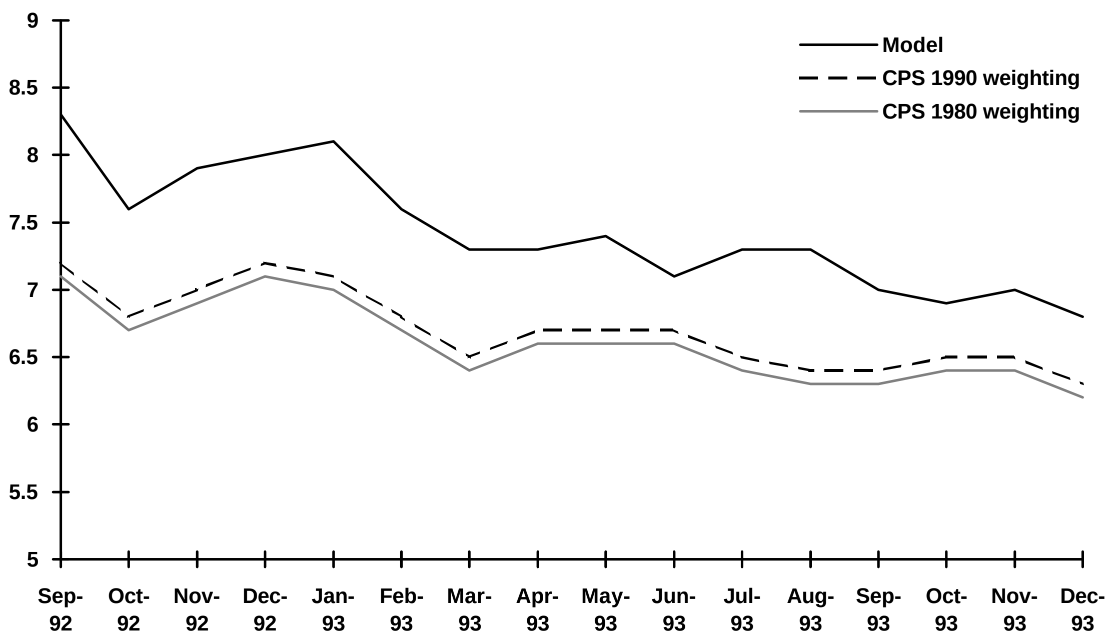
Unadjusted Unemployment Rates




Seasonally Adjusted Unemployment Rates for Men
9
8.5
8
7.5
7
6.5
6
5.5
5
Model
CPS 1990 weighting
CPS 1980 weighting
Sep-92
Oct-92
Nov-92
Dec-92
Jan-93
Feb-93
Mar-93
Apr-93
May-93
Jun-93
Jul-93
Aug-93
Sep-93
Oct-93
Nov-93
Dec-93


Unadjusted Unemployment Rates for Men
9
8.5
8
7.5
7
6.5
6
5.5
5
Model
CPS 1990 weighting
CPS 1980 weighting
Sep-92
Oct-92
Nov-92
Dec-92
Jan-93
Feb-93
Mar-93
Apr-93
May-93
Jun-93
Jul-93
Aug-93
Sep-93
Oct-93
Nov-93
Dec-93

Seasonally Adjusted Unemployment Rates for Women



Unadjusted Unemployment Rates for Women

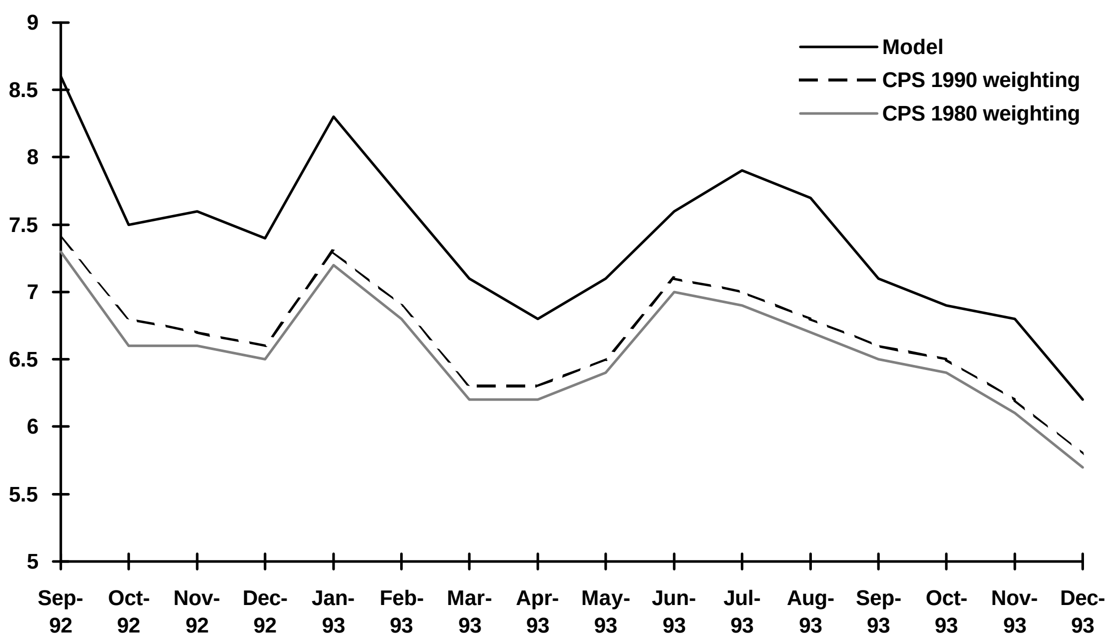


Table 5. Seasonally Adjusted Model Estimates (Based on *90 weighting*)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	67.2	66.7	66.8	66.7	66.7	66.6	66.5	66.5	66.7	66.8	66.8	66.8	66.5	66.7	66.7	66.5
EPR	61.6	61.4	61.5	61.4	61.6	61.6	61.6	61.6	61.7	61.7	61.7	61.8	61.7	61.8	61.9	61.9
UER	8.3	7.9	8.0	7.9	7.7	7.5	7.4	7.4	7.5	7.6	7.6	7.5	7.3	7.3	7.2	7.0
Men 16+																
LFPR	75.7	75.4	75.2	75.0	74.7	74.8	74.9	74.9	75.1	75.1	75.0	75.0	74.8	75.0	74.9	74.9
EPR	69.4	69.2	69.2	69.2	69.3	69.3	69.3	69.2	69.4	69.2	69.2	69.2	69.2	69.3	69.5	69.5
UER	8.3	8.2	8.0	7.8	7.3	7.3	7.5	7.6	7.7	8.0	7.8	7.7	7.6	7.6	7.3	7.1
Men 20+																
LFPR	77.3	77.2	77.0	76.7	76.3	76.3	76.4	76.5	76.7	76.7	76.7	76.8	76.7	76.9	76.7	76.6
EPR	71.5	71.4	71.3	71.3	71.4	71.3	71.3	71.3	71.4	71.4	71.4	71.5	71.3	71.5	71.7	71.7
UER	7.5	7.5	7.3	7.1	6.5	6.5	6.7	6.8	6.9	6.9	6.9	6.9	6.9	6.9	6.6	6.4
Women 16+																
LFPR	59.4	58.7	59.0	59.0	59.3	59.0	58.8	58.9	58.9	59.0	59.2	59.3	58.8	58.9	59.0	58.9
EPR	54.5	54.3	54.4	54.3	54.5	54.5	54.5	54.6	54.6	54.8	54.9	54.9	54.7	54.9	54.9	54.9
UER	8.3	7.6	7.9	8.0	8.1	7.6	7.3	7.3	7.4	7.1	7.3	7.3	7.0	6.9	7.0	6.8
Women 20+																
LFPR	59.9	59.3	59.4	59.5	59.8	59.5	59.3	59.3	59.3	59.5	59.6	59.7	59.2	59.3	59.4	59.3
EPR	55.4	55.2	55.3	55.2	55.4	55.4	55.5	55.5	55.5	55.6	55.6	55.8	55.6	55.6	55.7	55.7
UER	7.6	6.9	7.0	7.2	7.3	6.8	6.4	6.4	6.5	6.4	6.7	6.5	6.2	6.1	6.2	5.9
Teens 16-19																
LFPR	54.7	52.7	53.5	53.8	54.3	54.4	54.1	53.9	54.2	54.8	54.3	53.7	53.0	53.6	53.6	53.4
EPR	42.8	42.4	42.5	42.9	43.1	43.1	42.6	42.6	42.9	42.6	43.3	43.0	43.0	43.2	43.3	43.0
UER	21.6	19.6	20.6	20.3	20.7	20.8	21.1	21.0	20.8	22.1	20.2	19.9	18.9	19.4	19.3	19.4

Table 6. Unadjusted Model Estimates (Based on *90 weighting*)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	67.1	66.6	66.6	66.4	66.1	66.1	66.1	66.0	66.6	67.7	67.9	67.4	66.4	66.6	66.6	66.3
EPR	61.7	61.7	61.6	61.4	60.5	60.7	61.0	61.2	61.7	62.4	62.7	62.5	61.7	62.0	62.0	61.9
UER	8.0	7.4	7.6	7.5	8.4	8.1	7.7	7.3	7.3	7.8	7.7	7.3	7.0	6.8	6.8	6.6
Men 16+																
LFPR	75.5	75.1	74.8	74.5	74.0	74.2	74.4	74.3	75.0	76.4	76.6	75.9	74.7	74.8	74.6	74.4
EPR	69.8	69.6	69.1	68.8	67.7	67.9	68.2	68.6	69.4	70.3	70.8	70.6	69.6	69.7	69.5	69.2
UER	7.5	7.3	7.6	7.6	8.5	8.5	8.3	7.6	7.5	7.9	7.5	7.0	6.8	6.8	6.8	6.9
Men 20+																
LFPR	77.3	77.0	76.7	76.5	76.0	76.1	76.2	76.2	76.7	77.2	77.3	77.1	76.7	76.8	76.5	76.4
EPR	72.1	71.9	71.4	71.1	70.1	70.2	70.5	70.9	71.6	72.2	72.2	72.2	71.9	72.0	71.8	71.5
UER	6.7	6.7	6.9	7.0	7.8	7.7	7.5	6.9	6.7	6.6	6.5	6.3	6.2	6.2	6.2	6.3
Women 16+																
LFPR	59.3	58.9	59.1	59.0	58.8	58.7	58.5	58.4	58.8	59.7	60.0	59.6	58.7	59.1	59.2	58.9
EPR	54.2	54.5	54.7	54.6	53.9	54.1	54.3	54.4	54.6	55.2	55.3	55.0	54.5	55.0	55.2	55.2
UER	8.6	7.5	7.6	7.4	8.3	7.7	7.1	6.8	7.1	7.6	7.9	7.7	7.1	6.9	6.8	6.2
Women 20+																
LFPR	60.0	59.6	59.7	59.6	59.6	59.3	59.2	59.1	59.3	59.6	59.6	59.5	59.3	59.5	59.7	59.4
EPR	55.3	55.5	55.7	55.6	55.1	55.2	55.5	55.5	55.7	55.7	55.3	55.3	55.5	55.9	56.1	56.1
UER	7.8	6.8	6.7	6.7	7.6	6.9	6.2	6.0	6.2	6.6	7.1	7.1	6.4	6.0	6.0	5.6
Teens 16-19																
LFPR	52.2	50.6	51.3	50.8	49.2	50.0	49.8	49.5	52.4	63.1	67.1	60.9	50.7	51.5	51.5	50.5
EPR	40.9	40.7	40.7	41.3	38.5	39.0	38.7	39.3	41.1	47.5	54.0	50.7	41.2	41.5	41.6	41.6
UER	21.7	19.5	20.6	18.8	21.7	22.1	22.3	20.6	21.7	24.6	19.5	16.7	18.8	19.3	19.2	17.7

Table 7. Seasonally Adjusted CPS *90 weighted* Estimates (Composited beginning with October 1992)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	66.5	66.2	66.4	66.3	66.2	66.2	66.2	66.2	66.4	66.4	66.4	66.4	66.2	66.4	66.4	66.4
EPR	61.5	61.4	61.4	61.4	61.4	61.5	61.5	61.5	61.7	61.7	61.8	61.9	61.7	61.9	62.0	62.1
UER	7.6	7.4	7.4	7.4	7.2	7.1	7.1	7.1	7.0	7.0	6.9	6.8	6.7	6.8	6.6	6.5
Men 16+																
LFPR	76.0	75.7	75.7	75.6	75.4	75.5	75.5	75.5	75.6	75.6	75.6	75.6	75.2	75.4	75.2	75.2
EPR	70.0	69.8	69.8	69.8	69.8	69.9	69.9	69.9	70.1	70.0	70.1	70.2	69.9	70.1	70.2	70.2
UER	7.9	7.8	7.8	7.6	7.3	7.4	7.5	7.4	7.3	7.3	7.3	7.2	7.0	7.0	6.7	6.6
Men 20+																
LFPR	77.7	77.6	77.5	77.4	77.2	77.2	77.3	77.2	77.4	77.3	77.4	77.4	77.1	77.3	77.1	77.1
EPR	72.3	72.0	72.1	72.1	72.1	72.1	72.0	72.2	72.3	72.3	72.3	72.4	72.2	72.4	72.5	72.5
UER	7.0	7.1	7.0	6.9	6.6	6.6	6.8	6.6	6.5	6.5	6.5	6.4	6.3	6.3	5.9	5.9
Women 16+																
LFPR	57.8	57.5	57.8	57.8	57.7	57.7	57.6	57.6	57.9	57.9	57.9	57.9	57.9	58.1	58.2	58.3
EPR	53.6	53.6	53.7	53.7	53.6	53.8	53.8	53.8	54.0	54.1	54.1	54.2	54.2	54.3	54.4	54.6
UER	7.2	6.8	7.0	7.2	7.1	6.8	6.5	6.7	6.7	6.7	6.5	6.4	6.4	6.5	6.5	6.3
Women 20+																
LFPR	58.4	58.2	58.4	58.5	58.3	58.3	58.2	58.3	58.4	58.5	58.4	58.5	58.5	58.7	58.8	58.9
EPR	54.6	54.6	54.8	54.7	54.6	54.7	54.9	54.7	55.0	55.0	55.0	55.2	55.1	55.2	55.4	55.5
UER	6.5	6.2	6.3	6.5	6.4	6.1	5.8	6.1	6.0	6.0	5.9	5.8	5.8	5.9	5.8	5.7
Teens 16-19																
LFPR	52.3	50.4	51.3	51.6	51.2	51.8	51.4	51.5	52.3	51.7	52.2	51.8	51.1	51.0	51.1	50.8
EPR	41.4	41.1	40.9	41.5	41.1	41.6	41.3	41.1	41.9	41.6	42.6	42.4	41.9	41.4	41.8	41.8
UER	21.0	18.4	20.4	19.5	19.7	19.7	19.6	20.3	19.9	19.6	18.4	18.3	17.9	18.8	18.3	17.7

Table 8. Unadjusted CPS *90 weighted* Estimates (Composited beginning with October 1992)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	66.4	66.2	66.2	66.1	65.6	65.8	65.8	65.6	66.3	67.3	67.5	67.0	66.1	66.4	66.3	66.2
EPR	61.6	61.6	61.5	61.4	60.3	60.6	60.9	61.1	61.7	62.4	62.8	62.6	61.8	62.1	62.1	62.1
UER	7.3	6.9	7.1	7.1	8.0	7.8	7.4	6.9	6.8	7.2	7.0	6.6	6.4	6.4	6.2	6.1
Men 16+																
LFPR	75.9	75.4	75.3	75.1	74.6	74.9	75.1	74.8	75.5	76.8	77.2	76.5	75.1	75.2	74.9	74.7
EPR	70.5	70.2	69.8	69.5	68.2	68.4	68.8	69.3	70.1	71.2	71.8	71.6	70.4	70.4	70.2	69.9
UER	7.1	7.0	7.4	7.5	8.6	8.6	8.3	7.4	7.1	7.3	7.0	6.5	6.3	6.3	6.3	6.4
Men 20+																
LFPR	77.8	77.5	77.3	77.1	76.8	77.0	77.1	76.9	77.4	77.9	78.0	77.7	77.1	77.3	76.9	76.8
EPR	72.9	72.6	72.2	71.9	70.8	71.0	71.3	71.8	72.5	73.1	73.2	73.2	72.8	73.0	72.7	72.4
UER	6.3	6.4	6.6	6.8	7.9	7.9	7.6	6.7	6.3	6.2	6.1	5.9	5.6	5.6	5.6	5.8
Women 16+																
LFPR	57.7	57.7	57.9	57.8	57.3	57.4	57.3	57.2	57.8	58.5	58.6	58.2	57.7	58.2	58.4	58.3
EPR	53.4	53.8	54.0	54.0	53.1	53.4	53.7	53.6	54.0	54.4	54.5	54.3	53.9	54.4	54.7	54.9
UER	7.4	6.8	6.7	6.6	7.3	6.9	6.3	6.3	6.5	7.1	7.0	6.8	6.6	6.5	6.2	5.8
Women 20+																
LFPR	58.5	58.5	58.7	58.6	58.2	58.2	58.2	58.1	58.4	58.7	58.3	58.4	58.5	58.9	59.1	59.1
EPR	54.5	55.0	55.2	55.0	54.3	54.5	54.9	54.8	55.1	55.1	54.7	54.7	55.0	55.5	55.8	55.9
UER	6.7	6.1	6.0	6.1	6.6	6.2	5.7	5.7	5.7	6.1	6.3	6.3	6.0	5.8	5.6	5.3
Teens 16-19																
LFPR	49.9	48.3	49.1	48.6	46.2	47.5	47.1	47.0	50.5	60.2	65.1	59.1	48.8	49.0	49.1	48.0
EPR	39.4	39.4	39.1	39.9	36.6	37.5	37.4	37.8	40.1	46.6	53.3	50.2	40.1	39.8	40.2	40.4
UER	20.9	18.3	20.5	17.9	20.7	21.0	20.6	19.7	20.8	22.6	18.1	15.1	17.7	18.7	18.2	15.8

Table 9. Seasonally Adjusted CPS *80 weighted* Estimates (Composited beginning with October 1992)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	66.4	66.1	66.2	66.2	66.0	66.1	66.0	66.1	66.2	66.2	66.2	66.2	66.0	66.2	66.2	66.3
EPR	61.4	61.3	61.4	61.4	61.3	61.4	61.4	61.4	61.6	61.6	61.7	61.7	61.6	61.8	61.9	62.0
UER	7.5	7.3	7.3	7.3	7.1	7.0	7.0	7.0	6.9	6.9	6.8	6.7	6.7	6.7	6.5	6.4
Men 16+																
LFPR	75.8	75.4	75.5	75.3	75.1	75.3	75.3	75.3	75.4	75.3	75.3	75.3	74.9	75.1	75.0	75.0
EPR	69.9	69.6	69.7	69.7	69.7	69.8	69.7	69.7	69.9	69.8	69.9	70.0	69.7	69.9	70.0	70.1
UER	7.8	7.7	7.7	7.5	7.2	7.3	7.4	7.3	7.2	7.2	7.2	7.1	6.9	6.9	6.6	6.5
Men 20+																
LFPR	77.4	77.2	77.2	77.0	76.8	76.9	76.9	76.9	77.0	77.0	77.0	77.0	76.7	77.0	76.8	76.8
EPR	72.0	71.8	71.8	71.8	71.9	71.8	71.8	71.9	72.1	72.0	72.0	72.1	71.9	72.2	72.3	72.3
UER	7.0	7.1	6.9	6.8	6.5	6.6	6.7	6.5	6.5	6.5	6.5	6.4	6.3	6.2	5.9	5.8
Women 16+																
LFPR	57.8	57.5	57.7	57.8	57.7	57.7	57.6	57.6	57.9	57.8	57.8	57.9	57.9	58.1	58.2	58.3
EPR	53.7	53.6	53.7	53.7	53.7	53.8	53.9	53.8	54.0	54.1	54.1	54.2	54.2	54.3	54.5	54.7
UER	7.1	6.7	6.9	7.1	7.0	6.7	6.4	6.6	6.6	6.6	6.4	6.3	6.3	6.4	6.4	6.2
Women 20+																
LFPR	58.3	58.2	58.3	58.4	58.3	58.2	58.2	58.2	58.3	58.4	58.3	58.5	58.4	58.6	58.7	58.9
EPR	54.6	54.6	54.7	54.6	54.6	54.7	54.8	54.7	54.9	55.0	55.0	55.1	55.0	55.2	55.4	55.5
UER	6.4	6.1	6.2	6.4	6.3	6.0	5.7	6.0	5.9	5.9	5.8	5.7	5.8	5.8	5.7	5.7
Teens 16-19																
LFPR	52.5	50.5	51.4	51.7	51.4	52.0	51.5	51.7	52.4	51.5	51.8	51.6	51.2	51.1	51.2	50.9
EPR	41.5	41.2	41.0	41.6	41.3	41.8	41.5	41.2	42.1	41.5	42.2	42.1	42.0	41.4	41.8	41.9
UER	20.9	18.4	20.3	19.5	19.6	19.6	19.5	20.3	19.8	19.5	18.4	18.4	17.9	18.9	18.3	17.8

Table 10. Unadjusted CPS *80 weighted* (Composited beginning with October 1992)

	SEP92	OCT92	NOV92	DEC92	JAN93	FEB93	MAR93	APR93	MAY93	JUN93	JUL93	AUG93	SEP93	OCT93	NOV93	DEC93
Total																
LFPR	66.2	66.0	66.1	65.9	65.4	65.6	65.7	65.5	66.1	67.1	67.3	66.8	65.9	66.2	66.1	66.0
EPR	61.5	61.6	61.5	61.3	60.3	60.6	60.8	61.0	61.7	62.3	62.7	62.4	61.7	62.0	62.1	62.0
UER	7.2	6.8	7.0	7.0	7.9	7.7	7.3	6.8	6.7	7.1	6.9	6.5	6.4	6.3	6.1	6.0
Men 16+																
LFPR	75.6	75.2	75.1	74.8	74.4	74.7	74.8	74.6	75.2	76.5	76.9	76.3	74.8	74.9	74.6	74.4
EPR	70.3	70.0	69.6	69.3	68.1	68.3	68.7	69.1	70.0	71.0	71.6	71.3	70.2	70.3	70.0	69.7
UER	7.0	6.9	7.3	7.3	8.5	8.5	8.2	7.4	7.0	7.2	6.9	6.4	6.2	6.2	6.2	6.3
Men 20+																
LFPR	77.4	77.1	76.9	76.7	76.5	76.7	76.8	76.6	77.1	77.6	77.6	77.4	76.8	77.0	76.6	76.5
EPR	72.6	72.3	71.9	71.6	70.5	70.7	71.0	71.5	72.3	72.8	72.9	72.9	72.5	72.7	72.4	72.1
UER	6.2	6.3	6.5	6.7	7.8	7.8	7.5	6.6	6.2	6.2	6.1	5.8	5.6	5.6	5.5	5.8
Women 16+																
LFPR	57.6	57.6	57.9	57.8	57.2	57.3	57.3	57.2	57.8	58.5	58.5	58.1	57.7	58.2	58.3	58.3
EPR	53.4	53.8	54.0	54.0	53.1	53.4	53.7	53.6	54.1	54.4	54.5	54.3	54.0	54.5	54.8	55.0
UER	7.3	6.6	6.6	6.5	7.2	6.8	6.2	6.2	6.4	7.0	6.9	6.7	6.5	6.4	6.1	5.7
Women 20+																
LFPR	58.4	58.5	58.6	58.5	58.1	58.1	58.1	58.0	58.3	58.6	58.2	58.3	58.4	58.9	59.0	59.0
EPR	54.5	54.9	55.2	55.0	54.3	54.5	54.9	54.7	55.1	55.0	54.6	54.7	55.0	55.5	55.8	55.9
UER	6.6	6.0	5.9	6.0	6.6	6.2	5.6	5.6	5.6	6.0	6.2	6.2	5.9	5.7	5.5	5.3
Teens 16-19																
LFPR	49.9	48.3	49.1	48.6	46.2	47.4	47.1	47.1	50.6	60.3	65.3	59.2	48.7	48.9	49.1	48.0
EPR	39.5	39.5	39.1	40.0	36.7	37.5	37.4	37.8	40.1	46.7	53.5	50.2	40.1	39.8	40.2	40.4
UER	20.9	18.2	20.4	17.8	20.6	20.9	20.5	19.7	20.7	22.5	18.1	15.1	17.7	18.7	18.1	15.7

Appendix 1 Modeled Series Graphs

The following 6 pages present further modeling results. Each page contains four plots. The two plots on the left are for teenagers, and the two plots on the right are for adults. In both cases, the top plot is a scatter plot of the monthly data for both the Parallel Survey and CPS for the particular characteristic being represented. The gray line is a 45 degree reference line, and the solid black line is the estimated structural relationship as represented in equation (5). The bottom graph is a set of time series for the 16 months from September 1992 to December 1993. The solid black line is the CPS, the dashed line is the Parallel Survey, and the gray line is the model. Dots represent monthly estimates in all these series. The upper and lower gray lines (without dots) are the upper and lower bounds of an approximate 90% prediction confidence bound around the monthly model estimates. The prediction intervals form a range where we would have expected the *observed CPS* to have fallen (approximately 90% of the time) had the new methodology and weighting been used during that period. The prediction intervals account for the variance in estimating the true monthly values, as well as the variance in the monthly CPS sampling error. This is discussed more fully in Appendix 2. In all cases, the data are reported in thousands.

Figure 1. Agricultural Employment, Women.

Figure 2. Agricultural Employment, Men.

Figure 3. Non Agricultural Employment, Women.

Figure 4. Non Agricultural Employment, Men.

Figure 5. Unemployment, Women.

Figure 6. Unemployment, Men.

Appendix 2 Details of Statistical Methods

As described earlier, we modeled each of the twelve labor force series separately. We will describe the common procedure used for each below.

(A1) $Y_t =$ Observed monthly CPS estimate under the old method
$y_t =$ True monthly CPS value under the old method

and let

(A2) $$Y_t = y_t + e_t$$

where e_t is the CPS sampling error, and $t = 1, \ldots, T$, where $T = 16$. Also, let

(A3) $X_t =$ Observed monthly Parallel Survey estimate under the new method
$x_t =$ True monthly Parallel Survey value under the new method

and let

(A4) $$X_t = x_t + u_t$$

where u_t is the Parallel Survey sampling error. We will make the assumption that

(A5) $$y_t = \beta_0 + \beta_1 x_t$$

which says that the true values are linearly structurally related. If we write

(A6) $$\mathbf{e}' = (e_1, \ldots, e_{16})$$
$$\mathbf{u}' = (u_1, \ldots, u_{16})$$

then we can write our next assumption as

(A7) $$\begin{pmatrix} \mathbf{e} \\ \mathbf{u} \end{pmatrix} \sim N\left(\begin{pmatrix} \mathbf{0} \\ \mathbf{0} \end{pmatrix}, \begin{pmatrix} \Sigma_{\mathbf{ee}} & \mathbf{0} \\ \mathbf{0} & \Sigma_{\mathbf{uu}} \end{pmatrix} \right).$$

We have estimates of both $\mathbf{\Sigma_{ee}}$ and $\mathbf{\Sigma_{uu}}$, which we will consider as known and fixed for the purposes of estimation. The estimate of $\mathbf{\Sigma_{ee}}$ was based upon generalized variance function estimates and correlations obtained from previous research on the CPS. The estimate of $\mathbf{\Sigma_{uu}}$ was computed directly by replication using Robert Fay's program VPLX.

We treated the unknown parameters of the problem as

(A8) $$\theta = \left(\beta_0, \beta_1, x_1, \ldots, x_{16}\right)'$$

where we treated the x_t

θ by weighted nonlinear least squares. Second, use those estimates in a one-step Gauss Newton estimation to get the final estimates, as well as estimates of variance. We next describe the actual estimation of the model parameters and estimated true values in more detail.

STEP 1 Initial estimates.

Let $\mathbf{Z}_t = \left(Y_t, X_t\right)'$ and $\boldsymbol{\varepsilon}_t = \left(e_t, u_t\right)'$ for $t = 1, \ldots, 16$. Also let

(A9) $$\mathbf{\Sigma}_{\varepsilon\varepsilon tt} \equiv \mathbf{V}\left\{\boldsymbol{\varepsilon}_t\right\} = \begin{pmatrix} \sigma_{eett} & 0 \\ 0 & \sigma_{uutt} \end{pmatrix}$$

Let

(A10) $$\mathbf{m_{ZZ}} = 15^{-1}\sum_{t=1}^{16}\left(\mathbf{Z}_t - \overline{\mathbf{Z}}\right)'\left(\mathbf{Z}_t - \overline{\mathbf{Z}}\right)$$

$$\mathbf{\Sigma}_{\varepsilon\varepsilon\bullet\bullet} = 16^{-1}\sum_{t=1}^{16}\mathbf{\Sigma}_{\varepsilon\varepsilon tt} = \begin{pmatrix} \sigma_{ee\bullet} & 0 \\ 0 & \sigma_{uu\bullet\bullet} \end{pmatrix}$$

where $\overline{\mathbf{Z}} = 16^{-1}\sum_{t=1}^{16}\mathbf{Z}_t$. We estimated the parameters β_0 and β_1 by methods described in Fuller (1987). Let $\hat{\lambda}$ be the smallest root of the determinental equation

(A11) $$\left|\mathbf{m_{ZZ}} - \lambda\,\mathbf{\Sigma}_{\varepsilon\varepsilon\bullet\bullet}\right| = 0$$

and let $\hat{\alpha} = (\hat{\alpha}_1, \hat{\alpha}_2)'$ be the generalized eigenvector associated with $\hat{\lambda}$ which satisfies

(A12) $$(\mathbf{m}_{ZZ} - \hat{\lambda}\,\Sigma_{\varepsilon\varepsilon\cdot\cdot})\hat{\alpha} = \mathbf{0}.$$

Define

(A13) $$\hat{\beta}_1 = -\hat{\alpha}_2 \hat{\alpha}_1^{-1}$$

$$\hat{\beta}_0 = \bar{Y} - \bar{X}\hat{\beta}_1$$

$$\hat{x}_t = (\sigma_{eett} + \hat{\beta}_1^2 \sigma_{uutt})^{-1}\left[\sigma_{uutt}\hat{\beta}_1 (Y_t - \hat{\beta}_0) + \sigma_{eett} X_t\right] \text{ for } t = 1, \ldots, 16.$$

Call the initial estimates

(A14) $$\hat{\theta}^{(1)} = (\hat{\beta}_0, \hat{\beta}_1, \hat{x}_1, \ldots, \hat{x}_{16})'.$$

STEP 2 Weighted Nonlinear Estimation.

Define the function

(A15) $$G(\theta) = \sum_{t=1}^{16}\left[\sigma_{eett}^{-1}(Y_t - \beta_0 - \beta_1 x_t)^2 + \sigma_{uutt}^{-1}(X_t - x_t)^2\right].$$

Let $\hat{\theta}^{(2)}$ be the solution to the minimization of $G(\theta)$, obtained by using $\hat{\theta}^{(1)}$ as an initial estimates. There is an alternative formulation of this step. Define

(A16) $$H(\beta) = \sum_{t=1}^{16}(\sigma_{eett} + \beta_1^2 \sigma_{uutt})^{-1}(Y_t - \beta_0 - \beta_1 X_t)^2,$$

and let $\tilde{\beta}$ be the minimizer of $H(\beta)$, and let

(A17) $$\tilde{x}_t = (\sigma_{eett} + \tilde{\beta}_1^2 \sigma_{uutt})^{-1}\left[\sigma_{uutt}\tilde{\beta}_1 (Y_t - \tilde{\beta}_0) + \sigma_{eett} X_t\right] \text{ for } t = 1, \ldots, 16.$$

Then, $\hat{\theta}^{(2)}$ is equal to $\left(\tilde{b}_0, \tilde{b}_1, \tilde{x}_1, \ldots, \tilde{x}_{16}\right)'$. It turns out, in general, that if $\boldsymbol{\Sigma}_{\varepsilon\varepsilon tt}$ is constant over t, then the estimates in Step 1 and Step 2 give the same result.

STEP 3 One-Step Gauss Newton Estimation

Define

(A18) $$\mathbf{Z} = \begin{bmatrix} \mathbf{Y} \\ \mathbf{X} \end{bmatrix}$$

$$\mathbf{Y} = \left(Y_1, \ldots, Y_{16}\right)'$$

$$\mathbf{X} = \left(X_1, \ldots, X_{16}\right)'$$

$$\mathbf{f}(\boldsymbol{\theta}) = \begin{bmatrix} \mathbf{1}b_0 + \mathbf{x}b_1 \\ \mathbf{x} \end{bmatrix}$$

$$\mathbf{F}(\boldsymbol{\theta}) = \frac{\partial \mathbf{f}(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}}$$

and let

(A19) $$\mathbf{w} = \mathbf{Z} - \mathbf{f}\left(\hat{\boldsymbol{\theta}}^{(2)}\right)$$

$$\mathbf{V} = \begin{bmatrix} \boldsymbol{\Sigma}_{\mathbf{ee}} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{\Sigma}_{\mathbf{uu}} \end{bmatrix}$$

$$\tilde{\delta} = \left[\mathbf{F}'\left(\hat{\boldsymbol{\theta}}^{(2)}\right)\mathbf{V}^{-1}\mathbf{F}\left(\hat{\boldsymbol{\theta}}^{(2)}\right)\right]^{-1}\mathbf{F}'\left(\hat{\boldsymbol{\theta}}^{(2)}\right)\mathbf{V}^{-1}\mathbf{w}$$

$$\hat{\boldsymbol{\theta}}^{(3)} = \hat{\boldsymbol{\theta}}^{(2)} + \tilde{\delta}$$

where $\hat{\boldsymbol{\theta}}^{(3)}$ is the final estimate. The approximate distribution of $\hat{\boldsymbol{\theta}}^{(3)}$ is given by

(A20) $\qquad \hat{\boldsymbol{\theta}}^{(3)} \sim N\left(\boldsymbol{\theta}, \left[\mathbf{F}'(\boldsymbol{\theta})\boldsymbol{\Sigma}^{-1}\mathbf{F}(\boldsymbol{\theta})\right]^{-1}\right)$

and we estimated the variance of $\hat{\boldsymbol{\theta}}^{(3)}$ by

(A21) $\qquad \hat{\mathbf{V}}\left(\hat{\boldsymbol{\theta}}^{(3)}\right) = \left[\mathbf{F}'\left(\hat{\boldsymbol{\theta}}^{(3)}\right)\hat{\boldsymbol{\Sigma}}^{-1}\mathbf{F}\left(\hat{\boldsymbol{\theta}}^{(3)}\right)\right]^{-1}.$

When we speak of the approximate distribution, we refer to an approximation as variances of the survey errors get small. This definition of asymptotics implies that the estimators obtained in each of the first two steps are consistent estimators of $\boldsymbol{\theta}$, and that the final estimator in Step 3 is efficient in the sense that they have the same limiting distribution as the maximum likelihood estimator of $\boldsymbol{\theta}$.

From now on, we drop the superscript and refer to the final estimates as $\hat{\boldsymbol{\theta}}$, as well as the components of $\hat{\boldsymbol{\theta}}$. Note that the resulting estimates $\hat{\mathbf{x}} = (\hat{x}_1, \ldots, \hat{x}_{16})'$ are the estimates of the true (but unobservable) value under the *New CPS* definition, and $\hat{V}(\hat{\mathbf{x}})$ is an estimate of the covariance matrix of the estimates, where $\hat{V}(\hat{\mathbf{x}})$ is to lower 16×16 sub matrix of $\hat{\mathbf{V}}(\hat{\boldsymbol{\theta}}^{(3)})$ given above. The estimates $\hat{\mathbf{x}} = (\hat{x}_1, \ldots, \hat{x}_{16})'$ can also be thought of as a predictor of what the observed CPS might have been under the *New CPS* definition, and we can use

(A22) $\qquad \hat{V}(\hat{\mathbf{x}}) + \boldsymbol{\Sigma}_{\mathbf{ee}}$

as an estimator of the covariance matrix of the prediction errors, where we used the covariance matrix $\boldsymbol{\Sigma}_{\mathbf{ee}}$, the covariance matrix of the CPS sampling errors, in (A7). These prediction error variances were used to construct the prediction confidence intervals in Figures 1-6.

In addition, we computed the goodness-of-fit statistic

(A23) $\qquad \chi^2_G = \left[\mathbf{z} - \mathbf{f}(\hat{\boldsymbol{\theta}})\right]'\hat{\boldsymbol{\Sigma}}^{-1}\left[\mathbf{z} - \mathbf{f}(\hat{\boldsymbol{\theta}})\right]$

which is approximately distributed as a chi-square random variable with 14 degrees-of-freedom

In addition, we computed a structural relationship test, which tested the hypothesis $H_0: \beta_0 = 0, \beta_1 = 1$, which says that there is no difference in the true values as defined under the Parallel Survey and CPS. The test statistic used is

$$\text{(A24)} \qquad \chi_S^2 = \left(\hat{\boldsymbol{\beta}} - \mathbf{b}\right)' \left[\hat{\mathbf{V}}\left(\hat{\boldsymbol{\beta}}\right)\right]^{-1} \left(\hat{\boldsymbol{\beta}} - \mathbf{b}\right)$$

which is approximately distributed as a chi-squared random variable with 2 degrees-of-freedom under the null hypothesis, where $\hat{\mathbf{V}}\left(\hat{\boldsymbol{\beta}}\right)$ is the upper 2×2 sub matrix of $\hat{\mathbf{V}}\left[\hat{\boldsymbol{\theta}}\right]$ given above, and $\mathbf{b} = \left(0, 1\right)'$.

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