The Three-Day Week of 1974 and Measurement Error in the FES and NCDS Data Sets

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ABSTRACT

In the first three months of 1974, a drastic energy policy on the part of the British government limited the workweek to three days. Workers responding to income surveys during this period may report a “three-day week” wage rather than their usual weekly (five-day) income. The National Child Development Study (NCDS) and the Family Expenditure Survey (FES) questionnaires do not make clear which figure the respondents should have given. This study uses responses during and after the three-day week policy period to determine the magnitude of the measurement error in these two national surveys. It appears that very few respondents gave an “incorrect” three-day figure. In the FES, the estimated fraction of misreports is no larger than 3.2%; in the NCDS, the best estimate is zero.

INTRODUCTION

Constructing representative, national data sets is a tricky business. In the planning stage, researchers try to anticipate everything that could go wrong and address it in the construction of the survey tool. But sometimes the course of events cannot be predicted and the best laid plans are not enough. Such is the case with the data collected in the winter and early spring of 1974 in both the National Child Development Study (NCDS) (wave three) and the Family Expenditure Survey (FES).

The source of the problem is a coal miners work action and the government's energy policy in response. For almost three months, the government mandated that firms operate only three days per week. Many weekly earned incomes, of course, were much lower during this period. Unfortunately, both the NCDS and FES conducted a substantial portion of their surveys during this period. And while the questionnaires were carefully worded, the wording leaves open to interpretation whether the respondent should have reported the three-day weekly wage or the weekly wage before the policy took effect.

The result of this coincidence of survey and strange public policy is a potential for large measurement errors in income reports. Instrumental variable corrections (using education, for example) are available when the error-ridden income measures are used as independent variables in regression analysis. But IV estimates rely on the assumption that the instruments are truly exogenous. Often it is difficult to identify a clearly legitimate instrument. The problem is worse when the statistical analysis employed is not mean regression.

Whatever techniques researchers choose to employ, they will be concerned with potential contaminates affecting the data (see Dearden *et al.* pp 50-51, for example). This paper assesses how widespread the three-day week reporting errors are in the NCDS and FES datasets for 1974. The next section provides a brief history of the three-day week policy. The following section suggests several alternative methods for measuring the number of respondents reporting a three-day week wage. The third section describes the data, the sample selection rules, and reports results. The final section concludes.

I. The Three-Day Week of 1974

When the voluntary wage and price control agreement between unions and industry expired in the fall of 1972, the Conservative Heath Government set up a Price Commission and a Pay Board to impose price and wage restraint. (LT Nov. 1 and Nov. 7, 1972) The coverage of the government's price and wage controls was not complete, however. Some of the loudest union complaints pointed to the fact that while wage increases were subject to extreme scrutiny, food and rent prices went largely uncontrolled (LT Feb. 6 and Oct. 9, 1973). When the coal miners contract negotiations began in the fall of 1973, the stage was set for a confrontation. (Coal mining was a nationalized industry at that time.)

When the government's "best" offer fell 2 pounds short of the union's demand, the unions decided to stop working overtime (LT Nov. 9, 1973). Since the mines required regular maintenance that was routinely performed on the weekends with the workers out of the mines, the overtime elimination guaranteed a large drop in coal production. By the end of November, production was off as much as 33% (LT Nov. 30, 1973).

The government's initial response was to ask the nation to voluntarily reduce energy use while mandating restrictions on streetlights and lighted advertising (LT Nov. 14, 1973). By mid-December a coal shortage was imminent. Since part of the government's price control efforts included setting the price of coal below market prices, market mechanisms would not regulate consumption. Facing the prospect of running out of electricity and heat during the winter, the government announced that beginning at New Years firms would be restricted to only three days of operation per week (LT Dec. 14, 1973).

The three-day week had the desired effect of conserving coal stocks, but it caused a massive disturbance in the labor market. Workers' wages were slashed as 40% of their work was eliminated. The government responded with offers of unemployment benefits for the lost days. Three months later, the Heath government lost the election to the Labour Party and the three-day week policy was abandoned.

II. Estimating the Number of Three-Day Week Responses

The questionnaires for the NCDS and FES were not designed to account for this type of disturbance in wages. Clearly the writers of the questions recognized that any one week's wages may not be representative. The wording was created to elicit a "usual" wage. The wording of the questions was:

NCDS: "Ask the informant(s) to indicate the range in which the members of the household's usual net income falls."

FES: "What do you usually receive each time you are paid?"

These precautions are undoubtedly adequate to avoid responses that are unusually high or low due to the most recent week's bonus or vacation pay. But it is impossible to tell how respondents would view "usual" pay during a persistent, open-ended episode like the three-day week. In particular, there is no mention of the policy in the questionnaires. Micklewright (1986) notes that it is "NCDS lore" that a significant fraction of the survey participants incorrectly reported three-day incomes.

Without any indication in the individual responses as to whether the response corresponds to a three- or five-day week, we must turn to examinations of the distribution of observations in order to estimate the number of three-day responses. Fortunately, the collection of both the FES and the NCDS extended over the entire year of 1974. By comparing the data collected in the first 10 weeks with that collected in weeks 14 to 52, it is possible to estimate the proportion of those responding with a 3-day figure.

The following analysis assumes that when respondents gave a three-day figure, it was 60% of the true value. This assumption may be violated for two reasons. First, the three-day week resulted in temporary unemployment for many workers. These workers' three-day pay was zero. While this increase in the unemployment rolls was substantial in absolute terms, it represents a fairly small fraction of the total work force. Second, some salary workers may have had reductions in pay during the three-day week that did not equal 60%. I will ignore these complications since, in the end, they do not seem to significantly alter my findings.

If *w* is the true wage, then the reported log wage is

$ln(w)+ln(e)$ if a five-day figure is used

$ln(w)+ln(.6)+ln(e)$ if a three-day figure is used

where *e* is a mean-zero, classical measurement error due to typical misreporting. $ln(w)$ has mean μ_w and variance σ_w^2. The log wage is assumed to be independent of the reporting error and the likelihood of reporting a three-day figure. In Group 1 (those respondents questioned after the three-day policy was eliminated), assume all responses are five-day answers. In Group 2 (those questioned during the three-day policy), assume that *a* percent of respondents provide three-day week information while *(1-a)* provide five-day figures. The task is to estimate *a* given income observations for both groups.

Variance Difference

The first method of estimating the number of three-day responses examines the variance of the reported log incomes in both groups. This method is reminiscent of the signal-to-noise ratio from regression with classical measurement error in the independent variable. The variance of observed log income is $\sigma_1^2 = \sigma_w^2 + \sigma_e^2$ in Group 1 and $\sigma_2^2 = \sigma_w^2 + \sigma_e^2 + a(1-a)\ln(.6)^2$ in Group 2. Subtracting one from the other, $\sigma_2^2 - \sigma_1^2 = a(1-a)\ln(.6)^2$. This equation has two solutions between 0 and 1. Assuming that fewer rather than more respondents gave the five-day figure,

$$\hat{a} = \frac{1 - \sqrt{1 - 4\dfrac{\sigma_2^2 - \sigma_1^2}{\ln(.6)^2}}}{2}.$$

Means Difference

The variance difference approach requires that the variance of the misreporting error is constant in the two groups. There is good reason to doubt this assumption. Seasonal variation in misreporting (perhaps due to Christmas budgeting or end-of-year planning) will bias the estimate of *a* downward since the variance caused by the three-day week would be underestimated. An alternative estimation method is to compare the mean log incomes in the two groups. The mean log income is $\mu_1 = \mu_w$ in Group 1 and $\mu_2 = \mu_w + a*\ln(.6)$ in Group 2. Subtracting the group means, $\mu_1 - \mu_2 = -a*\ln(.6)$. So, the second estimate of *a* is

$$\hat{a} = \frac{\mu_1 - \mu_2}{-\ln(.6)}.$$

Maximum Likelihood

These two methods each use only one moment. It might make sense to use all of the information in the data simultaneously. A maximum likelihood estimate can be created to accomplish this. Suppose the distribution of Group 1 log incomes is used as an approximation of the “true” distribution. Let *F(W)* be the cumulative density function (cdf) of the Group 1 data. If the cdf of the Group 2 data would also be *F(W)* in the absence of the three-day week problem, then the cdf of the Group 2 data will be *(1-a)*F(W)+a*F(W-ln(.6)).*

In order to estimate the probability density functions (pdf), I discretize the support of the log wage into *K* intervals. Then the pdf is approximated by the probability mass function (pmf) $f(k)=\dfrac{F(W_k)-F(W_{k-1})}{W_k-W_{k-1}}$ where W_k and W_{k-1} are the upper and lower bounds of the k^{th} interval. Similarly, compute a pmf approximating the pdf of F(W-ln(.6)). Call this *f6(k).* The likelihood of observing the Group 2 data given the Group 1 distribution as the underlying distribution for Group 2 is $L=\prod_{k=1}^{K} a*n(k)*f6(k)+(1-a)*n(k)*f(k)$ where *n(k)* is the number of observations in the k^{th} interval. The estimate of *a* is that which maximizes this function.

Ordinary Least Squares

The cdf's written in the previous section suggest one final method for estimating *a*. Let the cdf of Group 2 observations be noted *G(W).* Then *G(W)-F(W)=a[F(W-ln(.6))-F(W)]*. If sampling variation in the two groups causes the actual difference in the groups cdf's to differ from this prediction, we might estimate a regression with no intercept: *G(W)-F(W)=a[F(W-ln(.6))-F(W)]+eps*. The slope coefficient is an estimate of *a*.

III. Data and Results

In order to focus the study on the rate of misreporting among those most likely to be attached to the labor force, the data are restricted to male heads of household ages 25 to 60. (Note, however, that the minimum age in the NCDS data set is 32.) Since the three-day week policy was discontinued in the second week of March, interviews taking place in the first 10 weeks are potentially misreported as three-day figures. Presumably interviews taking place in or after the 14th week will not be affected. Group 1 represents observations in weeks 14 to 52 while Group 2 represents observations in the first 10 weeks of the year.

Table 1 provides summary statistics for the FES data. The first column gives statistics for the Group 1, the second column gives statistics for Group 2, and the final column reports statistics for the full FES sample. Incomes were adjusted for inflation according to the month of the interview. Note that only 75.5% of the FES data were collected in or after week 14. As predicted, the mean log income in Group 1 is higher than the mean log income in Group 2. And the variance of log income is higher in Group 2 than in Group 1.

Table 1: FES Summary Statistics

	Group 1	**Group2**	**All Weeks**
Observations	2420	559	3205
Week of Observation	30.54 (10.20)	5.222 (3.087)	24.81 (13.55)
Age	41.65 (10.33)	41.91 (10.57)	41.74 (10.38)
Log Gross Earned Income	8.420 (0.369)	8.370 (0.406)	8.410 (0.376)

Note: Standard deviations in parentheses.

The First 2 rows in Table 2 report estimates using the four methods described in the previous section using the data from the FES. Between 8% and 13% of those interviewed in the first 10 weeks of the year gave three-day values. Since no more than 24.5% of FES interviews took place under the three-day policy, the estimates in Table 3 indicate that between 2.0% and 3.2% of all FES respondents gave three-day figures.

Table 2: Estimated Proportion of Three-Day Week Income Reports in the FES

	Difference in Variance	Difference in Means	MLE	OLS
1974 Estimated *a*	0.126	0.098	0.082	0.133
Test Statistic	1.21	2.83	13.8	11.3
1973,75 Estimated *a*	-	0.071	0.041	0.046
Test Statistic	0.949	3.28	11.38	4.56

The test statistics reported for each estimate tests the hypothesis that *a* does not equal zero. In the Difference in Variance test, the F statistic from a test of equality of variances is reported. The Difference in Means test statistic is a two-sample t-test of equal means. The MLE statistic is the Likelihood Ratio (LR) comparing the likelihood with *a* set at the optimal choice against that with *a* constrained to be zero. And the OLS statistic is the t-statistic from a regression with intercept. (As predicted, the intercept was not significantly different from zero.) All test statistics are significant at the 1 percent level.

Figure 1 graphically shows how well the MLE estimate of *a* fits the data. In the upper panel of Figure 1, the cdf's for the Group 1 and Group 2 data are plotted. The Group 1 data stochastically dominates the Group 2 data. In the lower panel, a random selection of the Group 1 data are reduced by 40% to mimic three-day income reporting. The proportion selected is equal to the MLE estimate of *a*. The information represented in the LR statistic in Table 3 is visually apparent in Figure 1—when we assume that about 8 percent of the Group 2 respondents are actually under-reporting their income by 40%, the distributions in Group 1 and Group 2 match much better.

One explanation for these results that is independent of the three-day week lies in the organization of the FES surveys. While the FES was designed to be representative in its whole, it may not be in its parts; perhaps the observed differences in distribution reflect differences in those sub-populations observed in the first 10 weeks as opposed to the last 39 weeks of the year. Another similar explanation is that the wage distribution may display seasonal patterns. One way to test these hypotheses is to perform the same analysis on the 1973 and 1975 FES data. If we do not find the same patterns in this data which was unaffected by the three-day week, then it seems likely that the patterns observed in 1974 are related to the policy.

The last 2 rows of Table 2 report the results when 1973 and 1975 data (combined) are used. While the 1973 and 1975 data do show a seasonal pattern in mean income that looks like misreporting, the pattern is not present in the variance. Seasonality may explain away as much as 75% of the estimated “misreports” in the 1974 data (if the means test is consulted) or none of the observed pattern (if the variance test is considered). These results only strengthen the conclusion that few observations in the FES are affected by the three-day week.

The NCDS data has several limitations that require attention before proceeding with estimation. The following discussion points to the adjustments made to accommodate the data.

The correct income measure for the purpose of this study is the gross wage. Unfortunately, the NCDS data only include net income measures. Net income equals gross income less deductions. Deductions are typically a fraction of gross pay. If the deductions were also reduced by 40% during the three-day week, then the fact that the NCDS reports net rather than gross income does not pose a problem. However, if the deductions were not reduced by the same fraction as gross income, the three-day net income will no longer simply be 60% of the five-day net income. Recognizing these problems, there is no way to address this problem with data in the NCDS.

The second problem with the NCDS data set is that respondents did not report the actual value of their net income. Instead they were given 12 intervals and asked to identify in which their net income fell. Some answered with monthly figures while others reported weekly figures. The intervals used for reports of monthly and weekly incomes were constructed so that the intervals are roughly the same in annual terms. I combine the monthly and weekly reports into one annual series with interval boundaries set at the average of the annual boundaries implied by the weekly and monthly intervals.

Assuming that log incomes are normally distributed, it is possible to construct consistent estimates of the expectations of log income for each income interval. (See Stewart (1983) for details.)

(i) Calculate the sample cdf of k, C_k, where $k=1,\ldots,K$ denote the intervals. Consistent estimates of the mean μ and standard deviation σ of log income are found by regressing A_k on $F^{-1}(C_k)$ $(k=1,\ldots,K-1)$ where A_k are the boundaries of the intervals and F is the normal cdf.

(ii) The conditional expected value of log income given the respondent was in interval k is

$$\hat{\mu}+\hat{\sigma}\frac{f(\hat{B}_{k-1})-f(\hat{B}_k)}{F(\hat{B}_k)-F(\hat{B}_{k-1})} \quad (k=1,..,K)$$

where $\hat{B}_k=(A_k-\hat{\mu})/\hat{\sigma}$.

Since there is reason to believe that the full sample actually contains information from two different normal distributions (one with three-day error and one without), the conditional means are estimated for the Group 1 and Group 2 samples independently.

Having calculated the conditional expected value of log income for each interview, these values are taken to be the observations of incomes. Because the data are grouped into intervals only 7 discrete intervals can be created for the cdf for which an estimate of *f(x)* and *f6(x)* both exist. (In the analysis of the FES data, the income distribution was divided into 31 intervals for the MLE and OLS estimation.) The small number of observations and the fact that *f* and *f6* are likely to be poorly approximated with such large intervals raises doubts about the MLE and OLS estimates.

An alternative approach is to take the assumption of normality in the log income data more seriously. Assuming normality, knowledge of the means and standard deviations of log incomes for Group 1 and Group 2 are all that are required to find the cdf's for both populations (*F(x)* and *G(x)*). The support of these distributions can be divided limitlessly without regard to the particular intervals used in the questionnaire. These cdf's are hereafter referred to as "simulated cdf's" to distinguish them from the sample cdf's. The estimates of *a* found using the MLE and OLS methods applied to the simulated cdf's will be denoted MLE^* and OLS^*.

Finally, the method just described makes it impossible to adjust for inflation month-by-month. All Group 1 incomes are adjusted using June prices; all Group 2 incomes are adjusted using February prices.

Table 3 provides summary statistics for the NCDS data. A large fraction of the observations are potentially contaminated with error; only one-third of the data were collected after the 13^{th} week of the year. However, the patterns in mean log income and log income variance are inconsistent with the presence of three-day week misreporting. The variance is slightly higher in the Group 1 interviews while the mean is slightly lower.

Table 3: NCDS Summary Statistics

	Group 1	**Group2**	**All Weeks**
Observations	2449	3294	7555
Month of Observation	5.768 (2.220)	2.238 (.5086)	3.655 (2.027)
Age	45.74 (5.357)	45.72 (5.430)	45.71 (5.411)
Log Net Earned Income	7.425 (0.370)	7.432 (0.370)	7.429 (0.370)

Note: Standard deviations in parentheses.

Table 4 repeats the estimation of *a* using the NCDS data. In most of the tests there is no evidence of misreporting. Since 32.4% of the NCDS interviews took place outside the policy window, the estimates in Table 4 suggest that no more than 8.5% of the NCDS income figures are misreported. Given the patterns in means and variances and the very small sample sizes used in the MLE and OLS tests which are the only indications of misreporting, the best estimate for three-day reporting appears to be zero.

Table 4: Estimated Proportion of Three-Day Week Income Reports in the NCDS

	Difference in Variance	Difference in Means	MLE	MLE*	OLS	OLS*
Estimated *a*	-	-	0.092	-	0.130	-
Test Statistic	0.956	-0.583	80.6	0.0	4.84	-3.00

Figures 2 and 3 show how the sample and simulated cdf's compare for Group 1 and Group 2 and how the MLE estimates of *a* bring the two samples into agreement. The Group 1 cdf does not stochastically dominate the Group 2 cdf. And so there is no need to reconcile the distributions with a fraction of the Group 2 responses coded as misreports.

Comparing the results from the FES and the NCDS, one might wonder why Group 2 respondents in the FES data set seem to have been more likely to report a three-week figure than their NCDS counterparts. One possible explanation is a bit ironic. The FES, as an expenditure survey, is designed to accurately measure dollar values. For instance, respondents are first asked to give the "wage/salary, including overtime, bonus, commission or tips after all deductions, the last time you were paid." This question is followed up by detailed questions concerning deductions for National Insurance and General Pension contributions as well as other deductions. Then the questionnaire turns to regular and overtime hours "in the weekly period you quoted before." One can easily imagine the individual looking for a pay stub to accurately answer these questions. (The interviewer is asked to code whether the respondent consulted a pay slip; one might infer from this that respondents were given this suggestion.) Then the interviewer asks the respondent whether this is the “usual pay.” The order of the questions could easily lead a respondent to think that the usual pay in the current three-day week (excluding overtime pay and bonuses) is the desired answer. Alternatively, having just reported a three-week figure for last week’s pay, the respondent’s answer to “usual” pay may be “anchored” to the three-day figure. The care taken in the FES makes this all the more likely since it pushes the respondent toward pulling out a pay stub and staring at a three-day figure.

The NCDS was not nearly as careful in its technique since the income data were not the primary interest of the study. The questionnaire was administered to mothers with no one else in the room (Micklewright 1986). Since the data I am using is for the males, it is not surprising that the women would be less likely to pick up temporary changes in wages such as the three-day week. Also, the question only asks for an interval for father’s income rather than an actual value. If only an interval answer is required, the woman would be less likely to seek a pay stub to confirm her perception. And so the respondent is less likely to give a three-day response.

IV. CONCLUSION

This paper examines the degree to which the three-day week of 1974 has corrupted data in the third wave of the NCDS and the 1974 FES. Several alternative methods of measuring the number of respondents who gave three-day figures are proposed. In the FES, between 8.2% and 13.3% of those interviewed during the first 10 weeks of 1974 are estimated to have given tainted responses. Given that a large majority of the FES data were collected after the policy concluded, I estimate that no more than 3.2% of the FES data are suspect. In the NCDS, the estimates are lower with the both mean and variance differences suggesting no misreporting at all. In conclusion, the results of this paper support the confident use of both the FES and NCDS data for 1974.

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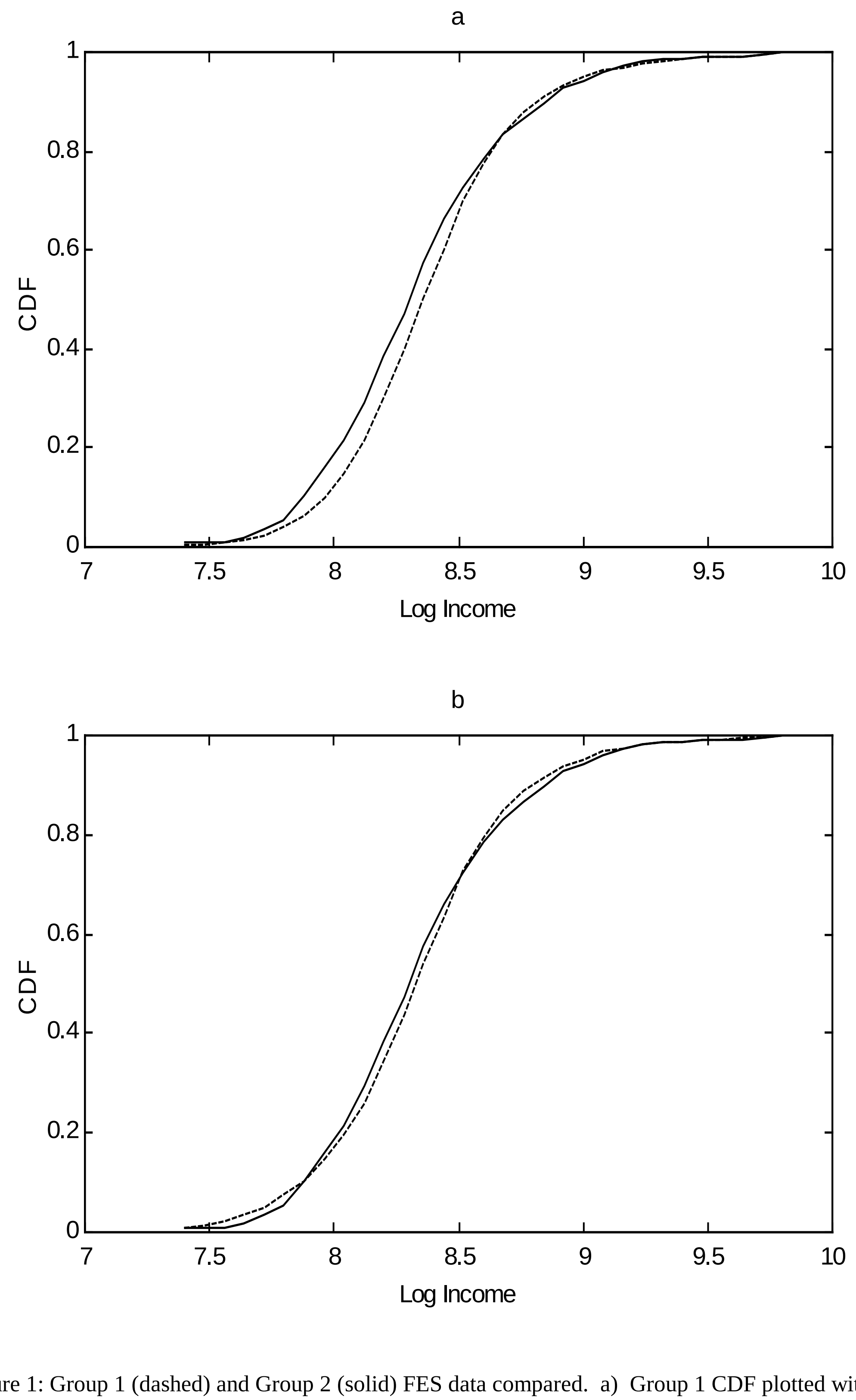
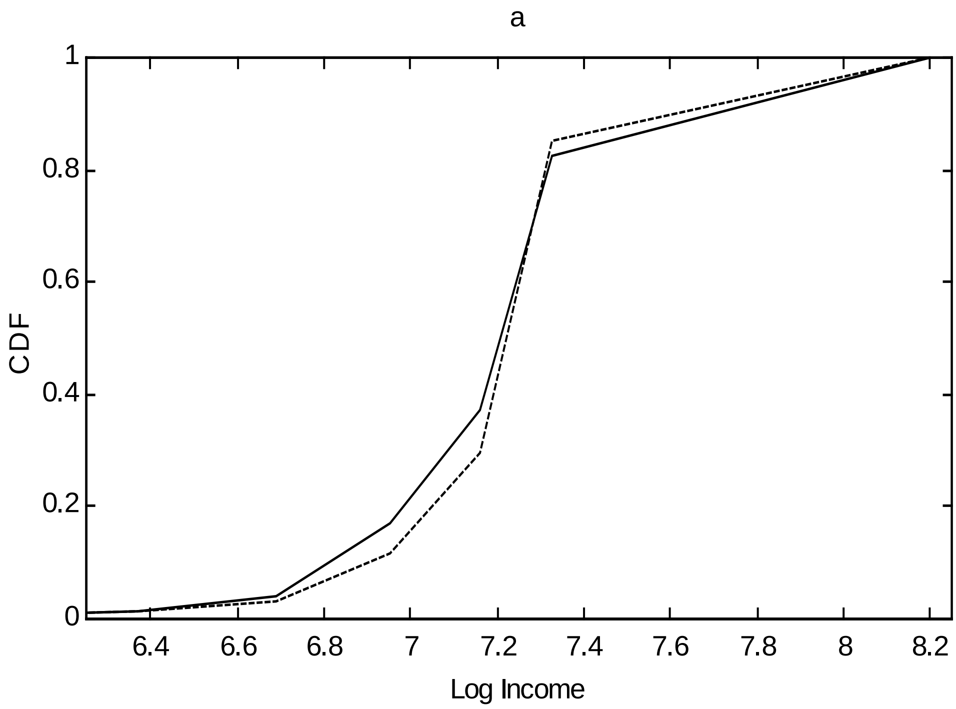


Figure 1: Group 1 (dashed) and Group 2 (solid) FES data compared. a) Group 1 CDF plotted with Group 2 CDF. b) Group 1 CDF adjusted with MLE estimated *a* plotted with Group 2 CDF.



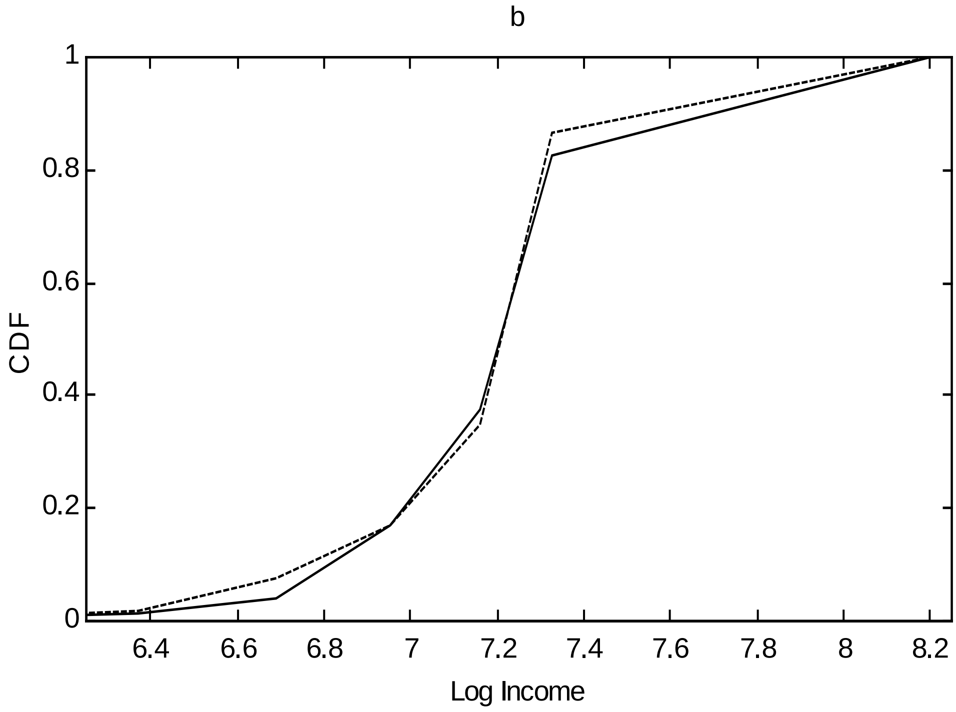


Figure 2: Group 1 (dashed) and Group 2 (solid) NCDS data compared. a) Group 1 CDF plotted with Group 2 CDF. b) Group 1 CDF adjusted with MLE estimated *a* plotted with Group 2 CDF.

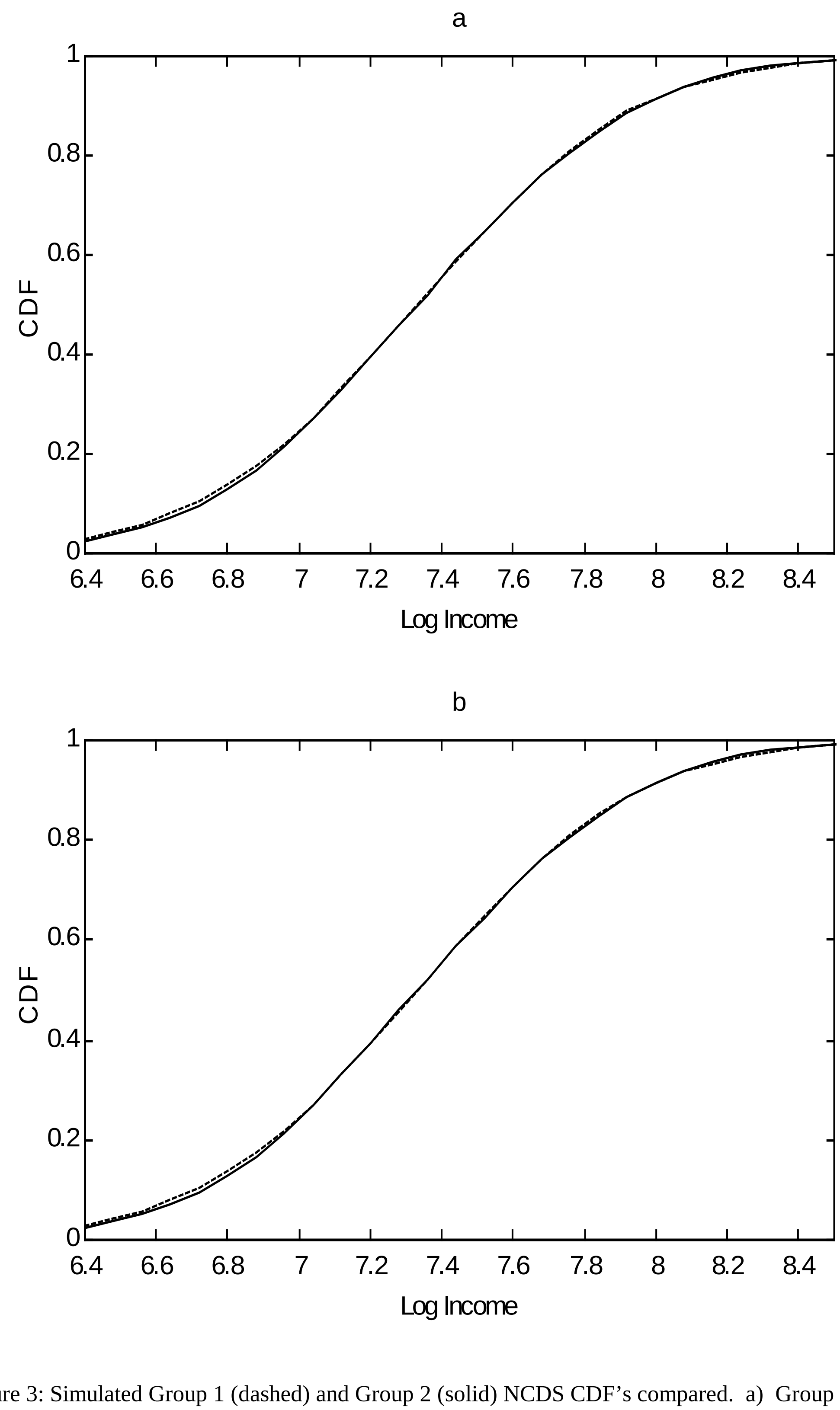


Figure 3: Simulated Group 1 (dashed) and Group 2 (solid) NCDS CDF's compared. a) Group 1 CDF plotted with Group 2 CDF. b) Group 1 CDF adjusted with MLE estimated *a* plotted with Group 2 CDF.