AER Web Appendix for Human Capital Prices, Productivity and Growth *

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January 30, 2012

The data for the analysis come from the March Current Population Surveys (MCPS). A consistent and annotated version of the files from UNICON was used as the data source. In this Appendix these data are described with particular reference to issues of data quality and comparability over time in Sections A1-3. Section A4 documents the robustness of the flat spot estimates presented in Figure 3, and Section A5 presents the alternative standard unit estimates for the dropouts.

A1. Consistent Education Categories

The issue of consistency of the education measure arises because of a break in the education questions in 1991. This break is studied in detail in Jaeger (1997) who compared the education answers from the same respondents at different points in their CPS rotation who were asked the old education questions in their earlier rotation and the new questions in their later rotation. Jaeger offers solutions of two types. First is a linearization of the new educational

*The authors wish to thank Lance Lochner and Todd Stinebrickner for helpful comments and discussion. We thank the editor and referees for detailed comments on earlier drafts. We also thank participants in seminars at the University of Virginia, the University of Guelph, McMaster University, the University of British Columbia, Wilfrid Laurier University and conference sessions at the 2006 CEA Annual Meetings, the first annual UM/MSU/UWO Labor Economics Day, the CIBC Human Capital, Productivity and the Labour Market Conference, and the 2011 CLSRN Annual Conference. This work was supported by the CIBC Human Capital and Productivity Centre and the Canadian Social Sciences and Humanities Research Council.

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attainment question that approximates the old “highest grade completed”. The recommended mapping to construct a consistent “highest grade completed” or “years of schooling” variable is provided in the first and last columns of Jaeger’s Table 2. Second, Jaeger considers 4 category matches rather than linearization. These are high school dropouts, 12th grade, some college, and college graduates. The recommended mapping for creating these four categories consistently across time is given in Jaeger’s Table 6. In this paper we use the same four categories as Jaeger and follow his category mapping across the break.¹

A2. Consistent Annual Hours Measures

The MCPS annual labor incomes are for the year preceding the survey. Prior to the 1976 survey (1975 earnings) reported working hours in the survey could not be related to the previous year’s earnings. In the MCPS data, hourly wages can be constructed as the ratio of annual labor income to annual working hours. Annual working hours can be constructed as the product of weeks worked per year and usual hours worked per week for the 1976 survey onward. Prior to this survey year, usual weekly working hours were not recorded and weeks worked were reported in grouped categories. An imputation procedure was used to create a series back to the 1964 survey.

- *Hours Worked per Week Last Year.* For the surveys before 1976, the MCPS variable *hrslыр* (“hours last year”) is not available, and an estimate has to be obtained from data on *hours* (“hours last week”). The question for this variable is always the same: “In the weeks that worked, how many hours did usually work per week?” An estimate of hours worked per week last year for the survey years prior to 1976 is constructed as follows. First, for the individuals who were working last week, their “hours last week” is used as an estimate of their “hours per week last year.”² Second, for the individuals who were not working last week but who had worked last year, their “predicted hours last week” is used as an estimate of “hours per week last year” where the predicted hours is obtained from a regression of “hours last week” on age, education in years and a female

¹There is a small difference in this mapping from a standard high school dropout/high school graduate cutoff using the linearization. For the period 1975-1990 this is the same under both sets of coding. However, for the period 1991-2001, in contrast to mapping of code 38 into the less than high school group, Jaeger’s category mapping puts them into high school. This is due to the use of the median rather than the mean in Table 2. The mean of the 38 group is actually 11.38 but the median is 12. Up to 1990 the fraction of high school dropouts is the same under both definitions. The cumulative fraction up to and including 11 over the 1985–1990 period was 17.76, 17.36, 17.31, 16.86, 16.68 and 16.09. Jaeger’s category mapping takes it to 13.40 for 1991 and the alternative takes it to 15.12. Further inspection, however, shows that the big drop is actually in the cumulative to 10 years which is common to both measures, so the less drastic drop from the alternative method is not to be preferred on this ground.

²The question for the hours variable in survey years 1962-1993 was: “How many hours did work LAST WEEK at all jobs?”

dummy variable for each year on the sample of those employed in the survey year.

- *Weeks Worked per Year Last Year.* For the 1962-1975 surveys the question is: “In 19XX how many weeks did work either full time or part time (not counting work around the house) ?” For the 1976 and 1977 surveys the question was amended to: “In 19XX how many weeks did work either full time or part time, not counting work around the house? Include paid vacation and paid sick leave.” From the 1978 survey on, the question became: “During [19XX/20XX] (last year) in how many weeks did work even for a few hours? Include paid vacation and paid sick leave.” Prior to the 1976 survey this variable was only available in intervals. UNICON created a time consistent variable for “weeks worked last year” by using interpolated values based on interval means from some post-1975 surveys.

A3. Consistency and Quality Issues for the Annual Earnings Measure

The annual wage and salaries earnings data are from the UNICON time consistent “income from wage and salary” variable derived from the MCPS variable *incwag* (income from wage and salary). The definition from the glossary is as follows: *Money wages or salary is defined as total money earnings received for work performed as an employee during the income year. It includes wages, salaries, Armed Forces pay, commissions, tips, piece-rate payments and cash bonuses earned, before deductions are made for bonds, pensions, union dues, etc. Earnings for self-employed incorporated businesses are considered wage and salary.*

The question for the survey years 1963-1968 is “Last year how much did receive: In wages or salary?” For the survey years 1969-1974, the question was slightly amended to “Last year (19XX) how much did receive: In wages or salary before any deductions?” and for survey years 1975-1979 was further amended to “Last year (19XX) did ... receive any money in wages and salary? If so, how much did ... receive before any deductions?” From 1980 onwards there are multiple questions for the source so that “income from wage and salary” is a sum of components, but there is a single top-code variable that applies to the total. From 1988B to 1995 the construction is (*incer1* if *ernsrc=1*) + *incwg1*, where *incer1* is the CPS “income from the longest job”, *ernsrc* is 1 if the source of income from the longest job is wage and salary, and *incwg1* is the CPS “income from other wage and salary.” There are two top-code flags for this period, one for *incer1*, and one for *incwg1*, hence the “income from wage and salary” variable can have a value above any single top-code cut off value. While the form of the question has been relatively stable over time, several potential quality issues arise from substantial time variation in the incidence and treatment of top-coding, and in allocated values.

Top-coding

The top-coding flag for the total *incwag* was not introduced until 1976. For 1964 – 1967 the highest value of *incwag* is 99900, but there is no apparent top-coding from inspection of the frequencies. For 1968 – 1975 the highest value is 50000 and there is clear top-coding from the frequencies, though without a flag it is not possible to say which of the observations with value 50000 are top-coded. For the years 1976 to 1981 the highest value is 50000; the top-coded observations can be identified from the flag except for 1977 when the flag indicates far too many top-coded and must be incorrect; the frequency at 50000 for 1977 strongly suggests top-coding at 50000. (The conditional frequency of 50000, given that the observation is above 45000, is almost the same as 1976.) The annual frequencies of top-coding for 1976-1981 are: 0.24, (30.83), 0.36, 0.51, 0.68 and 0.94. For 1982 – 1984 the highest value is 75000. It is possible to say which of the observations with value 75000 are top-coded from the top-coding flag; the information from the flag and the frequencies agree. The frequencies for these years are: 0.37, 0.47 and 0.52. For 1985 – 1988 the highest value is 99999. It is possible to say which of the observations with value 99999 are top-coded from the flag, except for 1985 where the flag must be incorrect.³ The frequencies are: (0), 0.42, 0.54 and 0.63.

Beginning in 1989 (1988B) top-coding is done separately on the two components of *incwag*: income from the longest job last year (*incer1*), and other wage and salary income (*incwg1*). For 1989-1995 the top-coded value for *incer1* is 99,999; the flags all appear to be correct. The top-coded value for *incwg1* is also specified as 99,999 for 1989 to 1995. However, there are problems with the flag. For 1989 the flag is present but all values are missing.⁴ The frequencies of top-coding on *incer1* (for positive values of *incer1*) and on *incwg1* (for positive values of *incwg1*) are as follows:

Year	<i>incer1</i>	<i>incwg1</i>
1989	0.80	-
1990	1.08	0.00
1991	1.05	0.00
1992	1.08	0.00
1993	1.23	0.00
1994	1.54	0.15
1995	1.77	0.21

The incidence of top-coding doubles over this period, reaching close to 2%. For calculating the price series, especially for the flat spot age group of college educated workers, this is a potential concern since the incidence for this group

³For 1985 all values of the flag are zero (no top-coding), despite a mass point at 99999 similar to adjacent years where the flag indicates top-coding.

⁴Unicon Appendix H4 notes some general problems with component top code flags, but apart from the problem with 1989, the frequencies are generally consistent with extremely low levels of top coding on *incwg1* throughout, so the pre-1994 zeros could be true. The 99,999 cut off is high for this “other wage and salary” component and was subsequently reduced.

of relatively high earners can be much higher. A greater concern is the break in treatment at 1995/96.

For 1996 to 2002, values above 150,000 on *incer1* and above 25,000 on *incwg1* are replaced by demographic cell averages. These averages are apparent from the frequency tabulations. The flags for 2000 are obviously incorrect. The replacement values for *incwg1* in 2000 also has the extreme value 236224 for 6 observations. For 2003 onwards, cut off values are raised to 200,000 for *incer1* and above 35,000 for *incwg1*; values above these are again replaced by demographic cell averages and these averages are again apparent from the frequency tabulations. The frequency of top-coding and the most frequent replacement values are as follows:

Year	<i>incer1</i>	<i>incwg1</i>	replacement <i>incer1</i>	replacement <i>incwg1</i>
1996	0.60	2.62	302539	64524
1997	0.71	2.12	318982	45749
1998	0.79	3.84	330659	61345
1999	0.83	3.69	306731	59925
2000	(89.30)	(96.88)	(229339)	(50037)
2001	1.07	5.58	335115	56879
2002	1.25	5.31	320718	60670
2003	0.74	2.66	390823	91360
2004	0.72	3.27	404469	89988
2005	0.71	3.27	422850	77282
2006	0.81	3.54	423545	79378
2007	0.92	4.21	437528	74091
2008	0.90	4.33	419969	73029
2009	1.05	4.51	389599	72946

The frequency of top-coding for each component changes substantially between 1995 and 1996 with the changes in top-coding cut-offs; the increase for *incer1* cuts the incidence on that component by two thirds, while the decrease for *incwg1* increases the incidence on that component more than 10 fold. The top-coding on the *incwg1* ("other wage and salary") varies substantially and reaches over 5% in some years. While the top-coding incidence changes are a concern, the shift to replacement values has the most dramatic effect. In general this effect is apparent in the upper tail, but the change is large enough to be clearly apparent in the mean wage for the whole sample. This is shown in the following table that reports the mean, median and maximum wage for *incwag*, as well as the 90th and 99th percentile.

Year	Mean	Median	90th Percentile	99th Percentile	Maximum
1990	24903.5	21000.0	50000.0	99999.0	199998.0
1991	25332.1	21223.0	50000.0	99999.0	180000.0
1992	25770.8	22000.0	51000.0	99999.0	199998.0
1993	26759.1	22428.0	54000.0	99999.0	193999.0
1994	27738.5	23180.0	56732.0	99999.0	199998.0
1995	29290.7	24648.0	60000.0	99999.0	199998.0
1996	32143.2	25000.0	60000.0	257390.0	464782.0
1997	33189.9	25000.0	61500.0	318982.0	454816.0
1998	35098.2	26999.0	66000.0	330659.0	418608.0
1999	36767.8	28831.0	70000.0	306731.0	492657.0
2000	36975.6	29000.0	72000.0	229339.0	364302.0

In 1995, the last year of non-replacement top-coding, the highest value is 199998, the 99th percentile is 99999, the 90th percentile is 60000, the mean is 29291 and the median is 24648. In 1996, the highest value jumps to 464782, the 99th percentile jumps to 257390 and the mean jumps to 32143, while the 90th percentile and the median both show modest or no increase in line with previous years and subsequent years.

Two additional concerns are the effect of the problem flags for 2000 and the extremely large value of 240674 for 8 observations used as the replacement values for *incwag1* in 2007. The effect of the problem flags for 2000 is shown in the following table that reports the top coding counts for *incer1* and *incwag1* and the mean income conditional on being above or at least equal to \$149000.

Year	top-coding count	top-coding count	mean	mean
	<i>incer1</i>	<i>incwag1</i>	> 149000	<= 149000
1996	372 (0.58)	309 (0.48)	274678.2	23587.27
1997	427 (0.65)	227 (0.35)	296586.4	24249.76
1998	471 (.073)	451 (0.70)	296775.1	25548.10
1999	511 (0.78)	428 (0.65)	297244.1	26808.38
2000	59543 (88.89)	64705 (96.59)	219548.8	27546.18
2001	659 (1.02)	577 (0.89)	294638.7	28954.72
2002	1304 (1.23)	852 (0.80)	292384.1	29989.74
2003	774 (0.74)	381 (0.36)	279471.4	30647.21
2004	716 (0.70)	438 (0.43)	263159.5	31345.67
2005	711 (0.71)	436 (0.43)	273961.5	32092.19

Clearly, the flag problem with 2000 results in a large change in the upper tail for that year. The mean, conditional on *incwag* > 149000 shows a smooth progression over the years, including for 2000. The mean conditional on *incwag* <= 149000 shows an abrupt fall for 2000.

Allocated Values

Allocated values are a serious issue in the MCPS data both because in some years as many as 25 percent of the values may be allocated, and because of time varying procedure for assigning allocated values.⁵ The main change in treatment happened after the 1988 survey when the entire supplement was evaluated for response quality and the supplement information was deemed either a “good match” to the basic record or not. If the supplement was deemed a good match, the allocation procedure for the supplement information was the same as for the basic record with some variables being subject to having values allocated, as indicated by an allocation flag. If the supplement was not deemed a good match, then the entire supplement was allocated. The fractions allocated for the income variable prior to 1989 ranged from around 11-18%. From 1989 there was a steady increase in the fraction of allocated values from around 18% in 1989 to over 30% in the mid 2000s. The allocation flag for income after 1988, only indicates an allocated value applied to a good match and only accounts for a minority of the allocations. For example, in 1989 there are 71226 records with positive *incwag*. Of these, 6963 were allocated as a results of the entire supplement being allocated. Then an additional 5504 were allocated as a result of the *incer1* part of a “good match” supplement being allocated, and these received an income allocation flag.⁶

A4. Robustness of the Flat Spot Estimates

The benchmark series are based on median wages using the FTFY sample. The results, however, are robust to alternative choices of samples and measures. The choice of sample and the wage measure are connected in that the use of medians largely avoids the problems of including or excluding top-coded or allocated values. Top coding is negligible for the flat spot samples for dropouts and high school graduates, and very low for some college.⁷ However, top-coding is very important for the college graduate flat spot sample where the rates are highly variable and can reach close to 10%.

Using the full sample with all allocated values and no corrections for top-coding changes, income from wage and salaries (*incwag*) shows an obvious break at the major point of top-coding changes. The real hourly wage shows the same

⁵The allocation and nonresponse problem was discussed at length in Lillard, Smith and Welch (1986). More recently Bollinger and Hirsch (2008) drew attention to the serious problem of proxy responses and allocated values in CPS data. Hirsch and Schumacher (2004) document a dramatic example of how very misleading results can be obtained without careful treatment of the allocated values

⁶The allocation problem is most serious for the income variables, but after 1988 when the entire supplement was allocated for many records, the hours and weeks last year were also subject to substantial allocation. However, compared to the income variable, only a small number of hours or weeks are allocated and flagged in the “good match” supplements.

⁷For dropouts, 1997 and 1998 have the highest rates, just below 0.5%, but for most years top coding is negligible. For high school, the rates are a little higher, reaching almost 1% in 2002, but for most years rates are below 0.5%. Some college has slightly higher rates, this time with several years around 1.5%, though most years are a lot smaller.

(a) High School Graduates

(b) College Graduates

Figure A1: Sensitivity to Sample Restriction

break in 1995/96, but in addition shows a number of other large jumps in the average wage relative to the median and the 90th percentile due to outliers. Most of the really major outlier problems are removed by the mild restriction of requiring at least 5 weeks of work for at least 5 hours per week. This drops only 1.6% of the sample. There do remain some very large hourly wage rates, but these are removed if the sample is further restricted to full-time and full-year (FTFY) workers, defined as working at least 40 weeks a years for at least 35 hours per week. The basic results are insensitive to the alternative sample restrictions on hours and weeks worked. This is illustrated in Figures 1(a) & 1(b) comparing the price series using the minimally restricted sample (requiring at least 5 weeks of work for at least 5 hours per week) instead of the FTFY sample for high school graduates and college graduates, respectively.

Figure 3 used all the FTFY observations, including top-coded and allocated values. The treatment of allocated values changed over time which could effect the results. The fraction allocated, especially for more recent years, is much higher for college graduates. Figures 2(a) and 2(b) show the sensitivity of the series to inclusion or exclusion of allocated values. The high school graduate series is virtually unaffected. The college graduate series is more sensitive, but the basic pattern with and without excluded values is the same. The same insensitivity is true for log wages.

Flat spot samples are particularly vulnerable to differences across pairs of years in the number (or treatment) of top-coded observations, especially for higher earners such as college graduates in their fifties. In the period prior to the use of replacement values, over years when the nominal top-coding cutoff was constant, aging a cohort of college graduates is likely to cause a downward bias as an increasing fraction are subject to the cutoff. Conversely, when the cutoffs are abruptly increased, there may be an upward bias. The use of medians avoids the bias problems.⁸ More importantly, the switch to the use of assigning “average” wages among top-coded individuals of a given type instead of the top-coded (truncated) values is likely to create very serious bias problems, given the magnitude of the effect of this switch in treatment on mean wages for college graduates in their fifties. As shown earlier, the shift was important enough to have a significant effect on mean income for the whole sample. The effect was much more significant for college graduates in their fifties. The median and 90th percentile values of *incwag* were largely unchanged over the switch to replacement values between 1995 and 1996, whereas the mean shifted up almost 15%. This is directly reflected in a large shift up in the price series at this break if wages are used without taking into account this break.

The price series were all estimated with and without including top coded values. The series using medians are largely unaffected for all education groups. The series for the education groups with little top-coding are also insensitive to inclusion of top-coded observations, whether medians, average wages or av-

⁸Calculations performed in Bowlus and Robinson (2010) with and without the top-coded and allocated observations revealed potentially large biases when raw wages are used, as illustrated by a spike in their Figure A1 where an outlier in the MCPS data turns out to be one of the mean income replacement values assigned to a top coded observation.

(a) High School Graduates

(b) College Graduates

Figure A2: Sensitivity to Allocated Values

Figure A3: Price Series by Education Group: Median Wages Excluding Top-coded Observations

erage log wages are used. However, the series for college graduates which are most affected by top-coding are very sensitive to the inclusion of top-coded observations with a major break, as expected, at the shift to replacement values in 1995/96. The use of average wages shows the highest sensitivity. Only the series based on medians are insensitive to the treatment of top-coding. Ideally, the top coded observations should not be dropped, but in practice it appears difficult to include them without serious bias unless medians are used. Figure A3 shows the price series using medians, excluding the top-coded observations. This is almost identical to Figure 3. Figures 4(a) & 4(b) show the similarity of the price series for high school graduates and college graduates based on three alternative underlying wage measures used to construct the annual differences for the flat spot groups: median wages, average wages, and average log wages. All measures use the same sample, excluding top-coded observations. The series for college graduates are slightly more sensitive in the in the period after 1995, but overall the general picture of Figure 3, and the high correlation of the series for the different education groups is robust to the alternative wage measures.

(a) High School Graduates

(b) College Graduates

Figure A4: Sensitivity to Wage Measure:Excluding Top-coded

A5. Robustness for the Dropout Series: Evidence from the Standard Unit Method

The standard unit method works by finding an observable “standard unit” of human capital that is the same across time. In this case, observing the wage paid for a standard unit at different points in time identifies the price change. This is similar to the notion of finding a time invariant common unit for computers. The solution in the computer case is to assume that the common unit that represents the factor provided by all computers is calculations per second. Calculations per second are the efficiency units. The relevant price is the price of a standard computer defined as having a given number of calculations per second.⁹ The identification problem in the computer case is relatively easy to solve since computations per second can be observed so it is not necessary to actually observe “standard” computers. In the human capital case it is necessary to observe a standard unit over time because efficiency units are not directly observed. Implicitly, the standard unit approach is used in “composition bias” studies over the business cycle.¹⁰

The standard unit method is an alternative application of Equation (2). The empirical counterpart to the $\text{Mean}[\ln w_{t+1,i}] - \text{Mean}[\ln w_{t,i}]$ series for the flat spot method is obtained from following individuals in the same cohort over a period where their supplied efficiency units do not change. The standard unit method replaces this by following a standard unit group across cohorts. The ideal standard unit group is one with the same initial endowment over time and a zero level of further human capital production. By definition this group would have the same human capital level across successive cohorts as well as across time. In practice, there is no such group. Instead it was approximated by young dropouts in the early years of their labor market career where the addition to the initial endowment is the smallest, so that the human capital stock for this group is closely proxied by the initial endowment.

While the main objective is to find a group that has the least contact with human capital production functions that may have been subject to technological change, it is also necessary to choose a group that has completed their education and become attached to the labor market. Checks on the frequency distribution for experience by schooling group show that if individuals under 19 are included, the contemporaneously measured schooling completed for the lowest schooling group is not the correct final frequency - i.e. many go on to more education. By 19-20, however, those contemporaneously reporting a completed level of high school dropout correspond closely to the fraction that would report that

⁹Of course it is a little more complicated than this, since there are other dimensions on which computers may differ, and a hedonic analysis is often performed, but the basic idea is that a meaningful comparison can be made that permits an aggregation in terms of a standard unit.

¹⁰A regression approach to composition bias correction implicitly estimates a price series for the “omitted group” in a dummy variable framework. For secular trends over longer time periods where E_s can change for the omitted group, the price series is biased unless the omitted group is a true standard unit.

same level at later ages. Thus, estimates using the standard unit method were restricted to samples aged 19 and above.¹¹

Finally, for the group to have the same initial endowment over time, we require negligible selection effects over the time period of the earnings data, i.e. that successive cohorts will be drawn from the same (lower) tail of the initial endowment distribution. Figure 1 shows that for the earliest cohorts about a third were high school dropouts. This was followed by a rapid decline until the first post-war birth cohort when the fraction stabilized at around 13%. The earliest cohorts in the sample of 19-21 years of age are the 1942 to 1945 birth cohorts. Thus, apart from the first few years, the sample is obtained from successive cohorts with the same fraction of high school dropouts as required.

Figure A5: Comparison of Flat Spot and Standard Unit Price Series

The benchmark flat-spot series in Figure 3 uses the FTFY sample. Examination of participation rates for the flat spot samples shows relatively constant rates across the period for all groups, including the dropout sample, for either the minimally restricted sample or the FTFY sample. The standard unit sample, however, is a much younger age group compared with the flat spot sample (19-21 vs. 44-53) and for them, while the minimally restricted sample shows approximately constant and relatively high participation, the FTFY restriction produces highly variable participation which is often less than 50%. Hence the

¹¹The youngest dropouts may not be fully attached to the labor market. More importantly, this process may vary over time as different policies have been in place to help youth in training and transition to the labor market. There are also sample size considerations. Price series were estimated for several young age groups, producing similar results.

FTFY is not suitable for standard unit. Figure A5 compares the benchmark flat spot series with standard unit estimates based on dropouts aged 19-21. Since the standard unit series uses the minimally restricted sample, the same sample is used for the flat spot estimates. The results show a close correspondence between the two methods except for the different recovery pattern out of the 1980 recession. The standard unit group showed more difficulty coming out of the recession, but eventually the series meet again.¹² Since the two methods are independent, this provides a partial check on the accuracy of the flat spot series for the dropouts.

¹²This may be due to participation differences.

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