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Does One Size Fit All? The CPI and Canadian Seniors

Matthew Brzozowski

SEDAP Research Paper No. 130

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Does One Size Fit All? The CPI and Canadian Seniors.

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Abstract:

This paper examines the effectiveness of the CPI as a measure of inflation faced by Canadian seniors. I construct a democratic price index and show that the average inflation rate (average when measured by the CPI) is often a very poor measure of inflation rates relevant to individual households. The proportion of individual, household specific price indexes falling more then one percentage point above or more then one percentage point below the CPI often remains high regardless of how closely the mean democratic index approximates the CPI. Further, I demonstrate that the CPI has considerably overstated the inflation faced by Canadian seniors during 1970s and 1980s while more or less accurately capturing inflation during the 1990s. I show that the limitations of the CPI apply to both the senior and the non-senior Canadians in a nearly equal manner. The proportion of individual inflation rates falling significantly above or below the CPI is similar for both segments of the society and so is the time pattern of overstating the average inflation rate.

JEL classifications: C1, D1, D12
Key words: Consumer Price Index, Inflation

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Does One Size Fit All? The CPI and Canadian Seniors

Matthew Brzozowski

Résumé:
Ce document examine la précision avec laquelle l'IPC mesure le taux d'inflation effectif qui s'applique aux personnes âgées au Canada. Nous avons défini un indice de prix alternatif (indice démocratique des prix) pour démontrer que le taux d'inflation moyen (moyenne mesurée par l'IPC) est une mesure très approximative du taux d'inflation effectif des ménages. Nous trouvons que la proportion des ménages individuels dont le taux d'inflation spécifique est supérieur ou inférieur de plus d'un point à l'IPC est très importante, indépendamment de la précision avec laquelle l'indice démocratique des prix moyen est capable de répliquer l'IPC. En outre, nous avons trouvé que, dans une large mesure, l'IPC a surévalué le taux d'inflation effectif des aînés au cours des années 70 et 80, mais que cet indice a mesuré l'inflation avec plus de précision au cours des années 90. Nous montrons que les imprécisions de l'IPC affectent également le groupe des aînés et le reste de la population canadienne. On retrouve une proportion similaire de taux individuels d'inflation significativement inférieurs ou supérieurs à l'IPC dans ces deux segments de la société canadienne ainsi qu'une même tendance chronologique à surestimer le taux d'inflation moyen.

1. Introduction.

A large body of literature has been devoted towards evaluation of the adequacy of the Consumer Price Index (CPI) as a measure of inflation. A comparably large body of literature has been devoted towards the analysis of the economic implications of the aging of the western populations. This paper connects both areas of research and offers a look at the adequacy of the CPI as a measure of inflation faced by Canadian seniors.

The CPI may be an inadequate measure of inflation in two broadly defined ways. (i) It may turn out that the observed average measure of inflation rate overstates (or understates) the true inflation experienced by the average household (ii) it may turn out that many households experience inflation that is not well represented by the inflation rate experienced by the average household.

Given sufficient over time variation in relative prices and the heterogeneity of consumption choices, the CPI may fail to account for the variance of the household specific inflation rates. Moreover, the CPI weights higher spending (wealthier) households more heavily than those with more moderate budget constraints. Thus the CPI is disproportionably influenced by the spending patterns of the rich. In other words: the CPI is a Laspeyres index that measures the changes in the price of a fixed basket of goods. This average basket is determined by the total spending decisions made by the sum of consumers in the economy. Consequently the CPI is biased towards reflecting the inflation faced by those whose expenditure account for a proportionally higher fraction of the total national spending. Household specific inflation rates are determined not by the

average consumption decisions, but by the consumption choices made by the individual households.

Crawford and Smith (2002) in their analysis of UK data, show that individual spending decisions often differ significantly from the national average. I adopt the technique used by Crawford and Smith and construct a series of year-to-year democratic price indexes for Canada. I show that, in each year the mean democratic index follows the CPI very closely. However, I also demonstrate that the average, measured by the CPI inflation rate, is often a very poor measure of inflation rates relevant to individual senior households. In each year, a significant proportion of individual democratic indexes falls more then one percentage point above or more then one percentage point below the CPI. This limitation however is not specific to seniors – the CPI falls equally short in measuring the inflation faced by non-senior individual households.

Regardless of the heterogeneity of individual choices, the CPI is by construction playing "catch-up" to changes in economic conditions on both the demand and the supply sides. Entry of new goods into the market, changes in the quality of old goods and the emergence of outlet discount stores all cause adjustments in relative prices and shifts in public demand. In order to accurately measure average inflation these changes need to be reflected by updates to the basket and to the individual commodity prices. When updates are not frequent or accurate enough, the CPI will bias the average inflation rate. The magnitude of the CPI bias may be different depending on the segment population experiencing the inflation. For example, a fall in the price of DVD players or digital cameras (substitution/quality bias) or the introduction of iPods (new goods bias) is likely to have little impact on the inflation experienced by seniors. At the same time, newly

acquired access to online pharmacies offering significant discounts on prescription drugs (outlet substitution bias) may be of considerable consequences.

If the official CPI does overstate true inflation, then it must be true that real growth rate of the economy is higher than publicly reported. Moreover, incomes and benefits indexed to the CPI grow in real terms over the period when the overstatement occurs. In Canada, old age pensions are the most important benefits indexed by the CPI, therefore I concentrate the analysis on senior households.

One way to account for such biases is to implement the method of Hamilton (2001) and Costa (2001). They use the movement of Engel curves over time to calculate the bias in the U.S. CPI. Blow (2003) uses U.K. data to show that the Hamilton and Costa results may be vulnerable to functional specification and the inclusion of relevant covariates. Beatty and Larsen (2005) have extended the method and applied it to Canadian data but did not focus on seniors.

I adopt the Hamilton – Costa method and use Canadian expenditure data to study the movement of senior food Engel curves from 1969 through 2001, and to thereby assess the potential bias in the official CPI. I find that over this time period the CPI figures overstated the inflation faced by Canadian seniors by about 50 percent. I also find that almost all of the bias occurred before 1990. My results show that in the last decade of the twentieth century, the Canadian CPI has more or less accurately captured the inflation experienced by seniors. The conclusions however, are not sample specific – the CPI understated the senior and the non-senior income growth in a similar manner. Thus it was during the preceding fifteen years that Canadian economy grew faster than reported, and that real incomes (senior and non senior alike) grew faster than observed.

For the analysis of the mean CPI bias I disregard the evidence of considerable heterogeneity of individual inflation rates. Instead I take the official observed CPI and compare it to alternative estimates of the 'true' index, ignoring any household specific variation within either measure. Thus, the analysis of the variability of individual inflation rates and the measurement of the mean CPI bias are independent of one another and should be seen as two separate perspectives for the evaluation of the adequacy of the CPI.

The remainder of the paper is composed as follows: Section 2 provides an outline of the relevant literature and methodology; Section 3 describes the data and the sample; Section 4 discusses the key results; Section 5 concludes.

2. Literature review and methodology.

2.1. Heterogeneity of household specific price indexes.

Several recent studies of the CPI examined its accuracy with respect to various segments of Canadian population. Denton and Spencer (2000) point out that in order for the CPI to be an equally accurate measure of inflation for any two groups of population, at least one of the following two conditions must hold. (i) Either the relative price of various commodities must remain constant over time or (ii) if the prices change at different rates then the composition of the consumption baskets of the two groups must not differ. If both relative prices change over time and the baskets differ between the

groups, then the CPI will necessarily be a less accurate measure of inflation for one group than for the other.

Denton and Spencer find that the CPI is an equally adequate measure of inflation faced by both senior and non-senior households. They use senior specific average expenditure weights, recalculate the Index and find little difference between senior specific and non-senior specific indexes. Chiru (2005a) also used average expenditure weights and looked at the same question. He reached a similar overall conclusion. His study also shows that senior homeowners faced inflation rates considerably higher than senior renters.

Again, looking at average groups specific expenditures, Chiru (2005b) investigated if rich and poor households were subjected to different inflation rates. He finds that the average cumulative inflation rate between 1992 and 2004 was roughly equal for both rich and poor households. While the cumulative inflation rate over this period is similar for both groups, the study also shows that rich and poor were "*taking turns experiencing lower inflation*". Chiru demonstrates that inflation rates compounded over shorter time frames show significant variation between the top and bottom quintiles of the income distribution. This variation is attributed to the changes in the relative prices. Finally, both studies conducted by Chiru show that the between province differences in the inflation rates were larger than between the income quintiles or between the senior and non-senior households. These studies suggest that the more disaggregated the sample, the more likely we are to find groups that at specific moments in time, face different than the CPI inflation rates. It seems natural to extend the analysis and to look specifically at

the variance of individual household-specific inflation rates. To do so I follow the methodology proposed by Crawford and Smith (2002).

Crawford and Smith point out that the CPI is a plutocratic index – one that weights households based on their shares of total expenditures. As such, the CPI gives higher weights to richer households. Thus, by construction, the CPI is biased towards measuring the inflation faced by the rich and is biased against measuring the inflation faced by the poor. Crawford and Smith propose a democratic index that unlike the CPI assigns equal weights to every household. In order to build a democratic index separate household specific indexes need to be obtained first. These are calculated as changes in the costs of obtaining the original household specific baskets. The mean of those individual indexes represents the democratic index. Their research shows that, while the mean democratic index follows the CPI quite closely, in each year there is a considerable variation between individual inflation rates. Only about one third of individual index falls within one percentage point of the mean rate.

2.2. Cumulative bias in the Consumer Price Index.

The well-publicized report of the Boskin Commission (1996) advanced the conclusion that the CPI overstates the true inflation. Following the report, Hamilton (2001) and Costa (2001) attempted to calculate the bias using US data. They found significant evidence of bias in the US.

Several studies group the sources of bias into four broad categories: the commodity substitution bias, the quality bias, the new goods bias, and the outlet

substitution bias. The commodity substitution bias occurs when the change in the price of a good is followed by a change in the consumption of its substitutes. Since the consumption of the good changes so should the weights in the CPI basket. Inevitably an upward bias arises when the price change is factored into the CPI without updating the weights to reflect the new consumption levels. Both, the new goods bias and the quality bias arise from technological progress that fosters introduction of new or improves in the quality of old goods. The time lag with which the CPI basket is adjusted for inclusion of the new goods is the source of the new goods bias.[1] The CPI does an incomplete job at capturing quality-adjusted prices. Moreover, just as it is the case with the new good bias, any quality updates happen with a considerable lag. The quality bias arises as a consequence of nominal price increases that reflect, unaccounted for by the CPI, quality improvements. The outlet-substitution bias is associated with the increase in popularity of large retailers and warehouse outlets. These stores tend to offer products at prices below the retail average. The bias arises when the CPI fails to capture the fall in average prices. For further discussion on various sources of bias consult Nakamura (1997), Abraham et al. (1998), Boskin et al. (1998) Deaton (1998) and Diewert (1998).

In a Bank of Canada study Crawford (1998) estimates separate components of the Canadian CPI bias. He explores several source specific methods of estimating the bias. For example, in case of the commodity substitution bias, he incorporates a Paasche price index, which, unlike the CPI, employs current rather than base period weights. In other cases he lacks suitable data and instead uses ad hoc approximations and judgments (often based on US results). Crawford estimates the sum of all biases to be about 0.5 percentage

[1] Since 1985 Canadian CPI basket weights has been adjusted in 1985, 1989, 1995, 1998 and 2001, however in the 32 years prior to 1985 there were only five adjustments (Crawford 1998).

points per year with an upper limit of about 0.7 percentage points. His study does not provide a long run perspective on the evolution of Canadian CPI bias over time. Further Crawford does not investigate the extent to which the bias estimates are representative of various segments of Canadian population.

The conclusion that the CPI is a biased measure of inflation has considerable implications. In Canada, as well as in the rest of the developed world, the CPI serves as an indexing tool for a wide variety of purposes. For example: the CPI often indexes pensions, income tax brackets, minimum wages or union contracts. The correct estimate of real economic growth directly affects the perspective from which equity-efficiency debates should be held. In the Canadian context, the arguably most important and timely issues related to the CPI bias are the distributional consequences of indexing social security pensions with the CPI.[2] If it can be shown that the CPI overstates inflation for seniors, then indexing old age pensions by the CPI translates to growth of senior income in real and not just nominal terms. This effect is of course not exclusive to pensions. If the CPI overstates inflation then any benefit indexed by the exaggerated inflation measure will entail an unobserved wealth increase – a fraction of what is deemed an inflation adjustment will in fact be a real increase.

A plausible approach for estimating the bias in the CPI is to examine the movement of Engel Curves over time. Hamilton (2001) and Costa (2001) were first to formalize this method. Engel's Law is a generally accepted proposition in microeconomics. It states that the share of expenditure households spend on food varies inversely with households' income. Food is the most basic necessity and it makes perfect

[2] It is a feature of Canadian economy that employment benefits are tied to an average industrial wage and not to CPI. Consequently, CPI bias has no direct impact on the relative incomes of the unemployed.

sense to expect poor households to sacrifice their discretionary consumption in order to maintain a necessary calorie intake. As households' incomes increase and basic nutritional needs are satisfied, the share of consumption devoted to food typically decreases.

Applying Engel's Law to national levels, we can expect that positive growth of any country's per capita GDP should be accompanied by a decrease in the average food share. While the average share may change, the mapping between food share and household income – the Engel Curve – should, *ceteris paribus*, remain the same from year to year. Recent studies (Hamilton 2001, Costa 2001), conducted using U.S. data, have shown that yearly Engel curves shift progressively to the left over time if income or expenditure figures are deflated by the official price indexes. Both studies found significant evidence in support of the conclusions of the Boskin commission.

In essence, Hamilton and Costa regress food share on the price of food relative to non food items, real income, time dummies and other covariates. Provided that the other covariates account for all the relevant time varying characteristics, the amount of bias is captured by the coefficients on the time dummies. The derivation of Hamilton – Costa estimates is covered in detail in the appendix.

Consequently, the bias estimates are a straightforward function of the coefficients obtained from the regression. As such they depend indirectly on the vector of other explanatory variables. It was this feature of the estimation procedure that prompted Blow (2003) to experiment with various functional forms and to question the robustness of the original results.

Blow conducted a similar study using UK data. Her conclusions differ from those derived through the analysis of US data. She found that a significant portion of what otherwise would be attributed to the CPI bias can be accounted for by the inclusion of the relevant covariates. Her result demonstrates a potential vulnerability inherent within the Hamilton-Costa framework. Their approach is effectively a *residual method*, where the authors attribute to the CPI bias whatever they cannot explain by other available covariates. This method resembles the residual approach common in the wage inequality literature. [3] As such, they are never able to conclude whether the observed outcome is a true result or merely a consequence of a missing variable.

The following scenario offers an example as to why missing a relevant variable may cause potential problems. Changes in mandatory retirement policies are likely to impact enior labor force participation rates. Increases (decreases) in labour force participation rates are likely to, over time, result in larger (smaller) proportion of seniors substituting home cooked meals for meals from restaurants (the more time people spend outside of their homes the more likely they are to eat out). Failing to control for employment status would thus result in spurious estimates of the CPI bias. In other words, the estimates of CPI bias obtained by the Hamilton-Costa method are vulnerable to a missing variable bias.[4]

In Canadian literature the first study building on the Hamilton - Costa methodology has recently been conducted by Beatty and Larsen (2005). To calculate the 1978 - 2000 bias in the Canadian CPI they utilize a flexible non parametric specification.

[3] See for example Wood et al, (1993).
[4] Ideally as argued by Becker in his widely cited 1965 paper, the changes in the price of time and the changes in the household technology are important determinants of household food purchasing and food preparation decisions and should also be included in the analysis.

They focus on demographically well defined household types. They evaluate the bias to be 45% for single adult and 50% for two adult households. These figures are roughly similar to the results I present in section 4 when the samples are comparable, even though in this paper I use the original parametric approach of Costa and Hamilton. While parametric specification suffers from relative limitations regarding functional flexibility it allows for an easy and convenient addition of demographic characteristics,[5] necessary given that I employ fairly broad demographic groups (and a somewhat longer time period). I demonstrate below that these characteristics play an important role thus, section 4 provides results from both the linear in income OLS model of Hamilton and the nonlinear method suggested by Blow.[6]

3. Data and sample selection.

The data for this paper comes from the Canadian Family Expenditure Survey (FAMEX) and the Survey of Household Spending (SHS). I use all the FAMEX surveys[7]. The SHS replaced the FAMEX beginning in 1997 and is based on the same Statistics Canada labor force sampling frame and the same weighting system. I use all of the available SHS surveys (conducted annually between 1997 and 2001). Both FAMEX and SHS surveys over- and under-sample the same geographic areas, and include a number of

[5] Further as shown in Banks et al, (1997) quadratic in real income Engel curves effectively approximate the non - parametric alternatives.
[6] Additionally Blow offers other improvements, e.g. introducing expenditure-demographics interaction terms and demand system estimation.
[7] Specifically these are the Public Use Microdata Files for years: 1969, 1974, 1978, 1982, 1984, 1986, 1990, 1992 and 1996 surveys. The sample sizes are provided in table 1.

identically or nearly identically defined variables. They have been merged according to Statistics Canada guidelines (2000).

The CPI series share a common base, with CPI in 1974 equal to 100. In this paper, the national CPI figures are compared to inflation estimates obtained through the methods described in the preceding section. Year-to-year household specific Laspeyres price indexes are constructed as ratios of the cost of obtaining the same household specific basket in the following year over the basket's cost in the present year. The baskets are constructed as the sum of expenditures on the following composite commodities: food at home, food at restaurants, shelter, medical services and supplies, household operation, household furnishings, car purchases, gasoline, car operation, public transportation, personal care services, personal care supplies, recreation reading and education, alcoholic beverages and tobacco. These expenditures are constructed as products of quantity purchased multiplied by the commodity and region specific[8] price indexes.

A consistent across survey years, sample containing the maximum cross-section of available observations (and as such providing the best possible reflection of Canadian population) has been used for the estimation. In addition to the Canada wide sample, every estimation procedure is repeated for a subsample composed only of senior household and a subsample of non-senior households. For the purposes of this paper, senior households are defined as those headed by an individual aged 65 or older.
The sample was selected as follows. In order to maintain the geographic consistency only observations recorded in urban areas were included. The deletion of rural households was dictated by the fact that the 1982, 1986 and 1992 surveys were conducted over urban

[8] Regions are defined as Atlantic, Quebec, Ontario, Prairies and B.C. The Atlantic and Prairie indexes are weighted averages of provincial indexes, with provincial population used as weights. The provincial price series are available from CANSIM.

samples only. In order to maintain continuity of definitions between the FAMEX and SHS surveys, age of the head of the household was top coded at 76 and bottom coded at 24 years. Household size was top coded at six, number of seniors (age 65 and older) was top coded at two and number of children (age 16 and under[9]) was top coded at three.[10] Additional covariates describing the head of the household are: sex and marital status and indicators of full time and part time employment. A vector of regional dummy variables is also included.[11] Finally, the dependent variable for each model has been defined as a share of total after tax expenditure devoted to food consumed at home. The only trimming not dictated by compatibility across surveys was the deletion of observations belonging to the top and bottom one percentile of food shares and total expenditures in each year. This was done in order to smooth out the excessive noise in the tails of the distributions.

4. Results.

4.1. Heterogeneity of household specific price indexes.

First set of results assess the effectiveness of the CPI in measuring the inflation rates faced by individual senior households. Figure 1 summarizes these results. The two top panels represent the comparison between the CPI and the democratic price indexes for senior and non-senior households respectively. They illustrate that the democratic

[9] Due to change in definitions of explanatory variables between FAMEX and SHS children age 17 were included in SHS surveys.
[10] The top coding had little effect on the results - the analysis was repeated for smaller samples were top coding could be relaxed and the effects on results were negligible.
[11] These are: Atlantic, Quebec, Ontario, Prairies and B.C.

index and the (plutocratic) CPI move in the same direction over time. The difference between the mean democratic index and the CPI never exceeds more than a percentage point for either type of households. Clearly this finding confirms the Denton and Spencer (2000) assessment that the CPI is an equally adequate measure of inflation faced by the seniors and the non-seniors.[12]

The most striking feature of Figure 1, are not the means of the democratic indexes but their variances. As indicated by the scatter in each year and by the two bottom panels of Figure 1 a significant portion of individual indexes falls considerably above or below either the mean democratic index or the CPI. The variance of the distributions of the individual indexes persists regardless of the several improvements already made to the basket.[13] The proportion of individual democratic indexes falling more then one percentage point above or more then one percentage point below the CPI often remains high regardless of how closely does the mean democratic index approximates the CPI. For example between 1990-1991 – during a year when the mean democratic index fell the furthest below the CPI, close to 12% of senior and about 20% of non-senior individual indexes were greater by more than one percentage point than the CPI.

There is little difference between the senior and the non-senior mean democratic indexes. The proportion of senior and non-senior individual indexes falling a significant distance above or below the CPI in each year is very similar. Only the distribution of individual indexes for the 1990-1991, 1992-1993 inflation differs somewhat between

[12] As an alternative to the mean democratic index a median democratic index was tried. Mean and median democratic indexes were very close for most of the years. Thus this modification provided no appreciable additional insight and was subsequently abandoned.

[13] For example, the early analysis was performed excluding medical and shelter expenses – adding them while theoretically warranted failed to provide any appreciable insight. It seems unlikely that further diversification of the already included expenditure categories would significantly reduce the variability of individual indexes.

both groups, with non-seniors experiencing somewhat higher inflation during the former period and seniors experiencing higher inflation during the latter.

4.2. Cumulative bias in the Consumer Price Index.

This section ignores the established above differences between the individual inflation rates, the democratic index and the CPI. To obtain estimates of the cumulative bias in the CPI I run regressions in the form of equations (A5) and (A13) that are derived in the appendix. These are stated below as equations (1) and (2) respectively.[14]

$$w_{it} = \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) + \beta\left(y_{it} - \pi_t\right) + \delta_t D_t + X'\theta + \mu_{it} \quad (1)$$

$$w_{it} = \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) + \beta_1\left(y_{it} - \pi_t - \omega_t D_t\right) + \beta_2\left(y_{it} - \pi_t - \omega_t D_t\right)^2 + X'\theta + \mu_{it} \quad (2)$$

Where: w is food at home share, π_{jt} is the log of one plus the percent cumulative increase in the CPI from year 0 to year t, y is the nominal income, D_t represents a vector of time dummies and X is the vector of other covariates. And where subscript i denotes a family, and subscript t denotes a time period.

Equation (1) is estimated by linear least squares. The correction factors are obtained through the steps outlined in the derivation of equation (A7). Equation (2) is

[14] Just like Hamilton and Costa I too drop the regional differences. Doing so greatly simplifies the calculations and has a negligible effect on results - each equation has been estimated for different geographic sub sample; ex: Ontario, Ontario and Quebec, Ontario Quebec and B.C. etc. and the results were consistent with those obtained from the Canada wide analysis.

estimated through iterative grid search. Once the iterative process is completed the correction factors are generated from the final set of coefficients. The method of generating the correction factors is analogous to the one used for a linear in income specification - the mechanics differ only due to a more complicated functional form of the underlying equation.

The results are summarized in Tables 2 to 5. For brevity, here I provide only the correction factors.[15] It should be noted that nearly all of the correction factors were generated by coefficients that were significant at the 1% level. All relevant coefficients were significant at the 2% level.[16] The correction factors tell by how much the biased CPI should be multiplied in order to arrive at the true levels. Therefore, the cumulative percentage bias in each year can be calculated as: (1-correction factor)x100%. For example: in the first column of Table 2, the figure corresponding to year 1978 is 0.816. It tells us that if we set CPI in 1974 to 100, the official CPI figure for 1978 should be multiplied by 0.816. Consequently the cumulative CPI bias between 1974 and 1978 is 18.4 percent.

Three key features are apparent. First, the results indicate that significant bias in the CPI overstating the inflation faced by Canadian seniors accumulated between 1974 and 1990.[17] During the 1990s relatively little additional bias was added. Second results obtained for senior households are very similar to those for the non-senior households. Third the results demonstrate that the simpler Hamilton method and the more

[15] These correspond to the following part of equation (A8): $\exp\left(-\delta_t / \beta\right)$

[16] Full sets of the regression results are available upon request and will be posted on internet.

[17] The results show that during 1969 to 1974 the CPI understated the inflation. The 1969 bias estimates are similar to 1978 estimates. This result suggests that the pattern of accumulation was reversed somewhere between 1969 and 1978 and that prior to 1974, CPI was understating the inflation. It is not clear why including the 1969 data makes such a difference. One possible explanation is that there were changes in data collection in FAMEX after the first year the survey was conducted.

computationally intensive Costa-Blow approach yield nearly identical results for both groups and for all years before and after the base year.

To address the Blow critique I explore the robustness of the results. Several alternative specifications of demographics controls were tried.[18] First a model with no covariates other than the relative price was estimated. These results are reported in Table 2. Depending on functional specification used they suggest a cumulative correction factor to 2001 of between 0.25 and 0.28 for inflation faced by seniors. The respective correction factors for non seniors are of similar magnitude. These correction factors translate to the CPI overstating inflation by 72 to 75 percent. These results are well in excess of other specifications and of anything reported in the literature for the same time period. As subsequent sensitivity testing shows, they seem to considerably overestimate the bias.

The first set of demographics tried were the age of head, the dummy variable for the presence of children and the household size. The results for specifications including these covariates are presented in table 3. Their addition significantly reduces the total cumulative CPI bias estimate to about 50 percent between 1974 and 2001.

Further sets of demographics were (a) those included in the Table 3 model plus the full time employment indicator, sex of head and marital status and (b) those included in Table 4 plus part time employment indicator, square of the age of head and regional dummies for Atlantic, Quebec, Prairies and B.C.[19] Estimates of specifications including these covariates are presented in Tables 4 and 5 respectively.

There does not appear to be much difference between the senior and the non-senior households. According to both the linear and the quadratic in income specification

[18] In addition to the results presented below a number of results reflecting other specifications are available from the author.
[19] Ontario is used as a base.

the cumulative 1974 to 2001 bias for senior households differs at most by one percent. The only difference seems to be in the rate of accumulation of the bias. For example if the full demographic specification (Table 5) is considered, then it appears that during the re - 1990 period the bias accumulated for senior households was lower than for non-senior households. It was only after 1990 when that trend in accumulation rates was reversed. This result however depends on the specification of demographics and the reverse is true if Table 3 or Table 4 demographic specifications are considered.

The conclusions obtained from the second specification change very little in the third and the fourth model. The data indicates that during the period of perceived economic slowdown, from the 1970s through 1980s, the Canadian economy grew considerably faster than observed. It appears that between 1974 and 1990 the cumulative bias reached about 50 percent. During the eight-year period of 1974 to 1982 the CPI was a poor measure of inflation, overestimating it by about 30 percent. In the following eight-year period the accuracy of the CPI has somewhat improved with the cumulative bias growing by an additional thirteen percent. Since then, the cumulative bias seems to be fluctuating around the 50 percent level.

The reason for the observed gradual improvement in the accuracy of the CPI is unclear. It may be that, the periods with lower rates of accumulation of the CPI bias may be characterized by lower rates of quality improvements and of new goods introduction. This hypothesis is questionable given that most bias accumulated during the period of the perceived economic slowdown and little to no bias accumulated during the period of the so called information revolution. It seems unlikely that; (i) technological progress was accounted for efficiently during a period associated with the introduction of new goods

and quality improvements and (ii) the opposite was true during a period of relative stagnation. Alternatively, this pattern of accumulation, conditional on the assumption of constant preferences over time, suggests a considerable improvement in the quality of updates of the CPI basket weights. This hypothesis is supported by the higher rate of basket updates starting in the second half of 1980s.

Figures 2a to 2c reinforce the above conclusion. They show the mapping of the semi-parametric (nonparametric in log expenditure), senior, yearly Engel curves obtained through the differencing method of Yatchew (1998).[20] Throughout the 1970s and 1980s, when expenditure records are deflated by the official CPI figures the yearly Engel curves map progressively to the left as time goes by. This pattern means that the cumulative CPI bias kept increasing between surveys conducted over those sixteen years. The Engel curves drawn for the 1990s show no movement. They lie on top of one another, confirming the conclusion that the CPI measured inflation accurately during the 1990s.

5. Conclusion

I look at two areas of limitations of the CPI as a measure of inflation faced by senior Canadians. I investigate the variation in the observed, individual, household specific inflation rates and I look at the extent to which the observed CPI overstates the true mean inflation rate. I compare these results with results relevant for the non-senior Canadian households.

[20] The linear (differenced) terms are all of the covariates included in Table 4. Figures for non-seniors and for Canada as a whole show the same pattern and are available from the author.

I present evidence of considerable variation in inflation rates faced by individual households. While the mean democratic index and the CPI remain within one percentage point of one another, a significant proportion of individual, senior inflation rates fall a number of percentage points away from the CPI. This variation is independent of the CPI overstating the inflation and persists even during the periods when the CPI accurately approximates the average inflation rate.

Apart for finding significant variation in individual inflation rates, I use a variation of the Engel method proposed by Hamilton (2001) and Costa (2001) to estimate the bias in the Canadian Consumer Price Index. I use the broadest sample available. Figure 3 provides the comparison between the actual (corrected) and the official measures of inflation. I find that the results are robust to various functional specifications. The CPI estimates corrected using the linear in income Hamilton method and quadratic in income Costa-Blow method are nearly equivalent.

I find evidence that from the mid 1970s till the end of the 1980s the Canadian CPI overestimated the true inflation faced be seniors by about 50 percent. I also find that the CPI has been reasonably accurate during the 1990s, which is during the period of more frequent CPI basket updates. The mapping of the semi-parametric yearly Engel curves reflects these results. During the first two decades Engel curves map progressively to the left as time goes by. The Engel curves corresponding to surveys conducted during the 1990s show no such pattern and map over the same space.

Denton and Spencer (2000) concluded that "*If the official Statistics Canada CPI is deemed to be satisfactory as an index of inflation for the average Canadian household, all ages combined, it is also then a satisfactory index for older households…*" This paper

confirms the above conclusion, or rather it confirms its corollary - my research shows that the limitations of the CPI as a measure of inflation are equally present when looking at either the senior or the non-senior segments of Canadian population. The results presented in this paper suggest, that average Canadian incomes grew faster than indicated by official statistics. Due to the fact that social security benefits are indexed by the CPI, the incomes of the traditionally vulnerable seniors outpaced true inflation and grew in real terms. This unobserved growth was not present during and after the 1990s when seniors' nominal income growth closely resembled the true inflation rate. The variance of individual inflation rates was high in every year, it remained high even when the growth of cumulative bias stopped. A significant proportion of senior households experienced inflation rates considerably higher than the CPI.

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Table 1. Yearly sample sizes.

Year	Sample size	
	Senior headed	Not senior headed
1969	927	5,200
1974	1,111	5,159
1978	689	4,045
1982	995	5,673
1984	758	3,835
1986	930	4,429
1990	790	3,592
1992	877	4,025
1996	1,451	6,063
1997	2,324	9,416
1998	1,915	8,122
1999	2,189	9,096
2000	2,059	7,874
2001	2,229	8,738

Table 2.
Correction factors*
(no additional covariates).

Year	Specification linear in expenditure		Specification linear and quadratic in expenditure	
	Senior headed	Not senior headed	Senior headed	Not senior headed
1969	0.657	0.718	0.668	0.731
1974	1.000	1.000	1.000	1.000
1978	*0.816*	0.779	0.865	0.792
1982	0.498	0.536	0.560	0.553
1984	0.378	0.452	0.434	0.468
1986	0.391	0.457	0.457	0.472
1990	0.290	0.341	0.335	0.354
1992	0.268	0.264	0.308	0.271
1996	0.243	0.261	0.276	0.269
1997	0.248	0.227	0.282	0.231
1998	0.245	0.219	0.278	0.222
1999	0.263	0.260	0.298	0.266
2000	0.251	0.246	0.283	0.250
2001	0.247	0.253	0.280	0.258

* These values indicate how much should the biased CPI be multiplied in order to arrive at true levels. Therefore, the cumulative percentage bias in each year can be calculated as: (1-correction factor)x100%

** Unless specified otherwise all underlying yearly dummy coefficients are significant at the 1% level. Italics indicate bias estimates generated by yearly dummies significant at 2% level only. All underlying log expenditure coefficients are significant at 1% level.

Table 3.
Correction factors*
(additional covariates: age of head, presence of children and household size).

Year	Specification linear in expenditure		Specification linear and quadratic in expenditure	
	Senior headed	Non senior headed	Senior headed	Non senior headed
1969	0.758	0.764	0.753	0.765
1974	1.000	1.000	1.000	1.000
1978	*0.905*	0.931	0.919	0.931
1982	0.692	0.748	0.709	0.748
1984	0.602	0.693	0.619	0.693
1986	0.627	0.701	0.649	0.701
1990	0.540	0.607	0.556	0.607
1992	0.501	0.524	0.513	0.525
1996	0.481	0.503	0.492	0.504
1997	0.493	0.474	0.504	0.476
1998	0.493	0.468	0.502	0.470
1999	0.510	0.501	0.520	0.502
2000	0.494	0.492	0.503	0.494
2001	0.491	0.499	0.501	0.500

* These values indicate how much should the biased CPI be multiplied in order to arrive at true levels. Therefore, the cumulative percentage bias in each year can be calculated as: (1-correction factor)x100%

**Unless specified otherwise all underlying yearly dummy coefficients are significant at the 1% level. Italics indicate bias estimates generated by yearly dummies significant at 5% level only. All underlying log expenditure coefficients are significant at 1% level.

Table 4.
Correction factors*
(additional covariates: age of head, presence of children household size, full time employment indicator, sex of head and marital status).

Year	Specification linear in expenditure		Specification linear and quadratic in expenditure	
	Senior headed	Non senior headed	Senior headed	Non senior headed
1969	0.762	0.771	0.756	0.771
1974	1.000	1.000	1.000	1.000
1978	*0.916*	0.934	0.934	0.934
1982	0.701	0.755	0.724	0.755
1984	0.608	0.703	0.632	0.703
1986	0.640	0.714	0.670	0.714
1990	0.548	0.618	0.571	0.618
1992	0.506	0.538	0.524	0.538
1996	0.485	0.517	0.501	0.517
1997	0.496	0.488	0.511	0.488
1998	0.493	0.483	0.507	0.483
1999	0.514	0.516	0.530	0.517
2000	0.499	0.509	0.513	0.510
2001	0.499	0.516	0.514	0.516

* These values indicate how much should the biased CPI be multiplied in order to arrive at true levels. Therefore, the cumulative percentage bias in each year can be calculated as: (1-correction factor)x100%

**Unless specified otherwise all underlying yearly dummy coefficients are significant at the 1% level. Italics indicate bias estimates generated by yearly dummies significant at 10% level only. All underlying log expenditure coefficients are significant at 1% level.

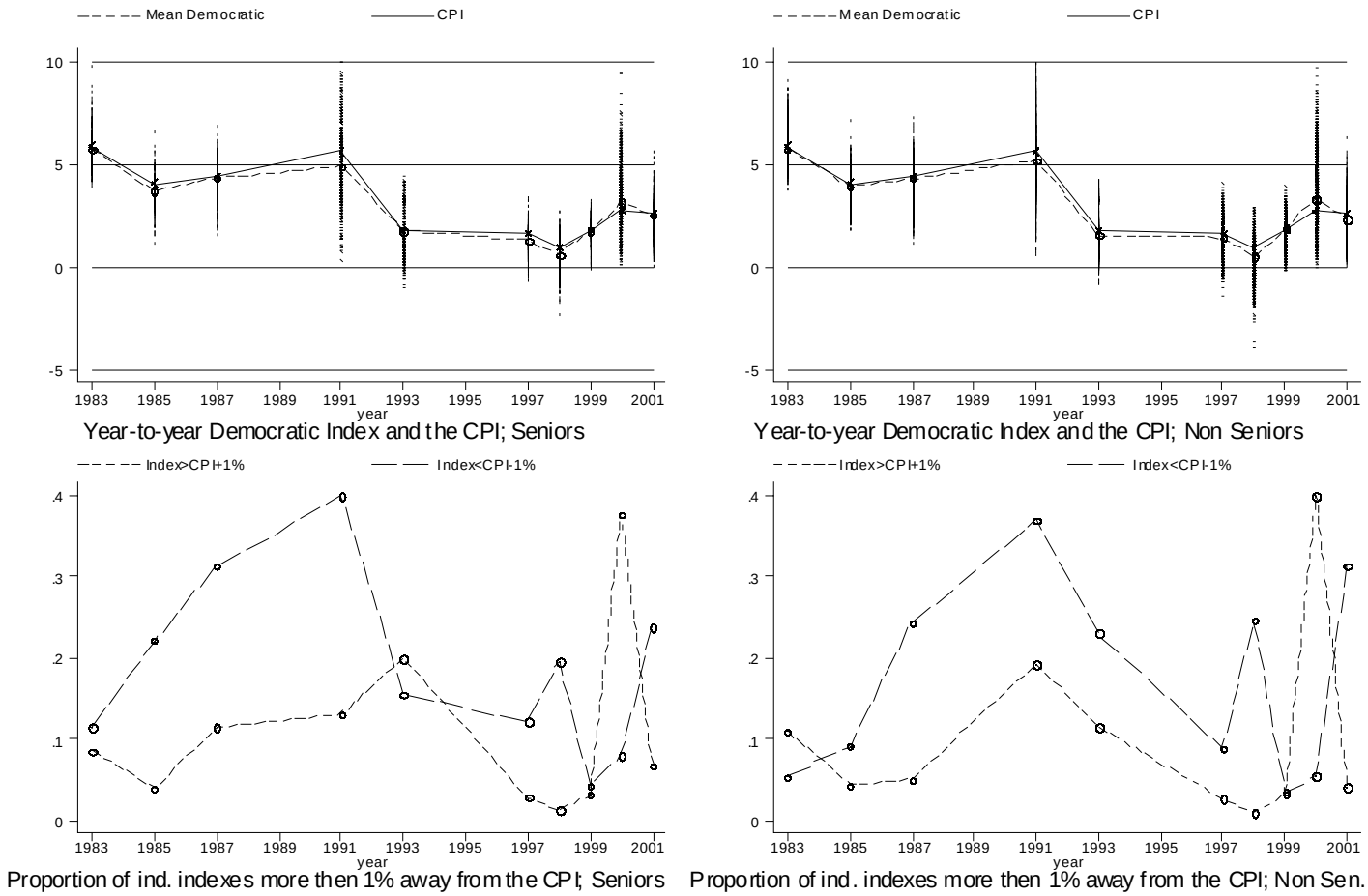
Table 5.
Correction factors*
(all additional covariates).

Year	Specification linear in expenditure		Specification linear and quadratic in expenditure	
	Senior headed	Non senior headed	Senior headed	Non senior headed
1969	0.897	0.898	0.852	0.902
1974	1.000	1.000	1.000	1.000
1978	*0.872*	0.889	0.902	0.892
1982	0.647	0.703	0.683	0.706
1984	0.571	0.664	0.603	0.670
1986	0.562	0.629	0.604	0.634
1990	0.509	0.569	0.539	0.580
1992	0.504	0.530	0.525	0.544
1996	0.483	0.509	0.503	0.526
1997	0.523	0.505	0.536	0.521
1998	0.518	0.500	0.531	0.516
1999	0.521	0.514	0.537	0.532
2000	0.507	0.511	0.522	0.527
2001	0.494	0.507	0.511	0.522

* These values indicate how much should the biased CPI be multiplied in order to arrive at true levels. Therefore, the cumulative percentage bias in each year can be calculated as: (1-correction factor)x100%

**Unless specified otherwise all underlying yearly dummy coefficients are significant at the 1% level. Italics indicate bias estimates generated by yearly dummies significant at 10% level only. All underlying log expenditure coefficients are significant at 1% level.

Figure 1. CPI vs. the Democratic index.[21]



[21] The year scale on the horizontal axis refers to year to year changes in the indexes. For example the year 1983 corresponds to changes in the price index from 1982 to 1983.

Figure 2a. Engel curves for food at home, seniors, selected years 1974-2001.

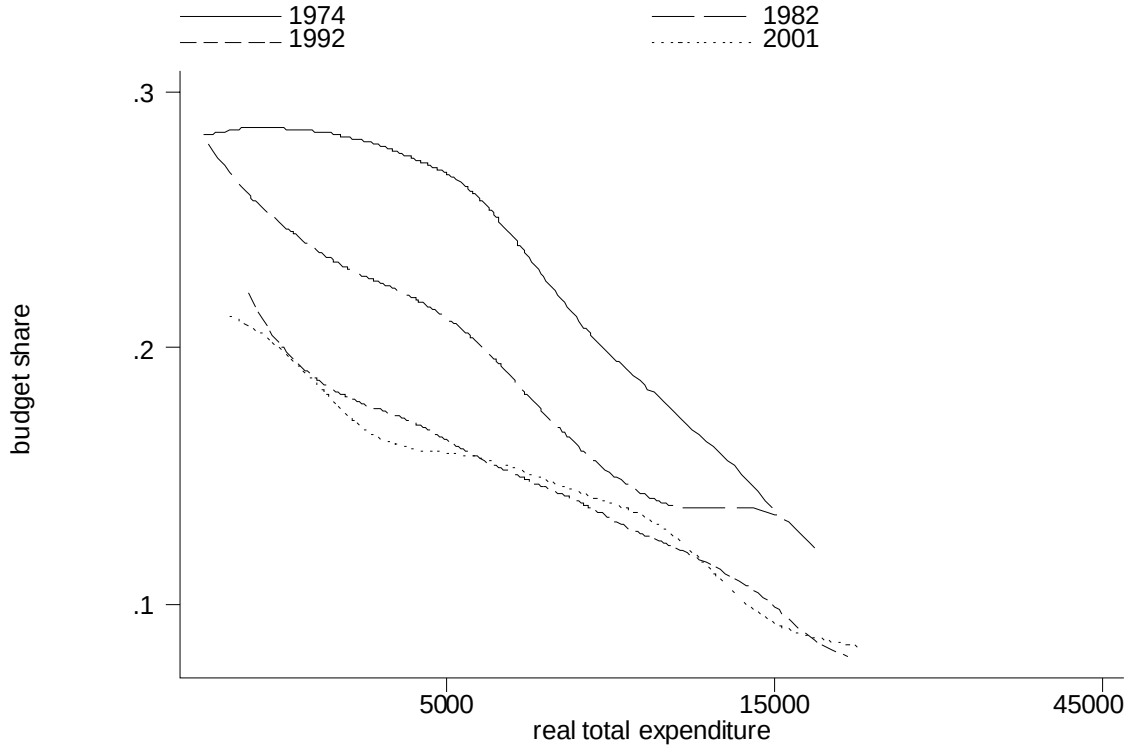


Figure 2b. Engel curves for food at home, seniors, selected years 1970s and 1980s.

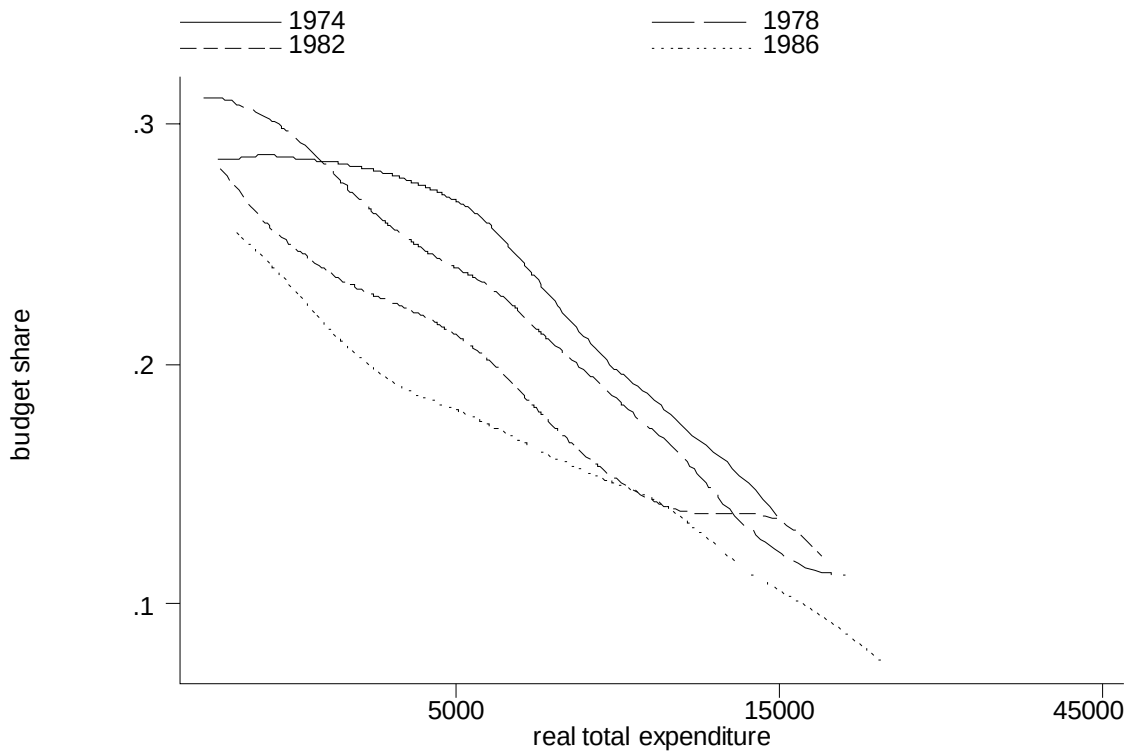


Figure 2c. Engel curves for food at home, seniors, selected years 1990s.

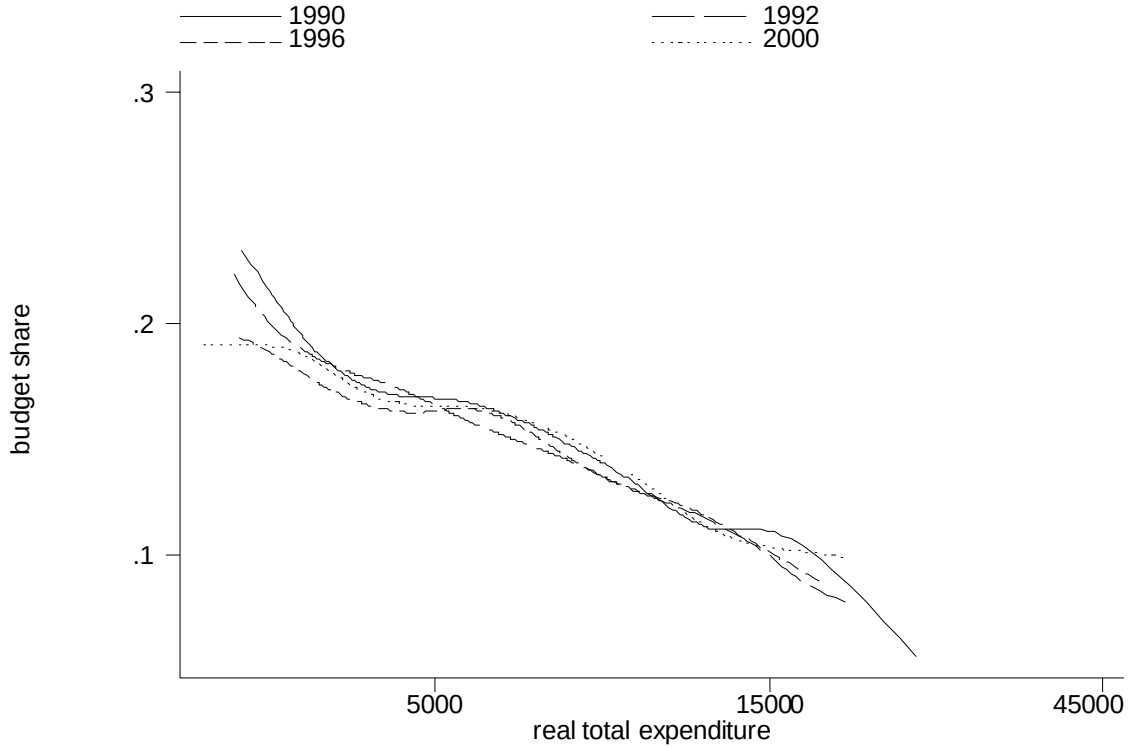
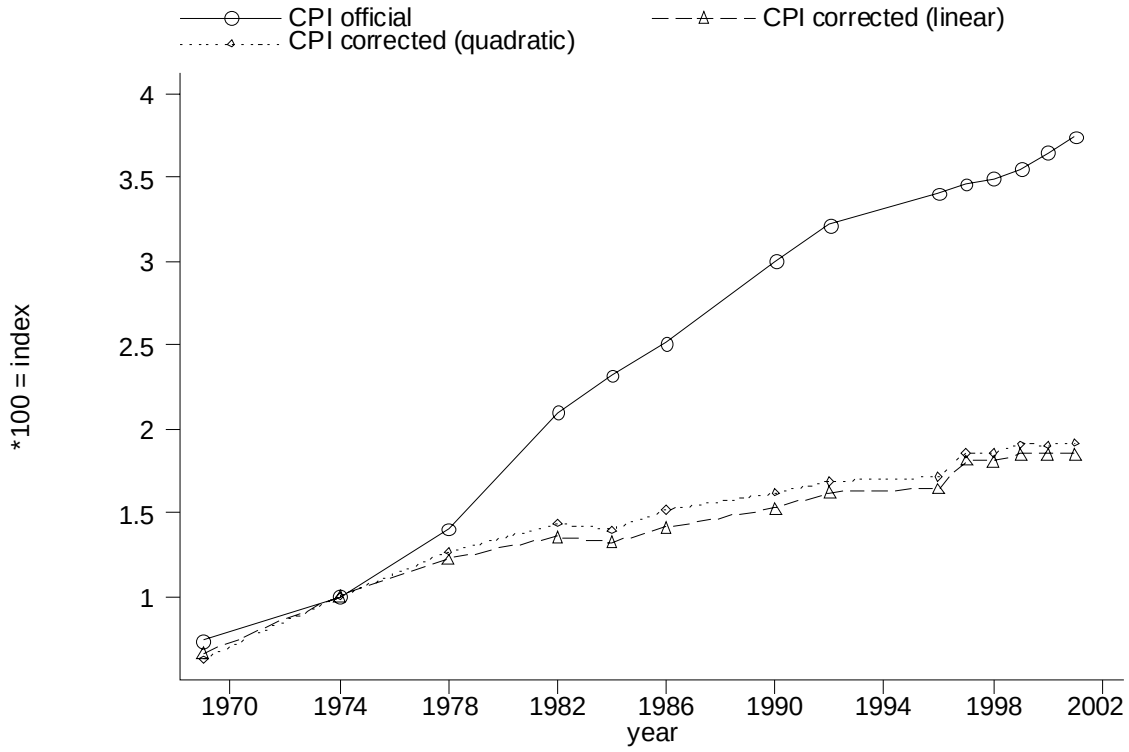


Figure 3. CPI official figures vs. corrected estimates, seniors, all covariates.



Appendix: The derivation of the Hamilton/Costa bias estimates.

Hamilton chooses the following formulation to specify the food budget share equation (the Engel curve):

$$w_{ijt} = \phi + \gamma\left(\ln p_{fjt} - \ln p_{njt}\right) + \beta\left(\ln y_{ijt} - \ln p_{jt}\right) + X'\theta + \mu_{ijt} \qquad \text{(A1)}$$

Where: w is food at home share, p_f is the true price of food for family, p_n is a true price of non-food p_{jt} is the true price level, y is the nominal income and X is the vector of other covariates. And where subscript i denotes a family, subscript j denotes a geographic area and subscript t denotes a time period.

The term inside the first bracket of the equation (1), can therefore be interpreted as the log of relative price of food and the term inside the second bracket as the log of real income. Hamilton notes that any price level can be decomposed into the following:

$$\ln p_{jt} = \ln p_{j0} + \ln\left(1+\Pi_{jt}\right) + \ln\left(1+\mathrm{E}_{jt}\right) \qquad \text{(A2)}$$

Where: p_{j0} is true price level at time 0, Π_{jt} is the percent cumulative increase in the CPI from year 0 to t and E_{jt} is the percent cumulative measurement error. Hamilton simplifies the notation by choosing:

$$\begin{aligned} \pi_{jt} &= \ln\left(1+\Pi_{jt}\right) \\ \varepsilon_{jt} &= \ln\left(1+\mathrm{E}_{jt}\right) \end{aligned} \qquad \text{(A3)}$$

Substituting (A3) into (A2) and then (A2) into (A1) generates:

$$\begin{aligned} w_{ijt} &= \phi + \gamma\left(\pi_{fjt} - \pi_{njt}\right) \\ &+ \beta\left(y_{ijt} - \pi_{jt}\right) + X'\theta \\ &+ \gamma\left(\varepsilon_{fjt} - \varepsilon_{njt}\right) - \beta\varepsilon_{jt} \\ &+ \gamma\left(p_{fj0} - p_{nj0}\right) - \beta p_{j0} + \mu_{ijt} \end{aligned} \tag{A4}$$

which after dropping the regional differences can be estimated it by:

$$\begin{aligned} w_{it} &= \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) \\ &+ \beta\left(y_{it} - \pi_{t}\right) + X'\theta \\ &+ \delta_t D_t + \mu_{it} \end{aligned} \tag{A5}$$

Where D_t represents a vector of time dummies. The coefficients of the time dummies reflect, c*eteris paribus*, the extent of the cumulative bias in the economy. The terms in the equation (A4) denoted by a subscript 0 are constants. It follows that:

$$\delta_t = \gamma\left(\varepsilon_{ft} - \varepsilon_{nt}\right) - \beta\varepsilon_t \tag{A6}$$

At this point Hamilton assumes that the bias in price of food and non-food is equal. Hence:

$$\varepsilon_t = \frac{-\delta_t}{\beta} \tag{A7}$$

and that the bias in each year can be calculated as:

$$\mathrm{E}_t = 1 - \exp\left(\frac{-\delta_t}{\beta}\right) \tag{A8}$$

Costa takes equation (A1) and modifies it to incorporate a square of the log of real income;

$$\begin{aligned} w_{ijt} &= \phi + \gamma\left(\ln p_{fjt} - \ln p_{njt}\right) \\ &+ \beta_1\left(\ln y_{ijt} - \ln p_{jt}\right) + \beta_2\left(\ln y_{ijt} - \ln p_{jt}\right)^2 \\ &+ X'\theta + \mu_{ijt} \end{aligned} \tag{A9}$$

The inclusion of the quadratic real income term in the budget share equation allows for adding a degree of curvature into Engel curves. Banks et al, (1997) demonstrate how quadratic in real income Engel curves effectively approximate their accurate non-parametric depiction.[22]

Substitution of equations (A2) and (A3) that decompose the price levels and simplify the notation, followed by again dropping the regional differences yields:

$$\begin{aligned} w_{it} &= \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) \\ &+ \beta_1\left(y_{it} - \pi_t\right) + \beta_2\left(y_{it} - \pi_t\right)^2 + X'\theta \\ &- \beta_1\varepsilon_t - \beta_2\varepsilon_t^2 \\ &- 2\beta_2\left(y_{it} - \pi_t\right)\varepsilon_t + \mu_{it} \end{aligned} \tag{A10}$$

[22] An added benefit of the quadratic in real income Engel curves specification (albeit one less important when food is the good considered) is that it allows for goods to be treated as either necessities or luxuries depending on the level of income.

Which in turn can be estimated by:

$$\begin{aligned} w_{it} &= \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) \\ &+ \beta_1\left(y_{it} - \pi_t\right) + \beta_2\left(y_{it} - \pi_t\right)^2 + X'\theta \\ &+ \delta_1 D_t \\ &+ \delta_2\left(y_{it} - \pi_t\right) D_t + \mu_{it} \end{aligned} \tag{A11}$$

Clearly the equation is overidentified and cannot be estimated by ordinary least squares. Since linear estimation cannot be used to effectively extract the bias component, nonlinear numerical methods can be used as an alternative. Blow suggests the following approach: Equation (A10) can simply be written as:

$$\begin{aligned} w_{it} &= \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) \\ &+ \beta_1\left(y_{it} - \pi_t - \varepsilon_t\right) + \beta_2\left(y_{it} - \pi_t - \varepsilon_t\right)^2 \\ &+ X'\theta + \mu_{it} \end{aligned} \tag{A12}$$

and approximated by:

$$\begin{aligned} w_{it} &= \phi + \gamma\left(\pi_{ft} - \pi_{nt}\right) \\ &+ \beta_1\left(y_{it} - \pi_t - \omega_t D_t\right) + \beta_2\left(y_{it} - \pi_t - \omega_t D_t\right)^2 \\ &+ X'\theta + \mu_{it} \end{aligned} \tag{A13}$$

Solving for ω_t's allows for the derivation of the bias estimates.

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