True Cost of Living Measures for 10 Provinces: Using an Engel Curve Approach

Herb Emery
Xiaolin Guo

Department of Economics
University of New Brunswick

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Abstract

In Canada, the Consumer Price Index (CPI) is an official measure of cost of living which is used by government, policymakers, and businesses to index wage and salary adjustments, public pension payments, tax brackets, minimum wages, social assistance transfers, and so forth. If the CPI does not accurately represent the cost of living, taxpayers can end up paying more than intended, and households may receive less in the form of transfers and wages. It is therefore essential that the "true cost of living" is measured accurately.

With Survey of Household Spending data from 1997 to 2015, we follow an Engel Curve approach to estimating CPI bias, which is inferred from consumers' behavior and is used to construct "true cost of living" measures for subgroups of the Canadian population in all ten provinces. Overall, we find that the official CPI contains substantial biases that increased in size after the 2008/2009 recession. Although the official CPI suggests there were no significant shocks to the economy in terms of cost of living, our estimates suggest that households in Canada experienced sharp increases in cost of living and decreases in real income after 2009. For females and households with children, these shocks have resulted in a persistently higher cost of living than those represented by the official CPI.

Introduction

The Consumer Price Index (CPI) represents the costs of reference consumption bundles, or market baskets of goods and services, for broad geographies. The CPI is used to index wage and salary adjustments in contract negotiations; to index public pension payments and tax brackets; to evaluate the temporal adequacy of minimum wages and social assistance transfers; and so forth. Therefore, if the CPI does not accurately represent the cost of living, or changes to the cost of living, the additional costs are borne by taxpayers who may pay more than was intended under policy adjustments. Likewise, cost of living adjustments that underestimate the actual changes to cost of living may result in households receiving too little due to insufficient increases in transfers or wages.

Many studies agree that the CPI is a biased measure of the true cost of living (Brzozowski, 2006; Costa, 2001; Hamilton, 2001a, 2001b). In particular, it is believed that the official CPI measurements overstate the true cost of living due to the availability of new goods, the improved quality of goods, and changes in the consumption patterns of households.[1] For instance, while the CPI is constructed using the data for representative households, consumption patterns differ across identifiable groups like seniors and non-seniors and may differ from those of average or representative households. Hence, the CPI may mismeasure the cost of living and changes to the cost of living for specific sub-groups.

When using real income to measure a household's standard of living, one must consider nominal income and the purchasing power of that income at the prevailing prices of goods and services. The purchasing power of income determines the affordability of consumption goods and leisure. Although information about the variability of nominal incomes of households by locations and characteristics of households is available, Canadians tend to rely on a single index of cost of living: The Consumer Price Index (CPI).

In New Brunswick, there is a single price index for the province and another index for the CMA of Saint John. Price data used to construct the index are primarily collected in Saint John, which leads us to ask how well the CPI for New Brunswick represents the cost of living for residents outside of Saint John. How well does it represent the cost of living in rural versus urban areas? For males versus females? For families with children versus those without children? For families with higher incomes versus those with lower incomes?

Is it possible to come up with a measure that better reflects the "true cost of living" than the official CPI? To address this question, we follow Costa (2001), Hamilton (2001a, 2001b), and Brzozowski (2006) and use an Engel Curve approach to estimate the size of the bias in the CPI, which in turn is used to adjust the official CPI to construct a "true cost of living" measure. The adjustments made to the CPI are inferred from consumers' behaviors and can be applied to identifiable sub-groups and sub-geographies.

Engel's Law states that the share of food in a household's budget is inversely related to the household's real income. An Engel Curve describes the relationship between the food share of a

[1] Ambler and Kronick (2018, p. 33) report that The Bank of Canada estimates that the CPI overstates the cost of living by approximately 0.5 percent a year.

household budget and a household's real income. We can estimate CPI bias by measuring the inconsistency between changes in the food budget share and changes in real income measured as nominal income deflated by the official CPI.

If household preferences are stable and there are no systematic errors in variables, there should be no systematic movement in the Engel Curve from one year to another (Hamilton, 2001a). If the CPI accurately measures real income, changes in food shares will move along the Engel Curve. However, if a bias in the CPI results in the mismeasurement of real income, changes in food budget shares will reflect a movement along the Engel Curve plus a shift in the location of the curve.

The Engel Curve approach to identifying CPI bias amounts to estimating the location of the Engel Curve, based on real incomes measured using a CPI deflator, and estimating the size of systematic deviations from that curve for groups or geographies by year. If food budget shares are lower (higher) than what the CPI-deflated measure of real income would predict, we can infer from consumer behavior that the real incomes are higher (lower) than suggested by the CPI. That is, the true cost of living is lower (higher) than that measured by the official CPI for a given year and/or a given group of interest.

In this study, we apply the Engel Curve approach to estimating CPI bias by using cross-sectional data from Statistics Canada's Survey of Household Spending (SHS) from 1997 to 2015. Following Hamilton (2001a), we use samples stratified by defined sub-groups and geographies to estimate group- and geography-specific CPI biases. We then use these biases to adjust the official CPI and produce group- and geography-specific indexes for the true cost of living.

Overall, we find that the provincial CPI measurements of the cost of living have significant biases that differ by demographic and economic groups. After 2009, these bias estimates suggest a sharp increase in the cost of living and a decrease in real incomes for all Canadian households – an economic shock that persisted beyond 2012, particularly for females and households with children. Further investigation shows that the income elasticity of food expenditure increased after 2009, also suggesting lower real incomes. Finally, the structural change in the location and slope of Engel Curves after 2009 coincides with a tightening of access to consumer credit and consumers paying down debt during a time of rapid increases in gasoline, energy, and food prices.

Engel's Law and Food Consumption

An Engel Curve describes the relationship between a household's food budget share and its income. According to Engel's Law, if nominal income deflated by the official CPI accurately measures the real income of a household (i.e., the true purchasing power of its income), the relationship between the share of the household budget spent on food and the amount of real household income should be stable (Brzozowski, 2006). In other words, if the cost of living is accurately measured by the official CPI, when incomes change, the change in the food budget share will be described as a movement along the Engel Curve.

When applying Engel's Law, there are advantages to measuring food as a consumption good (Costa, 2001; Hamilton, 2001a, 2001b). Food is a necessary good; therefore, as household incomes increase and basic nutritional needs are met, the share of food expenditure in a budget typically falls (Brzozowski, 2006). Food budget shares are sensitive to changes in real income and to mismeasurement of income because the income elasticity of food is typically less than 1. Moreover, food is non-durable, which means that expenditure today is for consumption today, as opposed the purchase of a car, which will cover consumption today and in future. Food is also separable from non-food in terms of consumer preferences, meaning the share of food in the household budget will not be influenced by complementarity and substitutability with non-food goods. Finally, food prices and food expenditures have been regularly tracked by Statistics Canada since the 1970s, and food lacks some of the definitional problems facing other goods, like recreation (see Costa, 2001).

In Engel Curve studies, authors often use expenditures on food consumed at home for the food expenditure measure. For example, a previous Canadian study of the CPI bias for seniors (Brzozowski, 2006) measures the budget share for food consumed at home. Alternatively, however, one can use total food expenditure as a measure, which includes spending on meals outside of the home at places like restaurants. Hamilton (2001a) observes that if home-cooked and restaurant meals are perfect substitutes, the dependent variable for analysis should be the total food expenditure share of the budget. Following Hamilton (2001a), we consider total food expenditure in our analysis.

Data and Estimation Approach

This paper follows Costa (2001) and Hamilton (2001a, 2001b) in adopting the empirical approach for estimating the CPI bias, which in turn is rooted in Deaton and Muellbauer's "Almost Ideal Demand System" (1980). Using data from the Survey of Household Spending (SHS) for the years 1997 to 2015, we estimate the bias in CPI by examining the movements of Engel Curves over time. We use robust standard errors in STATA.

The household data in this paper were all obtained from SHS microdata files in the Statistics Canada Research Data Centre at the University of New Brunswick. In the original SHS files, the naming conventions for the variables changed annually; therefore, we manually revised the variable names for consistency in our regression models.

Data for the CPI from 1997 to 2015 for all ten Canadian provinces[2] are from CANSIM. The annual CPI data for all items (2002=100), and for food and non-food items, are from CANSIM Table 326-0021 (Consumer Price Index, annual). To calculate the inflation rate of food, we used the food weight data of the CPI, taken from CANSIM Table 326-0031 1, 2, 9 (Basket Weights of the CPI).

The food share of household expenditure is derived by dividing each household's expenditure on food by the total expenditure of each household. Based on analyses of the food share of

[2] Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia

household expenditure by different income levels, we exclude households with real expenditure greater than $75,000.

$\ln\left(\frac{CPI_t}{CPI_{2002}}\right)$ measures each year's cumulative inflation rate.

The CPI bias is estimated for 11 (not mutually exclusive) samples: All households, Urban households, Rural households, Males, Females, Married families, Unmarried families, Families with children, Families without children, Households with lower income (below median income), and Households with higher income (above median income).[3]

Following Hamilton (2001a, 2001b), we specify the Engel Curve equation as follows:

$$\omega_{ijt} = \emptyset + \alpha\left(\pi_{f,jt} - \pi_{nf,jt}\right) + \beta\left(\mathrm{y}_{\mathrm{ijt}} - \pi_{jt}\right) + \sum_{t=1998}^{T} \delta_t D_t + \sum_{j=1}^{J} \delta_j D_j + X'_{ijt}\,\theta + \mu_{ijt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1).$$

Table 1 below presents the definition of each variable.

Table 1: The definition of each variable	
ω_{ijt}	Food share of family *i*'s expenditure in year *t* and in province *j*
π_{jt}	Logarithm of all-items CPI for province *j* in year *t* (2002=100)
$\pi_{f,jt}$	Logarithm of CPI for food items in year *t* in province *j* (2002=100)
$\pi_{nf,jt}$	Logarithm of non-food item CPI year *t* in province $j = \pi_{jt} - food\ weight_{jt} * \pi_{f,jt}$
y_{ijt}	Logarithm of current dollar household expenditure of family *i* in year *t* in province *j*
D_t	Year dummy equals 1 in year *t*; 0 otherwise
D_j	Province dummy equals 1 for province *j*; 0 otherwise
X'_{ijt}	Other covariates: household size, age, urban/rural, sex, married, and children aged 0-14 in the home
μ_{ijt}	Error term of the model

[3] For defining a lower income sample (below median income) and higher income sample (higher than median income, we used information on median incomes by province from CANSIM Table 206-0041 (Low income statistics by age, sex and economic family type, Canada, provinces and selected CMAs, annual).

In Engel's Law, if nominal income deflated by the official CPI accurately measures the real income of a household (the true purchasing power of its income), the relationship between the share of the household budget spent on food and real household income should be stable (Brzozowski, 2006). Thus, any form of CPI bias can be represented by time-dummy variables, since the shift in the constant term for the Engel Curve represents the extent to which real income is mismeasured by the CPI in year *t*. Using the Hamilton-Costa method, we assume that the degree of CPI bias in food and non-food items is approximately the same.

The CPI bias is calculated as the ratio of the coefficient estimate for a given year dummy variable divided by the coefficient estimate for the real expenditure (income) measure. It measures how much lower (higher) cost of living would need to be to have a real income high (low) enough to produce the observed food expenditure share in year *t*. The cumulative bias in the CPI in year *t* from the base year is calculated as follows:

$$\text{Bias}_t = \left(1 - \exp\left(-\frac{\delta_t}{\beta}\right)\right) \cdot 100 \qquad \text{(2).}$$

The estimate of the cumulative bias in the CPI can be used to adjust the official CPI to produce a "true cost of living" measure, which we refer to as the adjusted CPI:

$$CPI_t^{Adj} = CPI_t \cdot \exp\left(-\frac{\delta_t}{\beta}\right) \qquad \text{(3).}$$

The adjusted CPIs can be made specific to groups simply by estimating Model (1) for stratified samples.

Pooling Cross-Sections and Accounting for Structural Breaks in the Engel Curve

The administrative and household coverage of the SHS changed in 2010, and Statistics Canada has consequently stated that post-2009 data from the SHS should not be compared with earlier SHS data (Statistics Canada, 2017). Costa (2001) encountered a similar issue when pooling American survey data and observes that if the underlying parameter estimates of the econometric model are stable across surveys, they can be pooled. Costa combines survey data from different years only if including data from an additional survey does not change the estimates of slope coefficients of the model (the methodology by design exploits shifts in the constant term).

In our case, we do not find that post-2009 parameter estimates are the same as for earlier survey years. Therefore, by Costa's rule, we do not include all years of data when estimating our models. Instead, we estimate the models using one sample of 1997-2009 data and a second sample of 2010-2015 data. In each model, total expenditure is deflated to constant dollar terms using the cumulative CPI changes since 2002.

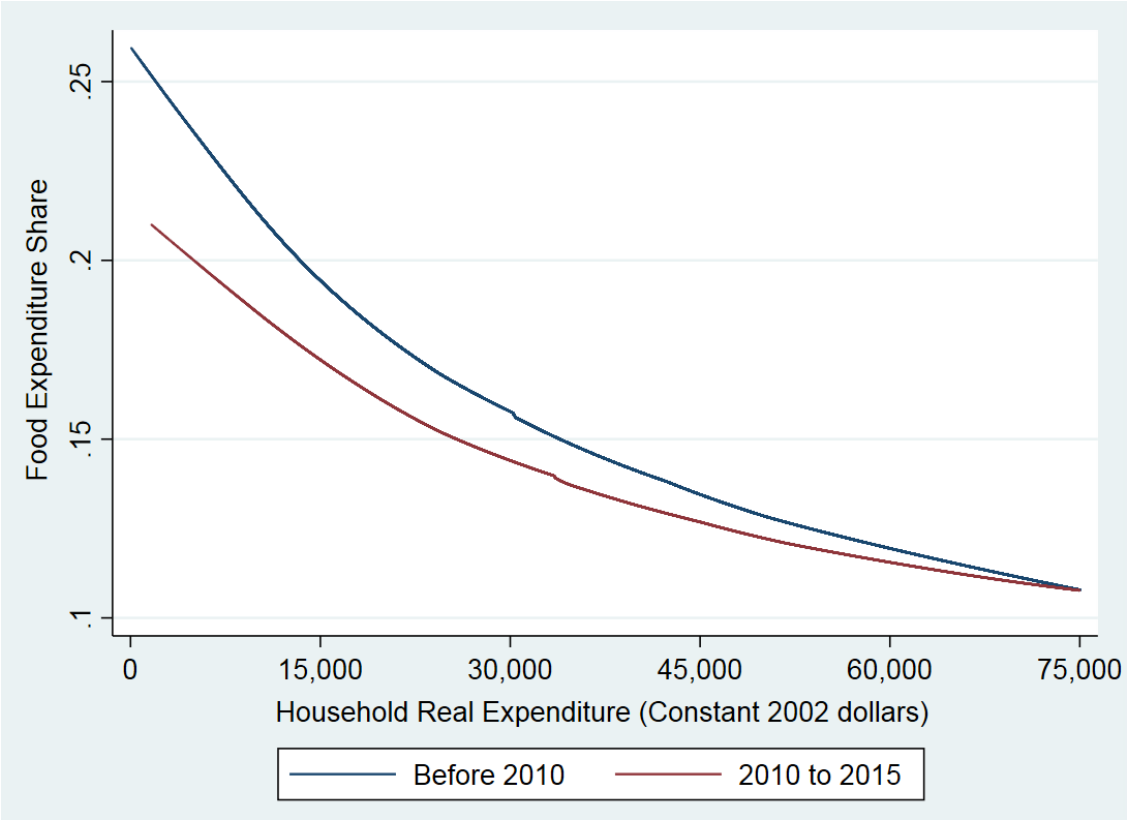
We determined that the years 2010-2015 produce an Engel Curve statistically distinct from that of the pre-2009 SHS sample. The structural change in the Engel Curve after 2009 complicates

the calculation of cumulative bias estimates. The shift in the Engel Curve after 2009 means that the cumulative bias estimates for the 2007-2009 sample and the 2010-2015 sample are not directly comparable.

After 2009, the CPI bias is measured by the distance of the observed food expenditure from the latter period's fitted Engel Curve, whereas the earlier bias is measured relative to the earlier period's Engel Curve.

To address this problem, we adjust the reference for the CPI bias estimate to the fitted pre-2010 Engel Curve. Using the fitted Engel Curves for the two periods, we calculate the difference in the food budget shares between the old and new Engel Curves for the post-2009 samples. This allows us to adjust for the distance between the fitted Engel Curves that resulted from the cost of living shock after 2009 in year *t* and the Engel Curve predicted by the earlier model.

Figure 2: Fitted Engel Curves for Food, 1997-2009 and 2010-2015 Samples



Fitted from models using SHS microdata from RDC

We wish to note that there are several different ways to interpret the differences between the Engel Curves before and after 2010. First, we recognize that changes in the SHS administration after 2009 may render these two curves non-comparable. However, if we can compare the fitted Engel Curves, there are two primary ways to interpret the implications of the 2010-2015 Engel Curve being lower than the 1997-2009 Curve.

On one hand, if food expenditures increased at a slower rate than total expenditures, perhaps the lower Engel Curve arose from the higher purchasing power of income after the 2008/2009 recession. Alternatively, if food expenditures fell faster than other expenditures, the lower Engel Curve after 2009 likely results from the lower purchasing power of income after the recession.

Results

Coefficient estimates are available for all samples in the Appendix.

The dependent variable in the work we present is the total food expenditure share of total household expenditures. Although Brzozowski (2006) uses expenditure on food in the home in his study, we found that when expenditure on food in the home was the dependent variable, the Engel Curve was never stable in terms of income/expenditure elasticities and price elasticities for each province by year.

We interacted all control variables, real income, and the relative price of food with year dummies. F-tests determined that when the budget share of food in the home was the dependent variable, the coefficient estimates for the real income and relative price variable were statistically different each year, suggesting the Engel Curve was not stable over the study period.

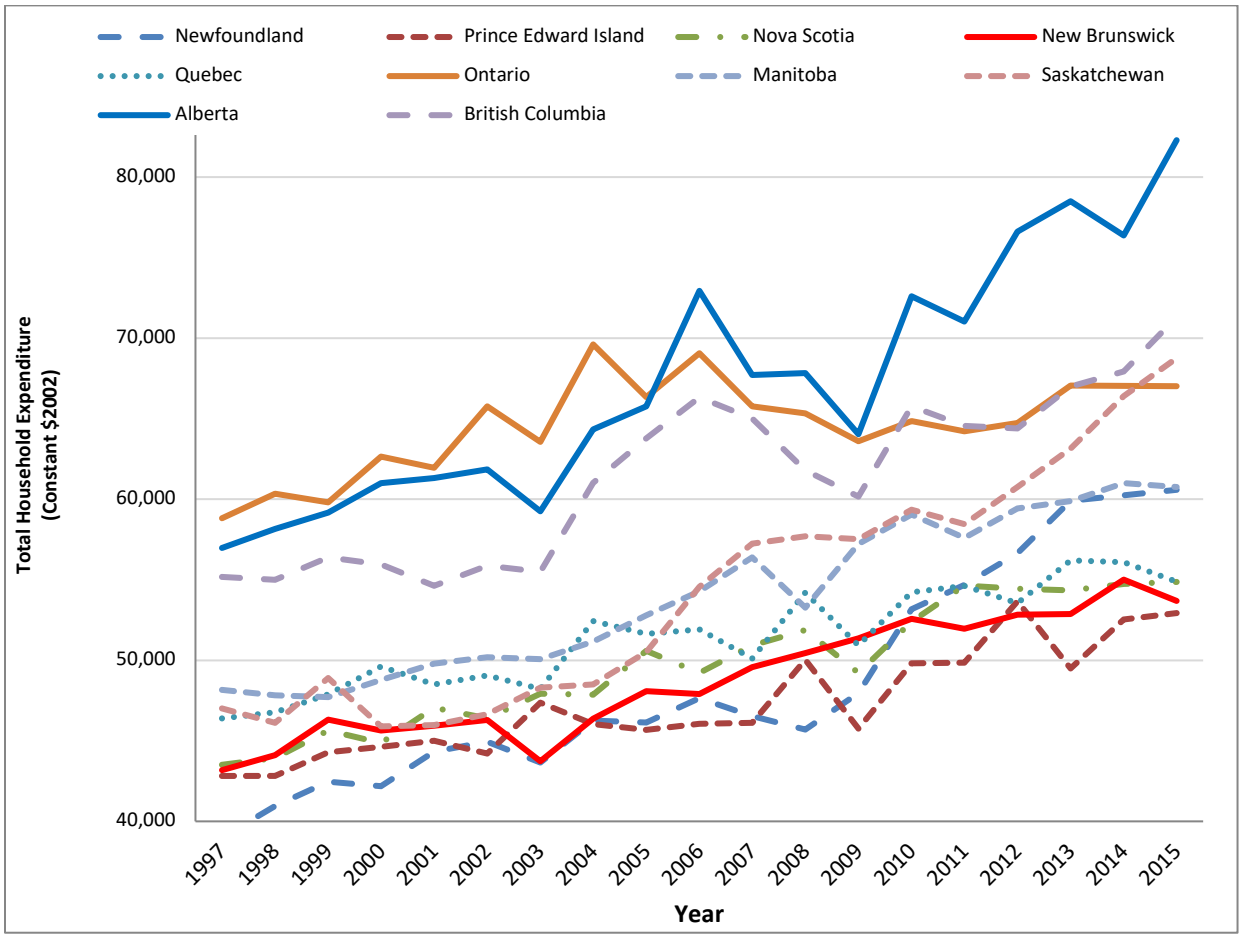
This lack of stability in the Engel Curve undermines the identification of a CPI bias that is comparable over time. In contrast, F-tests showed that when the budget share of total food expenditure was used as a dependent variable (food inside *and* outside the home), we could not reject the null hypotheses that the relevant coefficient estimates were equal for the years 1997-2009 and for the years 2010-2015, suggesting that the Engel Curves were stable over two periods.

The lack of stability resulted from a dependent variable of food consumed at home, whereas stability resulted from a consideration of total food expenditure. This could reflect that home-cooked and restaurant meals are perfect substitutes, and therefore the dependent variable for analysis should be the total food expenditure share of the budget (Hamilton, 2001b).

The critical variable in our model is the CPI-deflated total household expenditure. If the official CPI represents the true cost of living, the change in food budget shares should be captured by movement along the Engel Curve (after accounting for changes in relative food prices and variations in household characteristics, that is).

Figure 3 below reflects the constant dollar (2002=100) total household expenditure produced using the official CPI for the provinces and SHS data. Over the 1997-2015 study period, total expenditures followed an upward trend for all provinces except Ontario, where expenditures leveled out after 2006.

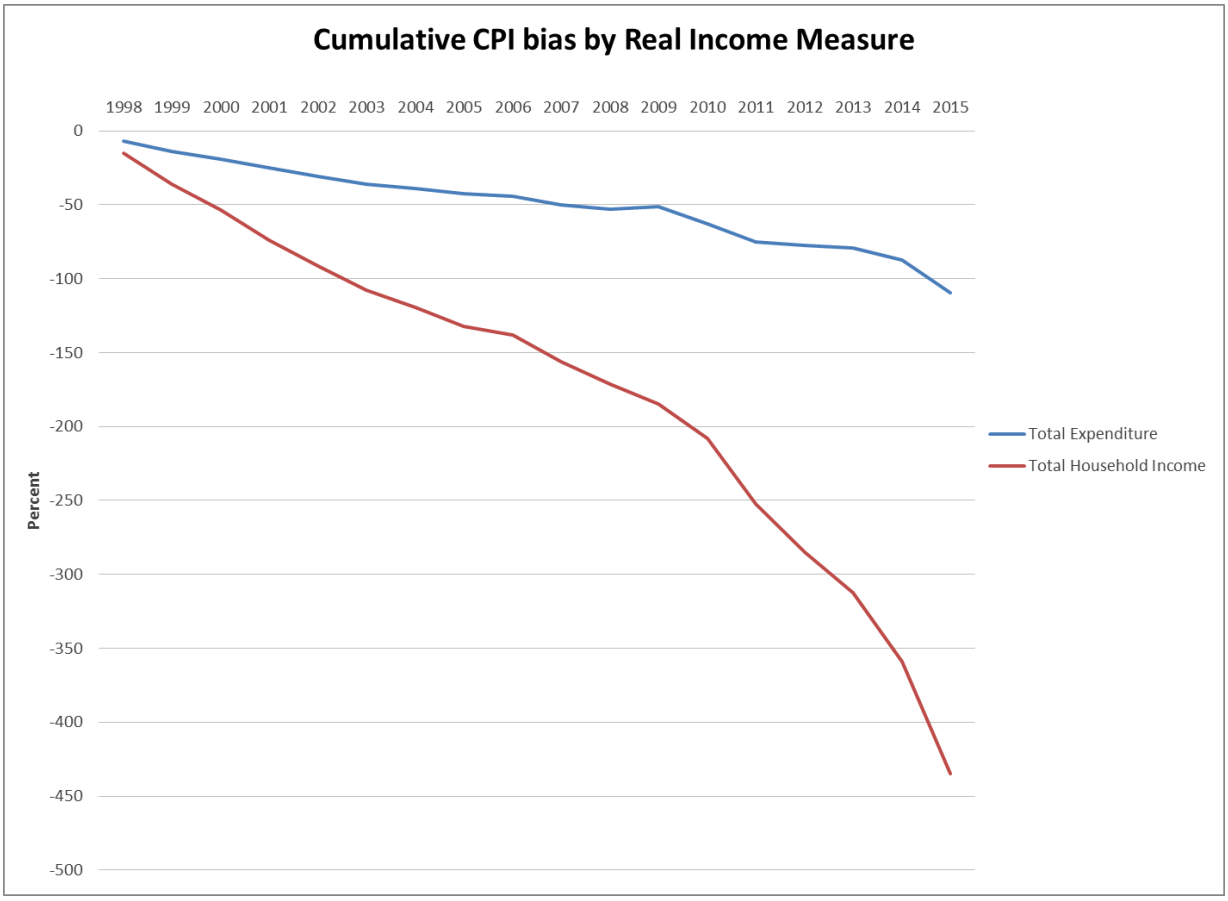
Figure 3: Average Total Household Expenditure by Province and Year, Deflated by Official CPI of Provinces



We present our results from models using total household expenditure as our measure of household income. For nominal income measures, Hamilton (2001a, 2001b) uses total household income after taxes; meanwhile, Costa (2001) uses total expenditures rather than total after-tax income, as she sees expenditures as better reflections of permanent income.

For our dataset, we have limited information on taxes and other deductions from income (e.g., union dues, CPP, EI, pensions) to get an accurate and consistent estimate of after-tax income over time; therefore, we include expenditures in our analysis. As Figure 4 shows, the cumulative CPI bias estimated from total household income is substantially larger than the bias estimated from total expenditure as a real income measure.

Figure 4: Cumulative CPI Bias by Real Income Measure



We calculate real expenditure and food price elasticities by year.[4] Figure 5 shows that, as expected, real expenditure (income) elasticity prior to 2010 was less than 1, sitting at around 0.5. After 2010, the real expenditure elasticity of food expenditure increased above 0.55, reaching 0.6 by 2013. A higher income elasticity for food suggests that real incomes must have been lower for households after 2010, since household consumption is more sensitive to changes in income. This Figure also reflects heterogeneity across samples.

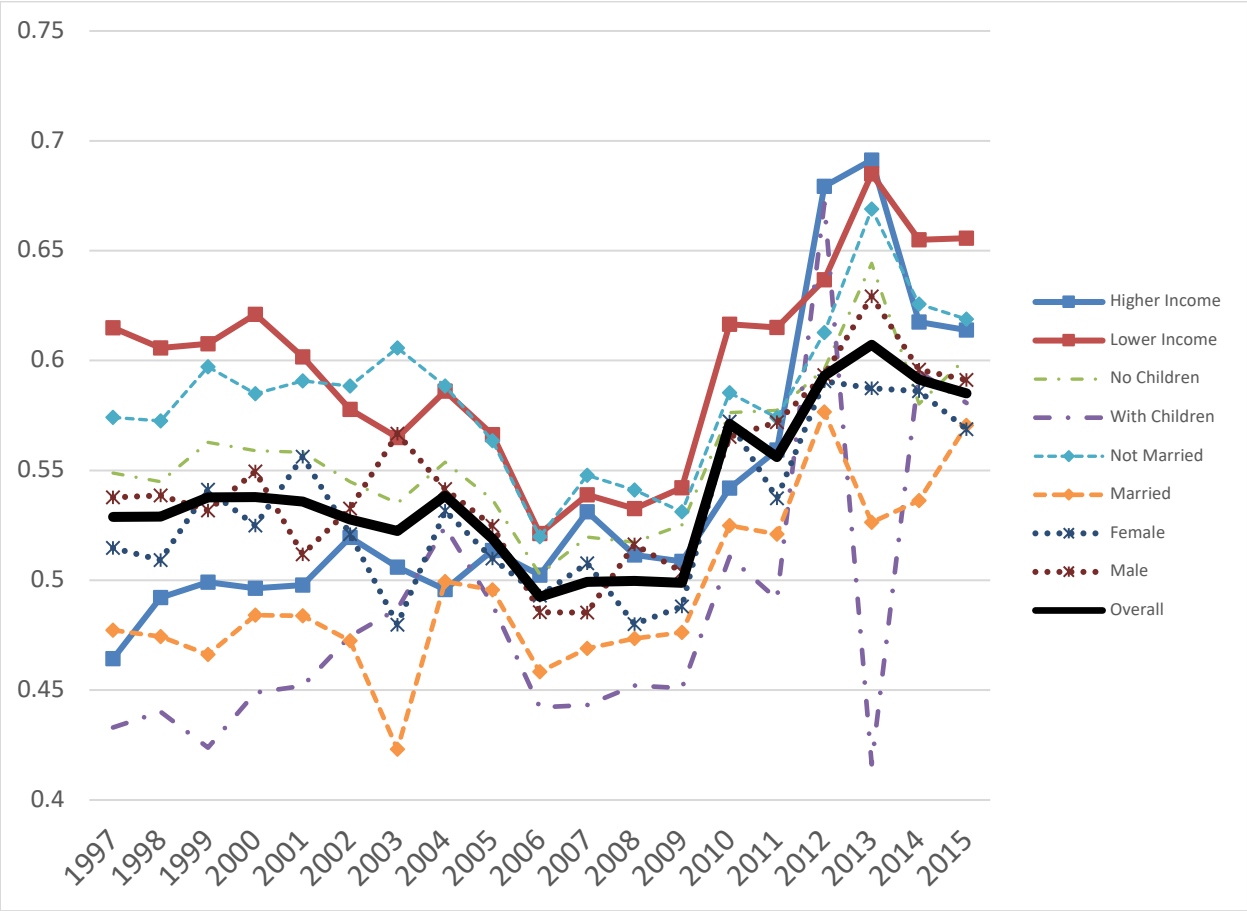
Lower-income households and unmarried respondents generally have higher elasticities, which are consistent with lower real incomes, throughout the sample period. The total expenditure elasticity fell between 2004 and 2010, suggesting that food expenditure was less responsive to income changes, before becoming more responsive after 2010.

Based on the fitted Engel Curves for the 1997-2009 and 2010-2015 periods, the elasticity of food expenditure with respect to CPI-deflated total expenditure would be equal, whereas the pre-2010

[4] Expenditure elasticity of food budget share ("Income Elasticity"): $\eta_Y = 1 + \frac{\beta}{\omega}$; Relative food price elasticity of food budget share ("Price Elasticity"): $\eta_P = -1 + \frac{(\gamma - \alpha\beta)}{\omega}$, where α is the all-items CPI weight on the food sub-index (Hamilton, 2001b).

food budget share is 1.3 times larger than the post-2009 food budget share. This suggests that although food budget shares of the post-2009 period are lower than in the earlier period, they are equivalent to food budget shares observed for the earlier period at much lower real total expenditures.

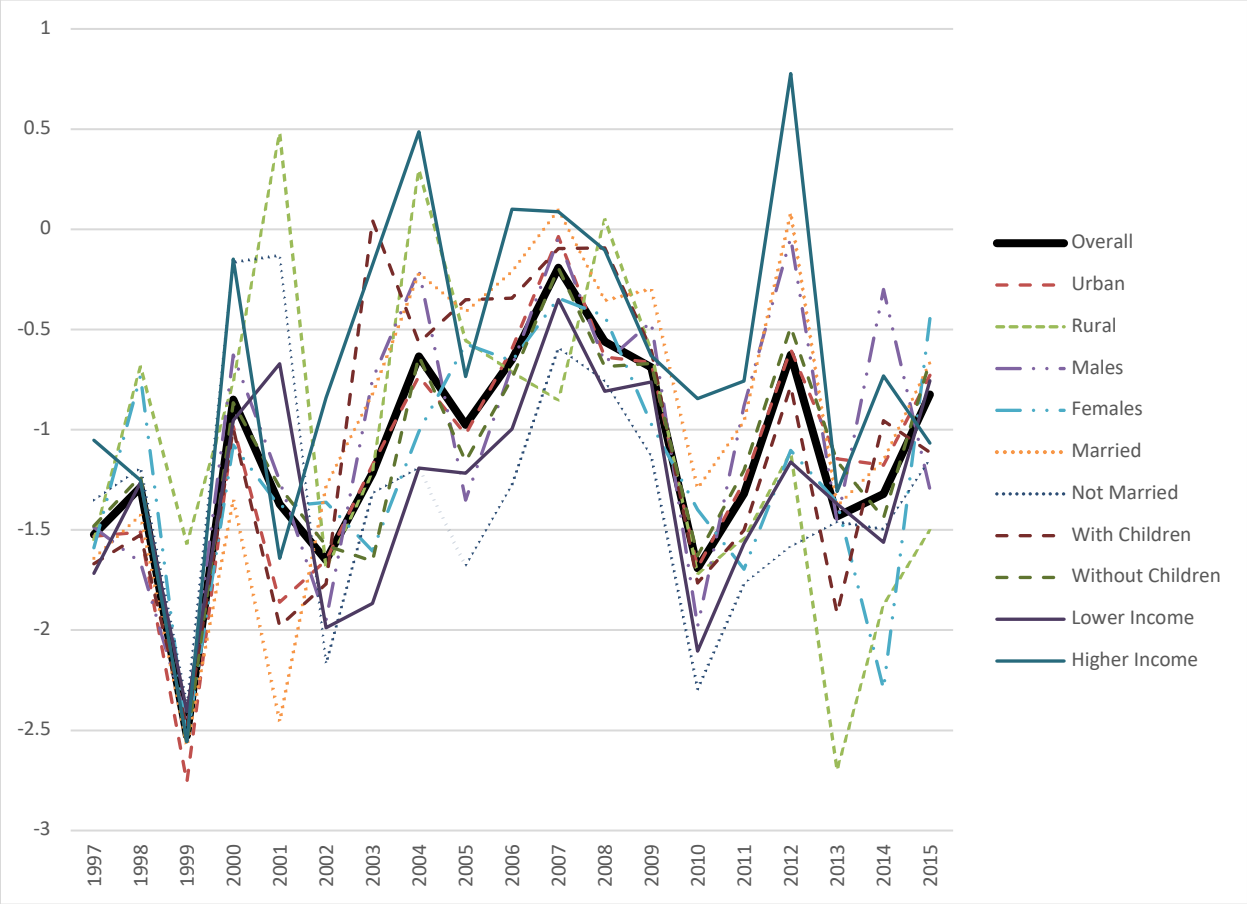
Figure 5: Food Budget Share Real Expenditure Elasticity by Sample (Percentage change in food budget share due to a one percent change in real expenditure)



Similarly, price elasticities of food expenditure shares suggest that household food expenditures were price-elastic (price-responsive) before 2004 and after 2010 but price-inelastic (less price-responsive) between 2005 and 2009 (Figure 6).

Across the samples, higher-income households have price-inelastic food expenditures, while lower income households have price-elastic food expenditures.

Figure 6: Price Elasticity of Food Expenditure Share



The price and expenditure elasticities for food both suggest that household food expenditure was less responsive to price and (current) income changes between 2004 and 2010. This period also coincides with households increasing their use of credit, and access to credit may have allowed households to increase their expenditure beyond what is reflected in the current year's income, enabling them to buffer consumption against transitory price and income shocks. The amount of household debt to disposable income increased over this period and remained stable after 2010 (Parliamentary Budget Officer, 2016, Figure 5.3). This change in the use of, or perhaps access to, credit can explain why households in Canada saw a return of income and price-elastic food expenditures.

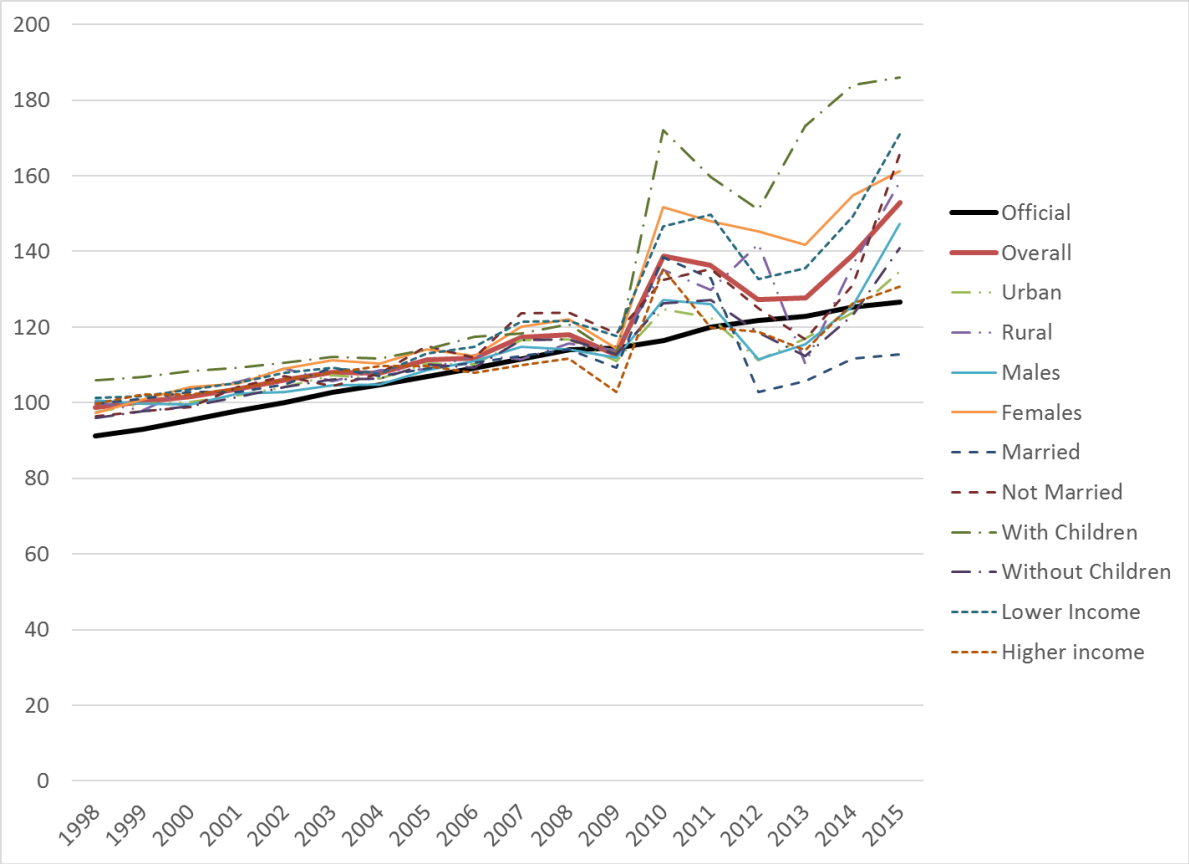
Figure 7 shows the official CPI for New Brunswick, as well as CPI bias adjustments for the 11 sample groups. The values for the adjusted CPI by sample can be found in the Appendix. These bias adjustments are not province-specific and therefore could be applied to any province's official CPI. The resulting adjusted CPIs show the true cost of living for identifiable groups.

Prior to 2010, the official CPI for New Brunswick understated the true cost of living for all groups in New Brunswick except for higher-income households after 2005. The adjusted CPIs show a smaller increase than the official CPI between 1998 and 2008, suggesting a slower rate of inflation. After 2009, the adjusted CPIs show volatility, whereas the official CPI shows no

dramatic change and, if anything, a slower rate of increase. For all samples of sub-groups, the adjusted CPIs show sharp increases in the cost of living in 2010 and 2011 before falling until 2013. The cost of living increased again in 2014 and 2015.

Among the sample groups, females, households with children, and lower-income households show the largest increase in cost of living – 15% to 30% higher than the cost of living as measured by the official CPI. In contrast, males, households without children, and higher-income households showed a much smaller increase in the cost of living.

Figure 7: Official and Adjusted CPIs (2002=100) for New Brunswick by Sample, Bias Not Provincially Disaggregated



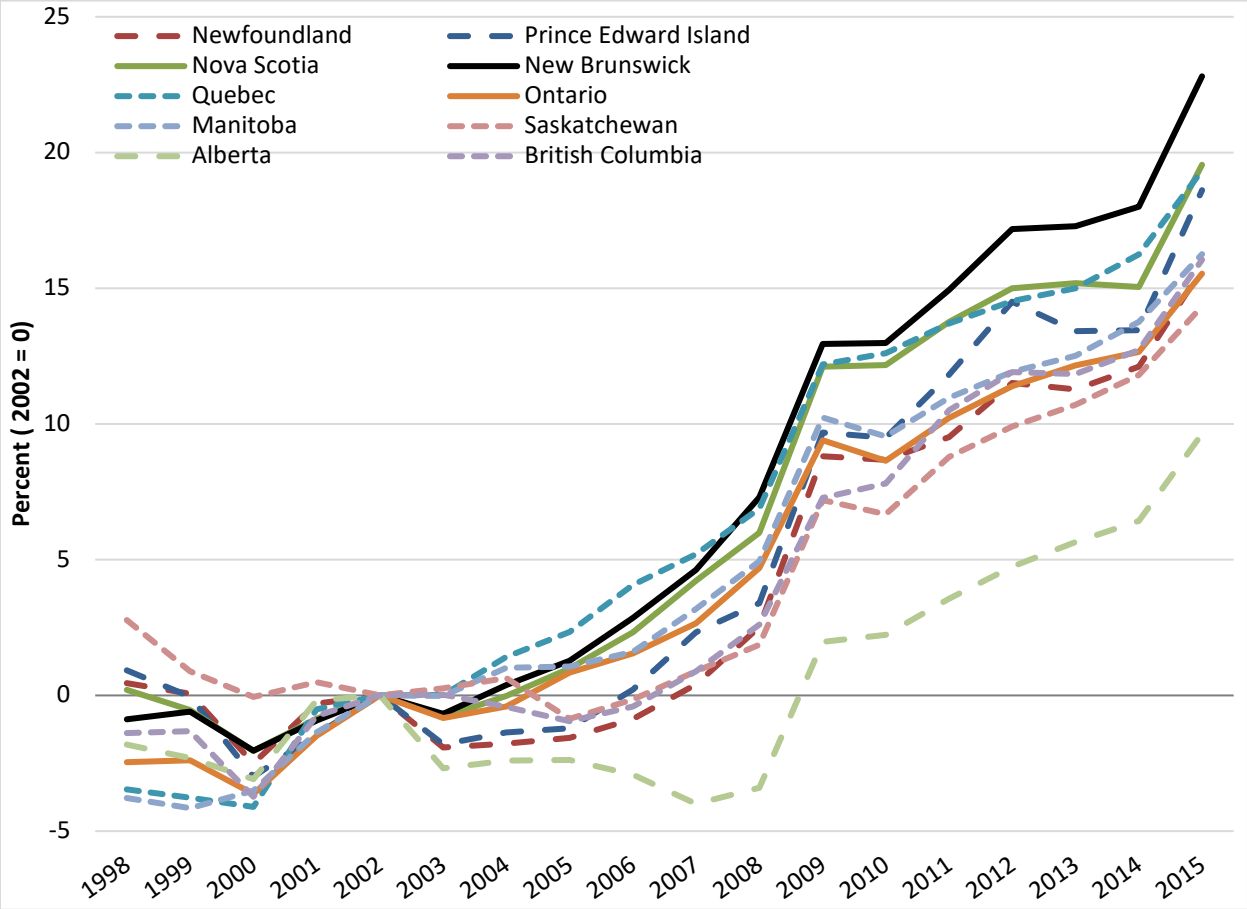
Province-Specific CPI Bias and Adjusted CPIs

The model above (Figure 7) produces a CPI bias common to all provinces, since there is no province-specific component to the time dummy variables used to represent the bias. Province-specific estimates for the CPI bias are generated by stratifying the sample by province, but in doing so, it is not feasible to include the relative price of food variable. Because the relative food price variable is based on the provincial CPI for food and CPI for all items excluding food, we cannot include year-province dummy variable interactions. In other words, the food price variable introduces variations in relative food prices across provinces over time.

Due to the lack of variation in the food price measure for observations within a given province, it is not possible to estimate the province-specific CPI bias including the relative food price variable. The relative food price measure is a province-level variable, which has the same value for all provincial residents in the sample in a given year; thus, it is collinear with the year dummy variables for a given province. Brzozowski (2006) uses CMA-level relative food measures, which could help produce bias estimates for large provinces like Ontario, but not for provinces with smaller populations, in which CPIs and CPI components are only available for one CMA.[5]

After 2008, the relative food price variable is highly influential on our Engel Curve estimates. Figure 8 shows that the inflation of relative food prices (which was high after 2008) was highest in New Brunswick. Generally, relative food price inflation increases more from west to east. The grouping of Newfoundland and Labrador with Alberta, however, suggests that commodity-exporting provinces could have had lower relative food cost inflation because of higher increases in the costs of all other goods, as opposed to lower increases in food costs.

Figure 8: Price of Food Relative to Prices of Non-Food Items



Hamilton (2001b) presents the option of excluding the relative food price variable and representing the omitted food price effects and the CPI bias with province/year interaction terms.

[5] It should be noted, perhaps, that Brzozowski (2006) did not estimate CPI biases specific to provinces.

In this case, omitting the relative price variable will change the error term of the regression model, and the CPI bias estimate will reflect the true CPI bias and the influence of the (omitted) relative food prices. Hamilton (2001b) demonstrates that the year dummy coefficients pick up not only the CPI bias but also the effect of intertemporal variation in the relative CPI-measured price of food, which is omitted because of perfect correlation with the year dummies. Hamilton recommends using a model estimated with relative food prices included to recover estimates of parameters needed to adjust the year dummy variable effect from the estimated model excluding relative food prices and thus recover a measure of the CPI bias.

Rather than recalibrating our year dummy variable coefficient estimates, which will have a non-linear effect on the CPI bias measure, we take a different approach. We estimate specifications of the models with and without relative food prices to produce two CPI bias estimates that are not province specific: one accounting for relative food prices and the other excluding relative food prices. We then multiply our province-specific CPI bias estimates by the ratio of these two cumulative, but not-province specific, CPI bias estimates. This allows us to account for the impact of omitting the relative food price. Like Hamilton's (2001b) approach, this adjustment suggests that the effect of relative food prices on the CPI bias is common to all provinces.

In Figure 9, we plot the cumulative CPI bias by year for Engel Curve models with and without the relative food price variable included. Prior to 2009, excluding relative food prices suggests a smaller cumulative bias than when relative food prices are included – the difference being approximately a ten percentage point difference by 2009, or, less than one percentage point per year. Both models suggest that the official CPI understates the true cost of living, but the understatement is less severe when food prices are included. After 2009, the model including the relative food price measure suggests that the cumulative bias grew, indicating a rapid increase in the true cost of living after 2009. The cumulative bias more than doubles its 2009 size by 2015.

Figure 9: Cumulative Bias: Engel Curve Models With and Without Relative Food Prices

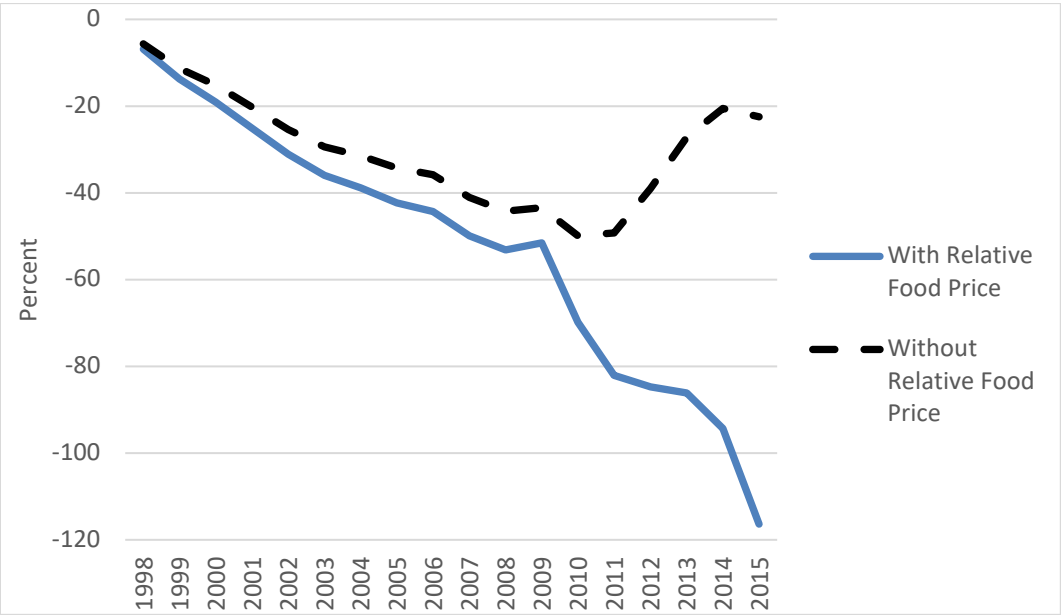


Figure 10 shows the official CPI for New Brunswick along with three adjusted CPI measures calibrated to New Brunswick. We present adjusted CPIs using the cumulative bias estimates from models including relative food price measures and using total household income and total household expenditure as nominal income measures.

After 2008, when the relative food price variable is included, the official CPI understates the true cost of living. Meanwhile, when we exclude the relative food price, the CPI bias suggests that the official CPI overstates the true cost of living. We have determined that after 2008, the share of expenditure on food tended to be lower than predicted by real income using the official CPI as a deflator. Given the much larger cumulative bias of the CPI when measured against CPI-deflated total household income, the adjusted CPI for total household income suggests a true cost of living much higher than that suggested by the official CPI, as well as a noticeable increase in the true cost of living after 2009.

The cumulative bias from models using total household expenditure are smaller but still suggest that the official CPI understates the true cost of living, which increased sharply after 2009. The CPI adjusted by the cumulative bias (produced from the total household expenditure model excluding relative food prices) suggests – inappropriately – that the true cost of living fell after 2009. Knowing that the post-2009 cost of living is too low in this model, we multiply the adjusted CPI by the ratio of the adjusted CPIs for the models with and without relative food prices.

Figure 10: Official and Adjusted CPIs by Household Income Measure, New Brunswick

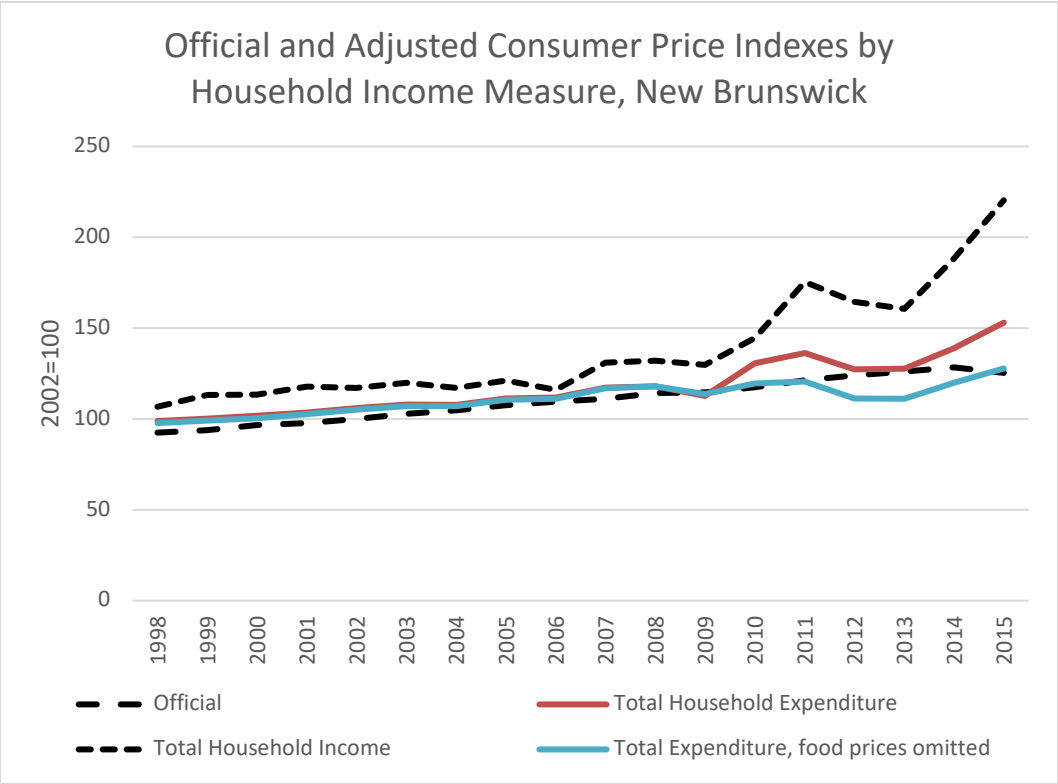
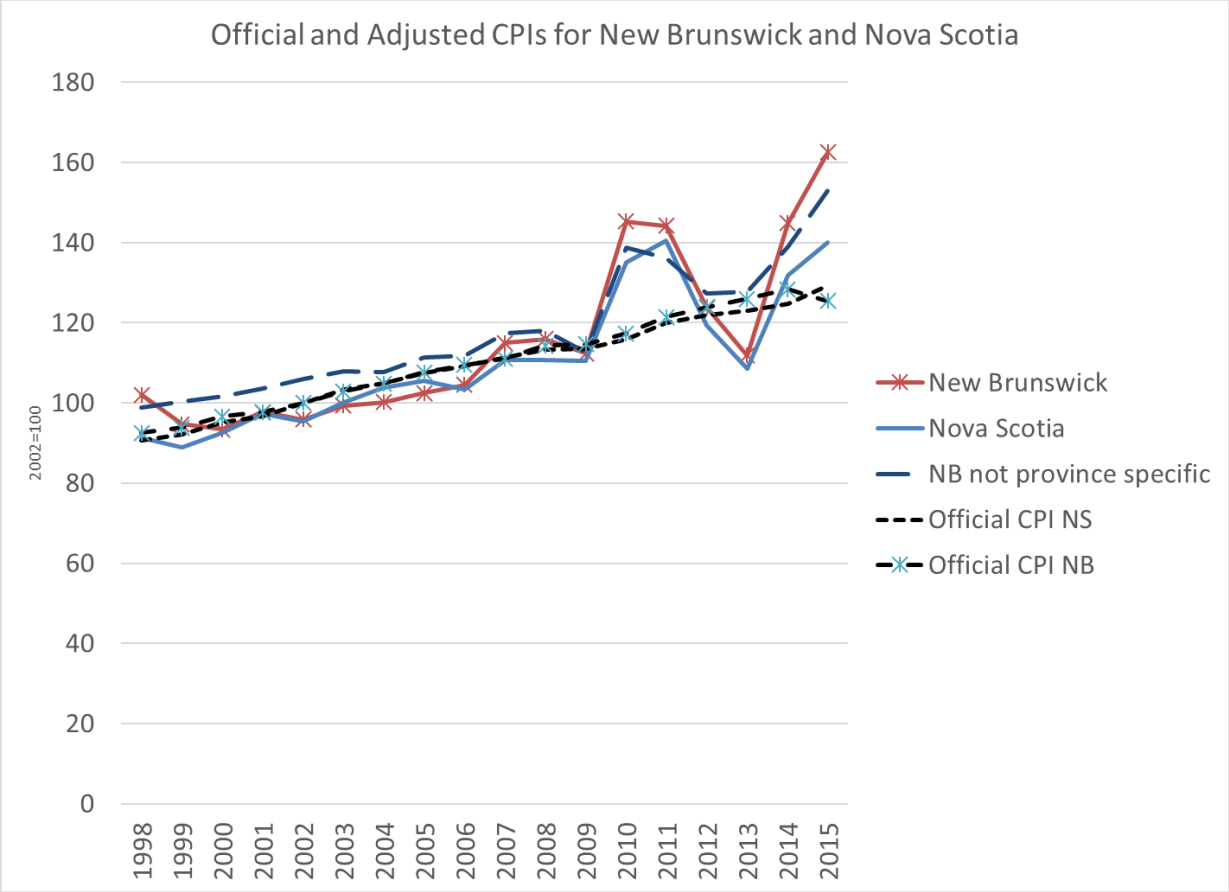


Figure 11 presents the overall adjusted CPI along with the province-specific adjusted CPIs for New Brunswick and Nova Scotia. The overall adjusted CPI is not province-specific and shows that the true cost of living was generally higher than that suggested by the official CPI. The province-specific adjusted CPIs show that for New Brunswick and Nova Scotia prior to 2010, the cost of living was lower than that suggested by the official CPIs for the two provinces.

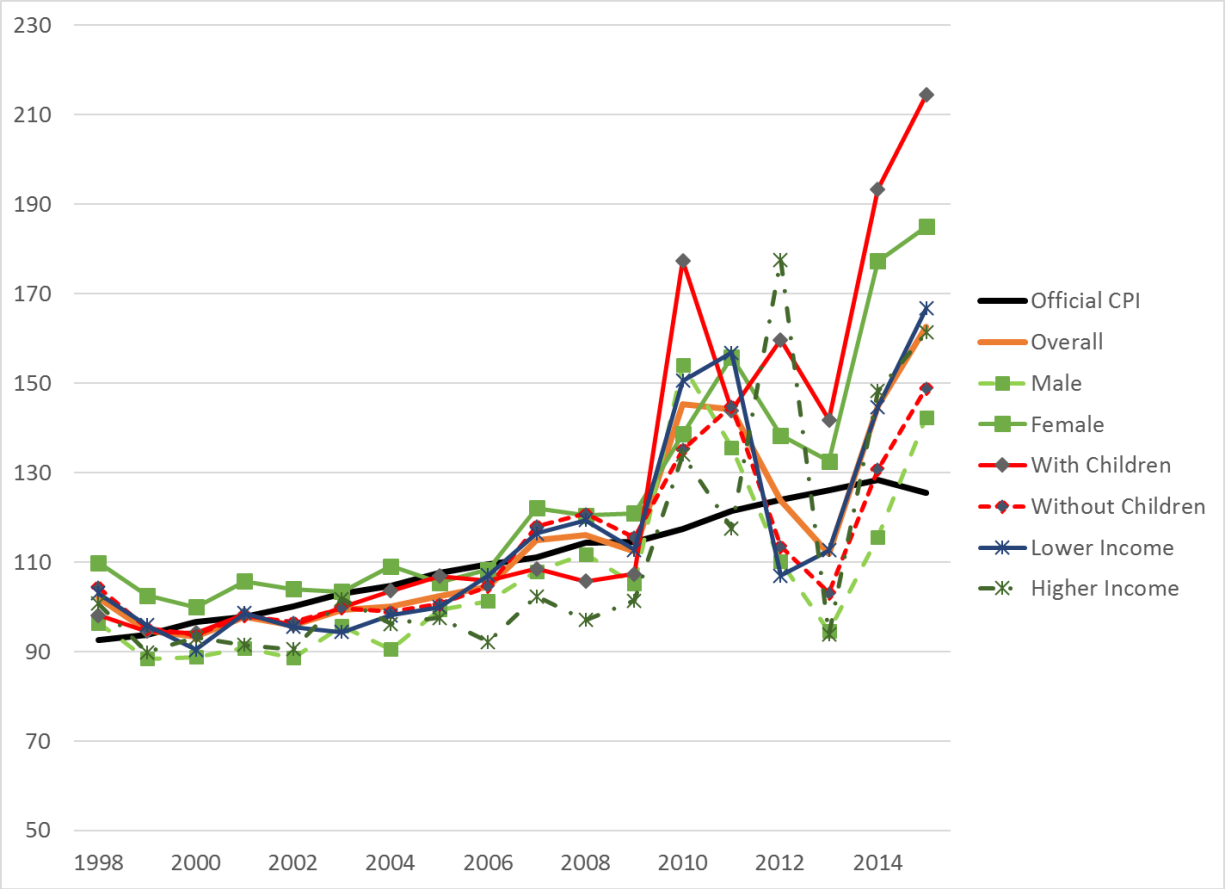
Both provinces show the same rapid increase in cost of living in 2010 and 2011 before falling in 2012 and 2013 and then increasing once more in 2014 and 2015. Whereas the fall in cost in living implied by the province-specific CPIs in 2013 is greater than for the overall adjusted CPI, the post-2010 adjusted CPIs show the same timing of increase and decrease in cost of living.

Figure 11: Official and Adjusted CPIs for New Brunswick and Nova Scotia



In the Appendix tables, province-specific adjusted CPIs for all 11 samples and all ten provinces are presented. In Figure 12, we show the province-specific adjusted CPIs for seven of the 11 samples for New Brunswick. Compared to previous figures, we can see that many of the pre- and post-2010 patterns are replicated, particularly the higher cost of living and greater volatility in the post-2009 period. Notably, however, after 2010, females and households with children show the highest and most sustained increase in cost of living.

Figure 12: Official and Bias-Adjusted CPIs for sub-populations in New Brunswick, 1998-2015 (2002=100)



Using the Adjusted CPIs to Measure Real Incomes

So far, we have presented CPIs adjusted to account for the bias in the CPI when measuring the true cost of living for sub-groups and provinces. To explore the implications of these adjusted CPIs when assessing the standards of living for sub-groups over time, we deflate median total family incomes in New Brunswick with the official CPI for New Brunswick and several of the group-specific adjusted CPIs. In Figure 12, we see the difference in purchasing power of a given nominal income between sub-groups.

Figure 13 shows that when the official CPI is used to deflate nominal income into constant 2002 purchasing power, median family incomes in New Brunswick grew until 2008 and then plateaued until 2014, rising again in 2015. When we use the bias-adjusted CPI for the overall New Brunswick sample in the SHS, the purchasing power of the median family income is not very different from that suggested by the official CPI for 2009.

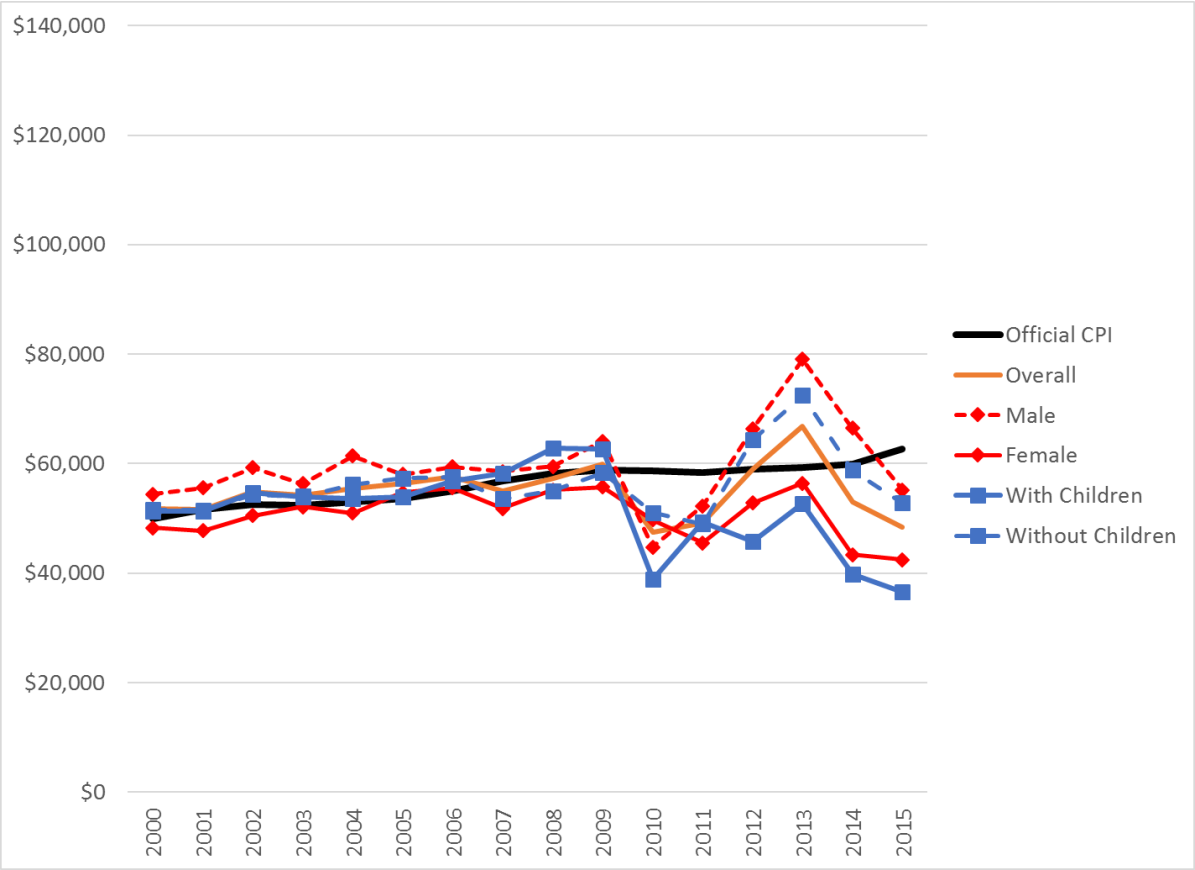
The abrupt increase in the true cost of living shown in Figure 10 results in a drop in the purchasing power of the median income after 2009, which recovers to the level suggested by the official CPI-deflated incomes in 2012 and 2013 before falling again in 2014 and 2015. In other

words, where the official CPI suggests the 2008 recession did no harm to the average New Brunswick household, the adjusted CPI suggests that the recession caused a fall in real incomes from which the province had not recovered as recently as 2015.

We use the adjusted CPIs for males and females and for households with and without children to convert nominal median total family incomes to constant purchasing power. The results show that males and households without children saw some recovery in real incomes after 2011, meaning the recession impacts were short-lived for these groups.

In contrast, the real incomes of females and households with children did not recover and return to levels seen before the recession or to the level of purchasing power suggested by the official CPI. For females and households with children, 2009 may have been the start of an economic depression rather than a transitory recession.

Figure 13: Median Total Family Income, New Brunswick



2002 purchasing power with alternative deflators (CANSIM 111-0012)

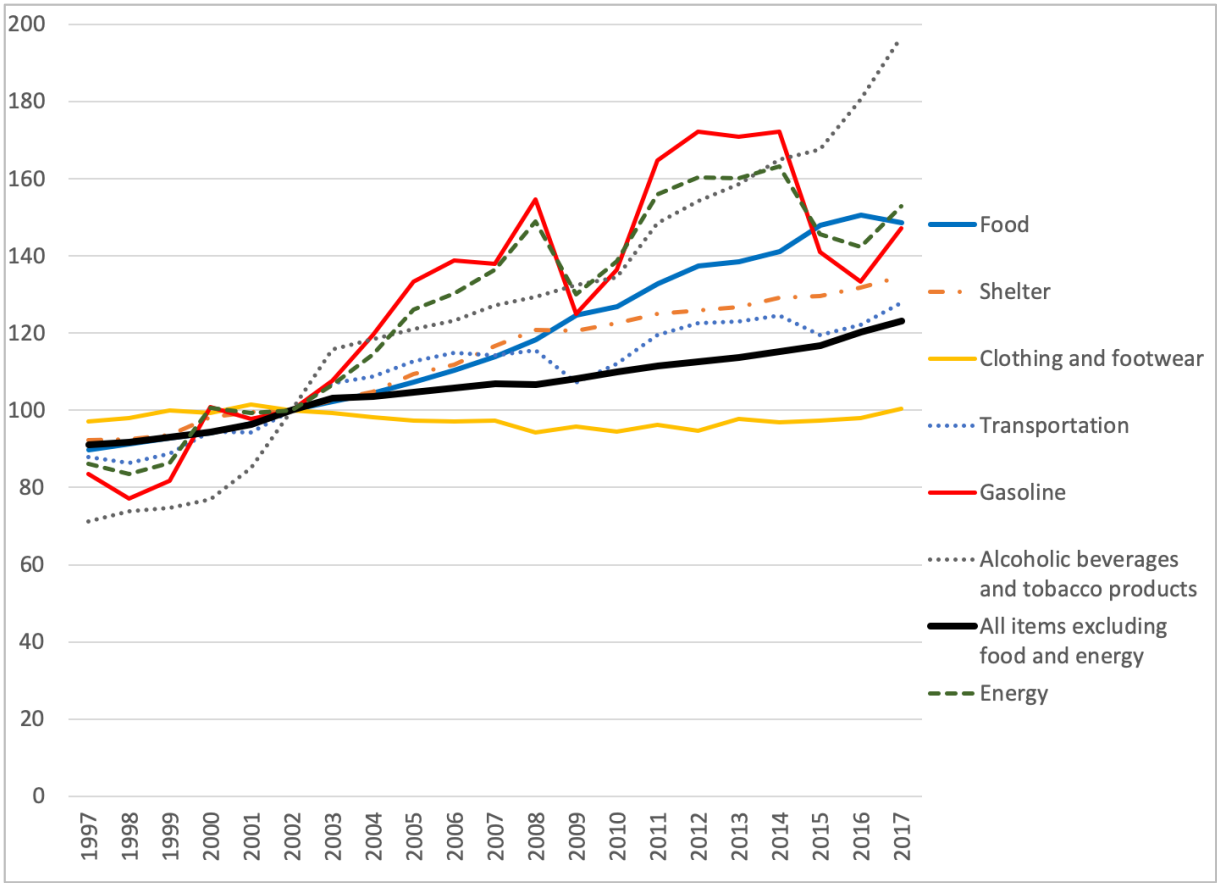
Why might the official CPI misrepresent the cost of living for sub-groups during periods of economic turmoil? Earlier, we discussed changes in potential access to credit leaving households more vulnerable to economic shocks, as they become more reliant on their current income for consumption. On the other hand, it is possible that the weights used to construct the official CPI

reflect the consumption patterns and preferences of a "representative household" when considering budget shares for the consumption of various goods and services.

Figure 14 shows sharp increases in gasoline and energy prices after 2009, which may have had a larger impact on certain sub-groups of the New Brunswick population than others. For instance, households with children are often younger, have higher levels of debt, and are usually reliant on car transportation, suggesting the official CPI would underestimate the importance of abrupt changes in prices for these households.

Regarding the differences in real incomes between females and males – aside from potential differences in consumption patterns – the sample stratification may confound the influence of gender differences in earnings, job security, access to credit, and so on.

Figure 14: New Brunswick CPI Components



Conclusion

As Hamilton (2001b) explains, the approach we follow in our analysis – the Engel Curve approach – infers the true cost of living from consumers' behavior. It is not calculated from price data using a normatively modelled consumption pattern, as official measures of cost of living are. Even if group-specific, or geographic, price data were never collected, the Engel Curve

approach could still be applied to subgroups of the national population to determine if true inflation rates differ across sex, age, income level, or other exogenous variables. As long as enough observations are available, one can estimate CPI biases for the population group of interest to recover group-specific estimates of past inflation rates.

In this study, we use Survey of Household Spending data from 1997-2015 to measure the "true cost of living" for 11 sample groups and for all ten provinces. Overall, we find that the official CPI is associated with substantial bias that increases in size after the 2008/2009 recession. For instance, a comparison of Engels Curves for food expenditure pre- and post-2009 shows that low-income households experienced the largest reduction in food expenditure after 2009, with food being crowded out by other budget expenditures.

We find heterogeneity in the CPI bias across groups, with extremely large increases in cost of living inferred from consumer behavior for females and households with children. While the official CPI suggests no important shocks to the economy in terms of cost of living, our estimates suggest that households in Canada experienced sharp increases in cost of living and decreases in real income following the 2008/2009 recession. Particularly for females and households with children, these shocks have resulted in a persistently high cost of living.

The post-2009 decrease in real incomes could be the result of various economic shocks. Firstly, retail gasoline prices increased abruptly in 2010 and remained high until 2013. Secondly, Canadian households had greater access to credit and borrowed continuously prior to 2009, which would have allowed them to buffer shocks like the gasoline price increases from 2007 to 2009 and to consume at a higher level than if they only had their current income. After 2009, however, households in Canada were shown to use less credit and reduce their debt levels, which suggests households were not buffering against price shocks.

Finally, we must acknowledge that problems with the Survey of Household Spending may explain at least some of the CPI bias and could be a reason for the apparent increase in the cost of living after 2009. Statistics Canada has cautioned against comparing post-2009 surveys with those from the preceding period due to changes in survey administration. Survey sample sizes are smaller after 2009, when Statistics Canada changed from a questionnaire to a diary-based collection of data on more frequent and detailed expenditures. The smaller sample sizes for 2010-2015 alone could contribute to a higher variability of bias estimates.

Given these data limitations and their potential impact on our estimates, we cannot be certain whether our adjusted CPIs show ordinal information about cost of living compared to the official CPI, or if the adjusted CPIs can be used directly as a deflator for calculating real wages and real incomes.

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APPENDIX TABLES

Least Squares Estimates for Engel Curves Models, dependent variable is the food budget share

Year	Overall	
	With Relative Food Price	Without Relative Food Price
Relative Food Price	0.0112	
	(1.01)	
NewSHSRelativeFood	-0.0635**	
	(-3.26)	
Real Expenditure	-0.0647***	-0.0648***
	(-87.18)	(-87.53)
NewSHSRealExpenditure	0.0148***	0.0151***
	(9.26)	(9.52)
NewSHS	-0.129***	-0.137***
	(-7.47)	(-8.10)
HouseholdSize	0.0156***	0.0156***
	(60.26)	(60.20)
Age	0.000451***	0.000451***
	(24.54)	(24.57)
Urban	-0.000251	-0.000323
	(-0.45)	(-0.58)
Female	0.00167***	0.00172***
	(4.04)	(4.15)
	(12.55)	(12.60)
Children under 14 in household	-0.00432***	-0.00431***
	(-6.64)	(-6.61)
NewSHSHouseholdSize	-0.00682***	-0.00680***
	(-8.64)	(-8.62)
NewSHSAge	-0.000173***	-0.000175***
	(-3.70)	(-3.74)
NewSHSUrban	-0.00566**	-0.00545**
	(-2.94)	(-2.84)
NewSHSFemale	-0.00339**	-0.00346**
	(-2.63)	(-2.69)
NewSHSMarried	0.00879***	0.00866***

	(5.19)	(5.12)
NewSHSchildren0to14	0.00532**	0.00531**
	(2.66)	(2.66)
D_1998	0.00126	0.00137
	(1.42)	(1.57)
D_1999	0.00127	0.00136
	(1.48)	(1.60)
D_2000	0.000290	0.000261
	(0.32)	(0.29)
D_2001	0.000747	0.00101
	(0.84)	(1.18)
D_2002	0.000711	0.00107
	(0.72)	(1.15)
D_2003	0.0000475	0.000339
	(0.04)	(0.30)
D_2004	-0.00122	-0.000858
	(-1.25)	(-0.93)
D_2005	-0.000841	-0.000407
	(-0.87)	(-0.45)
D_2006	-0.00173	-0.00121
	(-1.77)	(-1.36)
D_2007	0.000476	0.00111
	(0.45)	(1.19)
D_2008	-0.00100	-0.000178
	(-0.83)	(-0.17)
D_2009	-0.00410**	-0.00272**
	(-2.60)	(-2.66)
D_2011	-0.00263	-0.00347*
	(-1.63)	(-2.19)
D_2012	-0.00689***	-0.00831***
	(-3.39)	(-4.23)
D_2013	-0.00766***	-0.00935***
	(-3.68)	(-4.71)
D_2014	-0.00500*	-0.00710***
	(-2.43)	(-3.60)
D_2015	0.000802	-0.00294
	(0.36)	(-1.58)
Newfoundland	0.0124***	0.0124***
	(13.67)	(13.73)

PrinceEdwardIsland	0.0000529	-0.000266
	(0.05)	(-0.25)
NovaScotia	-0.000206	-0.000699
	(-0.25)	(-0.86)
NewBrunswick	0.00305***	0.00220**
	(3.56)	(2.64)
Quebec	0.0157***	0.0152***
	(23.05)	(20.48)
Manitoba	0.00128	0.00109
	(1.67)	(1.42)
Saskatchewan	-0.00782***	-0.00752***
	(-9.47)	(-9.22)
Alberta	-0.00216**	-0.00113
	(-2.81)	(-1.58)
BritishColumbia	0.00926***	0.00920***
	(12.30)	(12.28)
Constant	0.756***	0.757***
	(93.15)	(93.39)
N	219748	219748
t -statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001		

Note: NewSHS is an indicator variable equal to 1 in years 2010 to 2015. The prefix NewSHS indicates an interaction of the variable with the NewSHS indicator variable.