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# Does the CPI Mirror Costs-of-Living? Engel's Law Suggests Not in Norway

**Abstract:**
There is considerable interest in identifying the magnitude of the difference between increases in CPI and costs-of-living, and this article uses the technique proposed by Hamilton (2001) to measure this discrepancy for Norway for the 90s. The method is extended along several dimensions by introducing a framework in which measurement errors are modelled. A non-parametric approach is then employed to segment households into demographic types while allowing for flexibility in costs-of-living increases for different standards. Hamilton finds that American CPI overstates costs-of-living in the U.S. for the period 1974-1991, Norwegian results for 1990-1999 indicate that CPI sometimes may understate costs-of-living, perhaps because of a credit-financed boom in house prices. The Norwegian CPI rose 22 percent in the period, but the general consumer behaved as if costs-of-living increased more than 35 percent. For some segments of society, for example single-person households, the increase was substantially larger, suggesting potentially important distributional effects.

**Keywords:** Almost-Ideal-Demand-System, consumer price index bias, cost-of-living, demand for food, Engel's Law, household behavior, house prices, inflation, real income, standards of living

**JEL classification:** C13, D12, E31

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# 1. Introduction

Price measurement is important. Estimated changes in price level now serve as basis for inflation targets in central banks. Moreover, price indices are used in wage negotiations, contracts, and tax bracket adjustments. Price indices are used to deflate consumption figures in order to facilitate inter-temporal comparisons of material standards of living. Thus, economists take an interest in scrutinizing the precision of the consumer price index (CPI). What, if any, is the magnitude of the wedge between costs-of-living and the CPI? This is a frequently asked question that is unusually hard to answer. Usually, economists believe they know something about the sign of the bias. Conventionally; see e.g. Abraham (2003), Hausman (2003), and Schultze (2003); one thinks that costs-of-living rise slower than the CPI, because there exist quality improvements, substitution possibilities, and new goods. However, quality may deteriorate and goods may disappear. Thus, the sign of the bias is an empirical question. Moreover, some consumer services, for example services extracted from self-owned houses, are so difficult to include in the basket in a precise way that there may exist important unaccounted-for price developments. Presumably, consumers contemplate such price developments when they consume. Thus, it is worthwhile to study how consumers behave to examine what prices consumers act *as if* they face. This is the approach Hamilton (2001) uses in his novel technique of exploiting Engel curves on American data. His findings support the usual upward bias in the CPI. However, this article detects a different direction of the bias, and this direction may have important policy ramifications at any given time. I examine the bias empirically, and I replicate and extend Hamilton's method in order to measure what increases in costs-of-living in Norway during the 90s are consistent with actual, observed consumer behavior. In short, I ask: Do consumers behave as if increases in costs-of-living have risen faster than the CPI?

Yes. Norwegian consumers behave as if costs-of-living increased 35 per cent while the CPI rose 22 per cent. But different households use different goods, so different households necessarily face different price developments. Some types behave as if costs rose somewhat slower than the CPI, others as if costs rose substantially faster. The CPI is only one scalar constructed to give an overall impression of multi-dimensional price movements. The core question becomes which weights to put on which prices. This article shows that there is wide variation in price experiences across households, and finds that the general consumer behaved in a manner consistent with a downward bias in the CPI in the 90s. That finding is both surprising and important. Surprising because Hamilton finds a different sign in America and because I obtain different results for an earlier period. This makes it important because it sheds light on costs-of-living development during a housing boom and the crucial issue of how inflation should be measured in order to conduct monetary policy according to the proclaimed strategy.

It is, of course, a formidable challenge to disentangle the difference between an increase in the general level of prices and developments in relative differences between prices. Let me illustrate briefly why we distinguish between the two. If Robinson and Friday use nuts as tokens of payment and symbols of value in their economy, a sudden influx of nuts without an increase in production would inflate the number of nuts per traded good. In other words, they would experience a jump in the price level. If it persisted, they would face inflation. On the other hand, if climate change affected crops and made means of survival dearer, they would have to work longer to maintain their standard of living. Relative prices would change to reflect new scarcity. In other words, they would experience increases in costs-of-living. One can occur without the other even if they often coexist as price increases and relative price changes. This is the origin of the difference in the literature between a cost-of-goods index and a cost-of-a-standard index.

Hamilton's idea is to use actual household behavior in order to estimate the difference between the CPI and costs-of-a-standard. In an innovative way, he uses estimation of food demand in an almost-ideal-demand-system to estimate drift in Engel curves, which in turn illuminates the magnitude of the wedge between the CPI and costs-of-living. This idea is based on Engel's Law. It is one of the most stable empirical regularities found in economics, and says that the budget share for food falls with total expenditure or income, everything else being equal. It has proved robust over time and for different societies. In fact, economists have long realized that its stability may be used for certain practical purposes, e.g. to derive equivalence scales. Costa (2001) employs the law to measure the bias in consumer price indices (CPI) for the United States and estimates its consequences for real income. In essence, Hamilton uses the stability of Engel's Law to infer from the budget share of food to a material standard of living. Similarly, this article uses the law to focus attention on the relationship between unobserved costs-of-living and observed CPI in order to shed light on how real incomes and real total expenditures reflect material standards of living.

Hamilton offers good arguments for using food, and not other items. Its income elasticity is sufficiently different from unity, it has no durability, it is easily defined, it is plausibly separable from non-food in consumer's utility functions, and the almost-ideal-demand-system for it is thoroughly explored in the literature. He does not suppress the method's limitations: sensitivity to time-varying omitted variables, preference drift, and specification error. All will appear undeservedly as CPI bias.

We might add that food consumed at home is not trivially differentiable from food consumed away from home since it is unclear to what extent they are substitutes. Income might be misreported for tax purposes or contain transitory components. Thus, income may not reflect a household's perception of its economic position appropriately. Different types of households may behave different from other types, thus it may require different estimations. Finally, developments in costs of living may be different at different levels of standards of living. One common functional form for all levels may let important differences escape estimation. This article seeks to augment Hamilton's technique by removing several of these weaknesses without losing the advantages.

A full review of the literature on price indices cannot be offered. Let a few words suffice. Many attempts at identifying the magnitudes of deflator biases have followed since the widely noted investigation of Boskin et al. (1996) on how prices do or do not reflect the economic environment consumers find themselves in. Nordhaus (1997, 1998) delivered notable contributions by applying novel and creative ways of linking price increases to standards of living. Hausman and Schultze discuss conceptual difficulties and measurement obstacles. Abraham reports on the progress of actually developing a cost-of-living index. Pollak (1998) clarifies on difficult notions such as which population segment the CPI refers to; the fact that consumers face distributions of prices, not one price; and the highly challenging task of identifying empirical counterparts of theoretical "goods". Abraham, Greenlees, and Moulton (1998) describe the process towards precise indices, and Devine (2001) argues that inflation is understated because ignored non-market costs contribute to what households must pay for a given quality of life. Diewert (1998) presents suggestions for how to reduce the bias between the indices statistical agencies produce and theoretical constructs of costs-of-living. I would like to stress the importance of the latter of Pollak's points: what exactly is a "good". For example, Røed Larsen (2004) shows that if the price of the theoretical construct "housing services extracted from self-owned houses" is measured using a rental-equivalence principle then the increase in Norwegian CPI for 1993-2003 is 24,5 percent. If instead an interest-payment principle is used then Norwegian CPI would be 39,4 percent. The former is the official figure, after which the central bank targets its inflation rate. The latter may prove a more intuitive way of approaching prices owners face and a more precise instrument for observing consequences of monetary policy.

This article adds to these investigations by first replicating Hamilton's technique on Norwegian data for the 90s. I then extend his analysis along three dimensions. First, Hamilton uses income as the determinant of food share. But income is separated from consumption and thus material standard of living by savings, and income also includes a transitory component. In addition, there are opportunities for misreporting income, there exists tax evasion, and non-market activities are difficult to assess. This article offers a comparison analysis in which consumption is used instead of income in an errors-in-variables model where total consumption is a latent variable. Second, I segment households into several household types that possibly face different optimisation problems and estimate costs-of-living for each type. Doing so, we are in a position to inspect the different experiences of different types of households in case they solve their optimisation problem in different ways. Third, to avoid function misspecification and spurious findings, I employ a non-parametric approach that allows different trajectories of costs-of-living for different standards of living within each household type without imposing parametric structure. This has two important implications. First, I am able to examine the validity of the functional form in Hamilton's parametric approach. Second, it yields several interesting new findings. While couples without children and couples with children behave as if costs-of-living rise less than observed inflation, singles adjust their outlays as if the increase in costs-of-living is double that of inflation. Moreover, households at different standards of living appear to face very different developments in costs-of-living.

Allow a short expansion of the idea. If Engel's Law holds, households' budget share for food should move along a stable curve as households grow richer over time. Put differently, repeated estimations of this curve for different cross-sections of households at different times should yield identical estimates of the relationship's coefficients -- as long as the deflator is precise. Engel's Law, as much as it is an empirical regularity, encompasses estimation robustness. Assuming that Engel's Law really is a law, and we can do that for good reasons, we realize that explanations for possible drift in estimated coefficient lie in misspecification of the deflator. To see this, recall that a pair on the Engel curve has coordinates ($\omega$, X) for budget share and total consumption. If there is an increase in nominal outlays or costs to achieve a given bundle of real consumption and food share, the pair of coordinates drifts horizontally to ($\omega$, mX). Such nominal changes may change the intercept or slope depending on the specification. If the CPI deflator reflects true costs-of-living, and it is of magnitude m, then simply adjusting nominal consumption outlays by dividing with the deflator m realigns the Engel curve. But Consumer Expenditure Survey (CES) data show that the drift is larger than CPI indicates. In other words, households behave as if costs-of-living increases exceed measured core inflation.

Let me say in advance where I am headed. The next section presents some further remarks on the idea of using Engel's Law to estimate the relationship between costs-of-living and CPI. Section three introduces the estimation techniques. Section four contains empirical results. In section five I discuss sensitivity issues and speculate on the role played by housing prices. The last section concludes and discusses policy implications. An appendix includes description of the data and some additional estimation details.

## 2. The Basic Idea

Hamilton's idea for estimating increases in costs-of-living by using Engel's Law amounts to three steps. First, analysts must accept the validity of Engel's Law. This means that the curve should be stable over time. Second, analysts must estimate the Engel curve for food using for example an almost-ideal-demand system. Included in the estimation are dummy variables for each year. Third, if the regressor in the Engel curve is properly deflated and changes in relative prices are properly accounted for, the estimates of dummy coefficients will be zero. If estimates of dummy coefficients are positive, then the Engel curve drifts to the right. In that case, consumers behave as if costs-of-living exceed the deflator. If estimates of dummy coefficients are negative, then the Engel curve drifts to the left. In that case, consumers behave as if costs-of-living increase less than what the deflator indicates.

Let us examine how to use the idea in an even simpler case in which we have only two years. Let Z be a nominal expression of total consumption in year t, and Y be a nominal expression of the total consumption in year t+1. Let there be a linear relationship between the budget share for food and consumption, everything else being equal. Everything else being equal includes unchanged relative prices between goods, denoted p, and constant other factors, denoted x. When we write the relationship between the budget share for food and consumption in its two forms (1) and (2) for two different years we then in effect use differently denominated variables on the first axis. One krone in year t is not the same as one krone in year t+1. Thus, necessarily, the slope coefficients β and γ are different.

(1) $$\omega_{ht} = f(p, x_h, Z_h) = g(p, x_h) + \beta Z_{ht}, \qquad h \in H, t \in T,$$

(2) $$\omega_{ht+1} = f(p, x_h, Z_h) = g(p, x_h) + \gamma Y_{ht+1}, \qquad Y_t = \pi Z_t, \qquad h \in H, t \in T,$$

But if Y is a rescaled version of Z, one would know the slope γ from knowing the slope β and the scaling factor π. Similarly, if one knows β and γ, one may compute the scaling factor π since β=πγ. Given Engel's Law and relative prices are unchanged, then the ratio β/γ may be interpreted as a measure of the increase in costs-of-living. Of course, this is a trivial exercise, because if relative prices between goods are stable, then it suffices to measure the price increase of one good in order to measure price increases of all goods. And if you have measured all prices, it becomes equally trivial to measure increases in costs of a given basket of goods. Whether you estimate the two curves (1) and (2) and deduce $\pi$ or you estimate the price increase of one good $p_i$ and deduce $\pi$ becomes a matter of computational simplicity. You do what is simpler.

Whether you estimate the two curves or collect prices in a basket of goods is not a simple choice when many things happen at the same time. If relative price changes occur, then one must choose between an original basket of goods and a resulting basket of goods, since households make substitutions in between. New goods may arise or old goods may disappear. Goods may improve or deteriorate in quality. Goods may not be included in the basket at all. We know from theory that it is non-trivial to reduce changes in a bouquet of prices into one, and that the difficulty increases when goods change, come and go. Moreover, estimating the necessary magnitude of outlays to achieve a given utility level in every year is a daunting task. Trying to do the same for each individual in an economy enhances the challenges. In any case, Engel's Law offers an *indicator* of increases in costs-of-living. As Hamilton (p. 619) suggests given that the function is properly specified, preferences are stable, and there are no systematic errors: "The true cost-of-living index is that index which eliminates secular drift in estimated cross-section Engel curves."

# 3. Estimation Technique

This article first uses Hamilton's technique in order to compare older American data with newer Norwegian data. Let me present the highlights of Hamilton's model, then proceed to suggest improvements. The baseline model is a modified AIDS-model:

(3) $$\omega_{h,t} = \phi + \gamma[\ln(P_{f,t}) - \ln(P_{n,t})] + \beta[\ln(Y_{h,t} - \ln(P_t)] + \sum_j \theta_j C_{j,h,t} + \sum_{t=1}^{T} \delta_t D_t + \mu_{h,t}, h \in H, t \in T, j \in J,$$

in which food's share of net income is denoted by $\omega$, observed prices are denoted by P, net income by Y, individual characteristics by C from a set J, and time dummy variables by D. Subscripts h, t, j, f, and n refer to household, time, characteristic type, food, and non-food. The non-subscripted price is general, observed inflation. The error term $\mu$ captures omitted structure and stochastic elements. As Hamilton, I assume it behaves classically; its distribution has zero mean and constant variance. I use Greek letters for parameters to be estimated or latent unobservable variables, and Latin letters for observable variables, except for food's share for which I use the Greek notation, as is tradition in the Engel literature. Hamilton shows (his equation (9), p. 627) that for each year bias is given by:

$$(4) \qquad \varepsilon_t = -\frac{\delta_t - \gamma(\ln(P_{f,t}) - \ln(P_{n,t}))}{\beta}, \qquad t \in T.$$

Using a small (large) γ, we can obtain a lower (upper) bound for the CPI bias, the wedge between cost-of-living and measured inflation.

As Hamilton explains (p. 627), equation (3) cannot be estimated directly in the same regression because the inter-temporal variation in the relative price of food is correlated with the year dummies. Hamilton solves this by first estimating γ from cross-section variation of relative prices, but admits that the estimate is imprecise given little cross-sectional variation in prices for food even in the U.S. Norwegian data do not allow such estimation since there is no cross-section food price variation data. Moreover, had such data been collected, it would presumably have had very small variation. In fact, in the Engel literature the cross-section price variation in a small economy for a given good is usually assumed to be zero. In other words, consumers in Norway at a given time are thought to face the same set of relative prices. There are several ways to go about this practical problem. I shall use two. First, I shall simply use Hamilton's estimate for γ to produce an estimate of the necessary price correction. Then I shall examine how sensitive the results are to variation in the coefficient γ. Keep in mind that the actual price difference between food and non-food in Norway in this period was very small so the effect from changes in food's price relative to other prices is small. Second, I shall estimate Engel curves for food for *each* year assuming no cross-section price variation in food in a non-parametric approach, and then compare such cross-section curves and adjust for inter-temporal developments in relative prices afterwards.

Empirical work of this kind faces many challenges. Observers must deal with outliers in data, heterogeneity in households, the specification of functional form, omitted variables, measurement errors in variables, the stochastic nature of estimates, household idiosyncrasy, and problems in the definitions of the variables. I deal with these problems by using an array of techniques. I use winsorization to check for outlier influence, segmentation to investigate finite mixtures of heterogeneous household types, and a non-parametric approach to explore functional form. I employ sensitivity analyses of food share including and excluding food consumed away from home to assess the importance of how to define food. Moreover, I investigate the role played by additional determinants such as age structure, region, and ownership of house. For obvious reasons, I do not report all permutations. However, the relevant knowledge obtained by such experimentation is presented in the empirical section or discussion.

Most importantly, we know that there are several problems with using income data. Annual income includes a transitory component. Hamilton acknowledges this and employs a three-year average to estimate a permanent component. I suggest using total consumption in addition to net income as a supplementary analysis. This has several advantages and one major disadvantage. Consumption is advantageous because it is more closely related to the material standard of living for a household since the household holds information about its long-term economic position. A household consumes given its perception of its own economic position, and this perception may be better captured in total consumption than in annual income. The household presumably uses its own information when it establishes its material standard of living, an insight that goes back to permanent income hypothesis and the life-cycle consumption smoothing idea. Using consumption avoids including a business-cycle-related savings component, and it also avoids the contamination income variables suffer from when there exist income misreporting, underreporting, non-market activities and tax avoidance.

However, consumption is latent and unobservable. Instead, analysts use total expenditure. This leads to well-known errors-in-variables approaches because total expenditure of a household shares some measurement errors with expenditures on food, and thus food's share. This leads to simultaneity bias in OLS estimates. As a result, it is common practice to use two-stage-least-square approaches and instrumental variables. However, the two-stage-least-square model requires linearity in order to yield consistent estimates. But the linear model is unsuitable for our purpose since the budget share for food follows a curve that looks similar to the logarithmic function. Analysts appear to confront the trade-offs in either using a proper, non-linear functional form, a possibly inferior income variable, but consistent estimates; using a less appropriate linear functional form, two-stage-least-square errors-in-variables model, the potentially superior total expenditure and consistent estimates; or using a proper, non-linear functional form with instrumental variables for endogenous total expenditure and accepting that the n-size sample consistency features of the estimates are unexplored. It looks like an analysts trilemma: Choose at most two out of three of optimum functional form, optimum regressor, and known estimate properties. This trilemma is an active constraint only as long as one insists upon parametric forms.

$$(5) \qquad X_h = \xi_h + \eta_h, \qquad h \in H,$$

in which latent total consumption is denoted by $\xi$ and the error term by $\eta$. The error term arises, as shown e.g. by Røed Larsen (2002) and modelled in Aasness and Røed Larsen (2003), from the difference between purchases of goods and consumption of goods that emerges from such consumer behavior as stock pile-up, seasonality, and durability. This error is independent of variables such as net income, demographic composition, age, and wealth. Thus, by projecting total purchase expenditure X onto an instrument space consisting of such variables, analysts obtain a projected total consumption variable, $X_P$, that does not correlate with the error term in the Engel curve. This approach builds upon the parametric version of Aasness, Biørn, and Skjerpen (1993). Ultimately, the procedure allows one to investigate relationships between food's share and consumption as given in general for in equation (6):

$$(6) \qquad \omega_f = f(p, X_{hP}, D_h) + \lambda_h, \qquad h \in H,$$

where the classically behaved error term $\lambda$ is uncorrelated with the projected consumption $X_P$, where D denotes other exogenous determinants, p denotes prices, and where $\omega$ now refers to food's share of projected consumption. Having projected total expenditure onto the instrument space, I proceed to explore the relationship in equation (8) non-parametrically by using a local regression technique and by choosing appropriate smoothing parameters. The local regression method fits a linear weighted regression line in a local neighborhood for each projected total expenditure, $X_{hP}$. The neighborhood is chosen so that it contains a percentage of all available observations in the sample. These observations are weighted by a smooth, decreasing function of their distance for each center $X_{hP}$. One then repeats the procedure through the spectrum of projected total expenditures. The linear regression weight assigned to an included observation $X_{iP}$ around $X_{hP}$, for which the local line is fit, is given by equation (7):

$$(7) \qquad W(X_{iP}, X_{hP}, b_i) = K_0(t) = K_0\left(\frac{X_{iP} - X_{hP}}{b_i}\right), \qquad i \in I, h \in H, t \in \Re,$$

where $X_{iP}$ is member of the bandwidth set around $X_{hP}$, where $b_i$ specifies the range of bandwidth, and where $K_0$ is a smooth weighting function. The neighborhood set I is a subset of the set H that contains all household observations. The intermediate variable t is member of the set of real numbers R, and is included to show the set from which the function $K_0$ maps. In local regression, the bandwidth specifies the percentage of all (nearest) observations in H that are included in I for each computation mid-point. This article uses the Tri-Cube function for $K_0$:

$$(8) \qquad K_0(t) = \begin{cases} (1-|t|^3)^3, for\ |t| \leq 1, \\ 0, otherwise. \end{cases}$$

Hamilton posits a logarithmic f, as is custom since Deaton and Muellbauer's (1980). But imposing structure may obfuscate the information in data or make some results be structure-driven and thus structure-dependent. In this article, I supplement and extend Hamilton's method by using the non-parametric approach in which I do not impose a specific functional form on f, but where I let the data sketch the curve. Thus, this article is in a position to verify the validity of the choice of parametric form, or to reject it, and to obtain new insights from the increased flexibility. However, a balance must be struck between over-smoothing that allows general inferences, mimicking parametric form, but entails losing idiosyncratic elements; and under-smoothing that shows any and all details, but disallows generalization. In the section below, I present the results and discuss the underlying choices I made in order to identify Engel curves for food without specifying functional form.

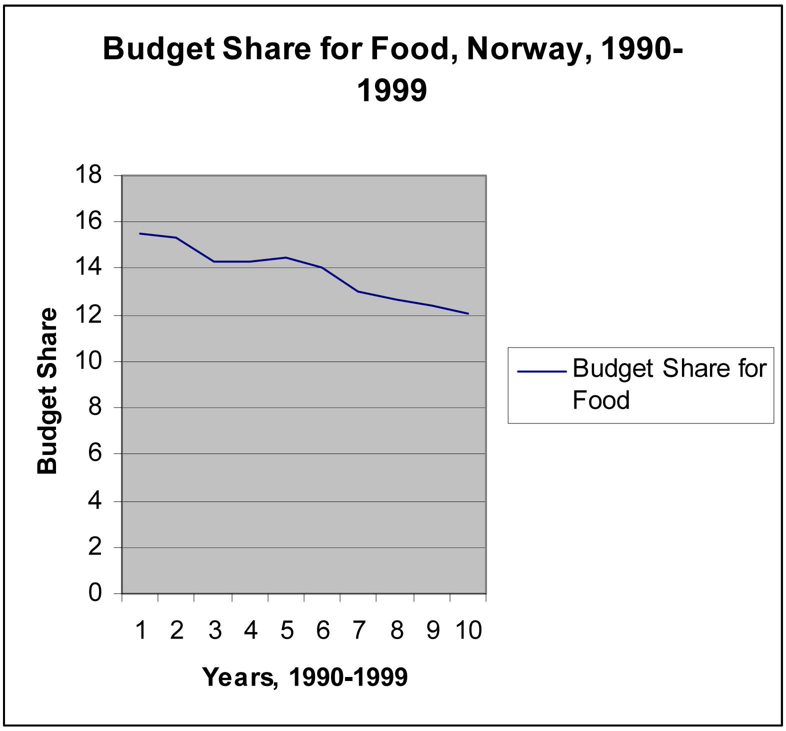
In addition, there is the well-known challenge in micro consumption studies posed by the composition and size of the household. These demographical challenges divide into two major groups of solutions. First, one may model households as if they are identical and share the same set of preferences, but differ on the realizations of variables. In this approach, a couple without children would have behaved the same way as a couple with children does had they had children, and vice versa. Second, one may model households as types that do not necessarily share the same set of preferences. Then a couple without children may not have behaved the same way as a couple with children does had they had children, and vice versa. Then solutions to optimisation programs for different types do not share an identical functional form. This idea leads to finite mixture models and the implementation of segmentation techniques. I use both approaches. In the empirical section below, I first replicate Hamilton on all households, then supplement with analysis in which I segment the sample into sub-samples of different household types. These types are singles, couples without children, and couples with children.

Finally, there exists a debate on how to define food and what is the relevant variable in Engel's Law. Food at home may emphasize intake of energy, but food away from home also contains energy and fulfil caloric needs even if food away from home also serves social purposes and helps solve time constraint issues. In any case, food away from home may be a substitute for food at home, and not controlling for the extent to which a household or household type eats out may lead to spurious results. I thus employ sensitivity analyses that both include and exclude food consumed away from home.

## 4. Empirical Results

An interesting overall picture emerges. Evidence shows that CPI underestimates costs-of-living by about 13 percentage points for the 90s. Inflation is observed at 22 percent over the decade while the general consumer behave as if costs-of-living increase 35 percent over the decade. Couples without children and couples with children behave as if costs-of-living increase approximately at the same rate as the inflation rate or less. Singles behave differently. They solve their consumption programs as if costs-of-living rose 43 percent over the decade. These results indicate that there exist important differences in costs-of-living increases for different types of households. Moreover, there are different costs-of-living trajectories within segment types for different material standards of living. Lower standards appear to experience higher cost increases. Hamilton's choice of the logarithmic functional form is supported by this article's non-parametric approach.

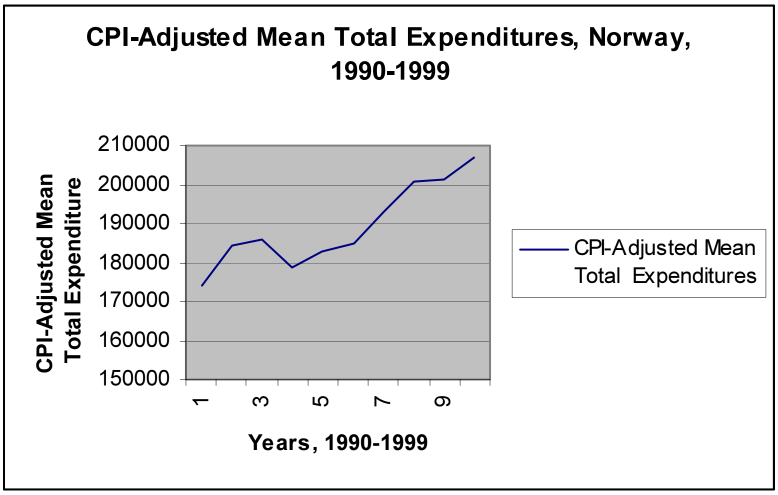
**Figure 1. Budget Share for Food, Norway, 1990-1999, Percentage of Total Expenditures**




Note: The budget share is defined as the ratio of mean expenditure on food to mean total expenditure. Mean expenditure on food and mean total expenditure were computed from each cross-section sample using correction weights for sampling probability.

The general time trend of the budget share for food is shown in Figure 1, and it demonstrates that in the 90s the budget share for food falls each year, except one. It is 15.5 percent in 1990 and 12.1 percent in 1999. This is indicative of a general increase in material standards of living.

**Figure 2. CPI-Adjusted Mean Total Expenditures, Norway, 1990-1999**




Note: Mean total expenditure was computed from each cross-section sample using correction weights for non-respondents. Official CPI numbers from Statistics Norway, mean for each year, were used as deflators.

From Figure 2 we observe that mean total real (CPI-deflated) expenditures in Norway increased over the 90s, although there is a local dip around 1992-1993, reflecting the business cycle. Mean total real expenditure in 1990 was 173 959 kroner while it was 206 905 kroner in 1999, an increase of 18.9 percent. What we would like to know, and what this article focuses attention on, is whether material standards of living increased as much as, or more or less, than total deflated expenditures. In other words, this article seeks is to examine the difference between real total expenditures or real net income -- as adjusted by the official deflator CPI -- material standards of living -- as adjusted by costs-of-living. Thus, we need to estimate costs-of-living.

**Table 1. Regression Results. Hamilton's Model. Food's share of real net income on log(net income), year dummies, and household size and composition (parsimonious model), Norway, 1990-1999**

| Variable | Estimate (t-value) | Accumulated Difference, Cost-of-Living vs Inflation Using Hamilton's $\gamma$ (Range: $\gamma$ +/- $\sigma_\gamma$) |
|---|---|---|
| Intercept | 3.22 (63.5) | |
| Log(Income/CPI) | -0.271 (-60.2) | |
| Number of Adults | 0.103 (28.4) | |
| Number of Children | 0.0474 (26.8) | |
| Dummy, 1991 | 0.00500 (0.55) | 0.021 (0.019-0.023) |
| Dummy, 1992 | 0.0000937 (0.01) | 0.005 (0.002-0.007) |
| Dummy, 1993 | 0.0136 (1.50) | 0.060 (0.053-0.066) |
| Dummy, 1994 | 0.0184 (2.04) | 0.078 (0.071-0.084) |
| Dummy, 1995 | 0.0093 (1.03) | 0.045 (0.038-0.053) |
| Dummy, 1996 | 0.0142 (1.57) | 0.063 (0.056-0.070) |
| Dummy, 1997 | 0.0248 (2.70) | 0.101 (0.094-0.107) |
| Dummy, 1998 | 0.0292 (3.12) | 0.113 (0.109-0.117) |
| Dummy, 1999 | 0.0345 (3.68) | 0.132 (0.129-0.135) |
| | | |
| Adjusted $R^2$ | 0.232 | |
| Root MSE | 0.2250 | |
| F-value, Pr>F | 323.6, <.0001 | |

Note: 12816 households, 21 observations deleted due to missing values. Food's share is expenditure on food divided by net income. Net Income is income after tax. Children are children below 20 years of age.

In Table 1, I report results from a regression replicating Hamilton's regression using Norwegian CES data for 1990-1999. We observe in the right-most column that the difference between costs-of-living and observed inflation is estimated to be of magnitude 13 percentage points for the ten-year period. From the second column with regression estimates we observe that most coefficients are both highly statistically significant and economically important. Notably, when income increases, the share of food falls, and the t-value for the coefficient of logarithm of real net income coefficient 60.2, clearly rejecting the null of a zero derivative. This supports Engel's Law of decreasing food shares with increasing income, everything else being equal.

We also observe that when income is held constant, an increase in the number of adults in the household is associated with an increase in the food's share of net income. The interpretation is that an additional adult needs food, and given income, increased food expenditure leads to an increase in food's share. Moreover, we observe that when income and number of adults are held constant, an increase in number of children in the household increases food's share of net income. The partial effect of an additional child is smaller than the partial effect of an additional adult. This is natural since children need fewer calories on average than adults.

Let us turn to the dummy variables. For each year, the estimates of dummy coefficients are positive. It means that for each year a given food share is associated with a larger real net income. In other words, the curve drifts rightward. In contrast, Hamilton's dummy coefficients were negative. His curves drift leftward. Hamilton's interpretation of such drift is that the CPI-deflator does not capture all costs-of-living effects. In contrast, Norwegian consumers behave as if costs-of-living increase more per year than the CPI increases.

Notice that I, as Hamilton does, adjust the bias obtained from the ratio $-\delta/\beta$ by subtracting a price correction term, $-\gamma(\log(P_f)-\log(P_n))/\beta$. This correction is the part of the bias that emerges from relative prices of food. In our case, food becomes cheaper. It rises by 19 percent compared to 22.9 percent for non-food over the period. For 1999, the dummy coefficient is 0.0345. The income slope $\beta$ is -0.271. Thus, the uncorrected bias is 12.7. The resulting bias after relative price correction is 13.2. From this we learn two things. First, relative prices explain a small component of the total bias, 0.5 of 13.2 is less than one twenty-fifth of total bias. Second, since food becomes cheaper the ratio $-\delta/\beta$ that is not corrected for relative prices constitutes a lower bound on cost-of-living increases. Everything else being equal, lower food prices lead to lower costs-of-living so when lower food prices is incorporated in household behavior but not adjusted for by analysts, the constant-price costs-of-living increases are higher. We shall keep this in mind when we examine non-parametric results that do not control for relative price effects.

I expanded the model to include preference shifters and wealth proxies such as mortgage and mortgage payments, number of cars, number of boats, age of reference person, and number of income earners. The results are reported in Table 2. We observe that the main results remain stable. Interestingly, everything else being equal, an increase in number of cars, mortgage payment, and age of reference person are associated with increases in food's share. There may be a number of reasons for this, including spurious effects. For example, older people may focus on home activities and number of cars may indicate an emphasis on home activity, or the positive derivatives may simply hint at consumption substitutions. Our focus of attention, however, is on the empirical regularity that the cumulated difference between cost-of-living and observed inflation is of the order 12.4 percent, similar to 13.2 in the parsimonious model.

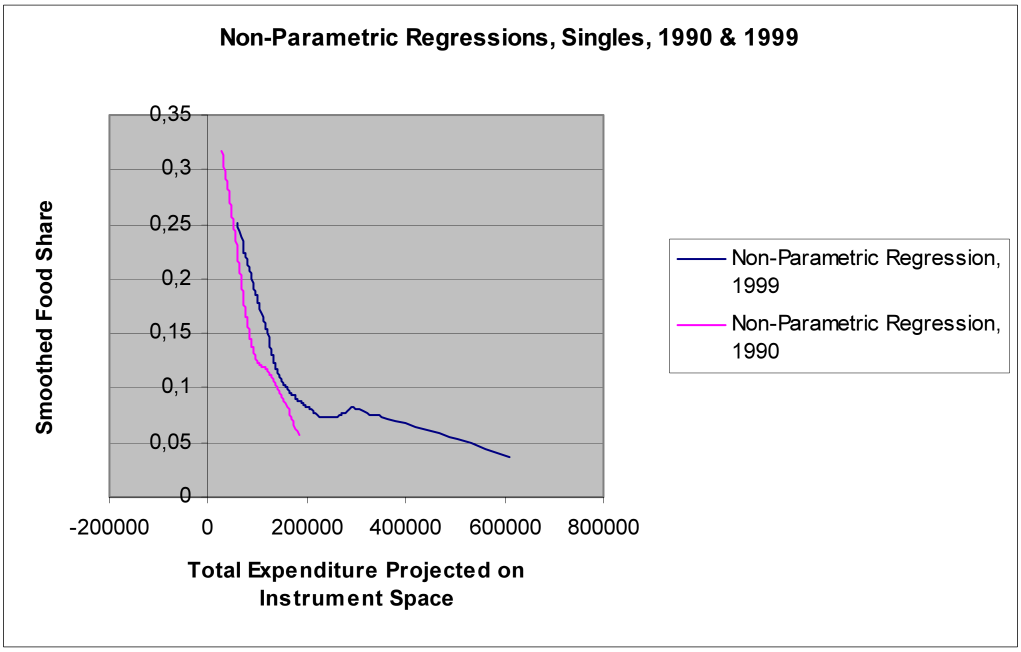
**Table 2. Regression Results. Hamilton's Model. Food's share of net income on log(real net income), year dummies, household size and composition, and other determinants of material standard (extended model), Norway, 1990-1999**

| Variable | Estimate (t-value) | Accumulated Bias, Cost-of-Living vs Inflation, Using Hamilton's $\gamma$ (Range: $\gamma$ +/- $\sigma_\gamma$) |
|---|---|---|
| Intercept | 3.75 (64.6) | |
| Log(Income/CPI) | -0.323 (-61.9) | |
| Number of Adults | 0.088 (22.8) | |
| Number of Children | 0.040 (21.1) | |
| Dummy, 1991 | -0.00082 (-0.09) | -0.000 (-0.002-0.001) |
| Dummy, 1992 | -0.00146 (-0.17) | -0.001 (-0.003-0.001) |
| Dummy, 1993 | 0.0142 (1.59) | 0.052 (0.046-0.058 |
| Dummy, 1994 | 0.0174 (1.95) | 0.062 (0.056-0.067 |
| Dummy, 1995 | 0.0088 (0.98) | 0.036 (0.030-0.043 |
| Dummy, 1996 | 0.0135 (1.49) | 0.050 (0.045-0.056 |
| Dummy, 1997 | 0.0223 (2.41) | 0.077 (0.071-0.082 |
| Dummy, 1998 | 0.0320 (3.37) | 0.104 (0.100-0.107 |
| Dummy, 1999 | 0.0390 (4.11) | 0.124 (0.122-0.127) |
| Number of Cars | 0.0126 (4.01) | |
| Number of Boats | 0.0177 (3.84) | |
| Mortgage Payment | 3.92e-7 (4.92) | |
| Mortgage | 6.78e-8 (9.32) | |
| Main Persons Age | 0.00069 (4.25) | |
| Number of Inc. Earners | 0.0357 (11.1) | |
| Number of VCRs | 0.0174 (4.39) | |
| Number of Refrigerators | 0.0112 (2.91) | |
| | | |
| Adjusted $R^2$ | 0.254 | |
| Root MSE | 0.2218 | |
| F-value, Pr>F | 218.9, <.001 | |

Note: 12816 households, 23 observations deleted due to missing values. Food's share is expenditure on food divided by net income. Net Income is income after tax. Children mean children below 20 years of age.

Hamilton recognizes several problems with using income variables as regressors since income contains permanent and transitory components. This article uses the scheme of latent total consumption as observed in manifest total expenditure described above, and projects observed total expenditures onto an instrument space in order to solve the endogeneity problem. This set-up allows us to sketch Engel curves for food that are *not* based on parametric assumptions. Such sketches are included in Figure 3, 4, and 5.

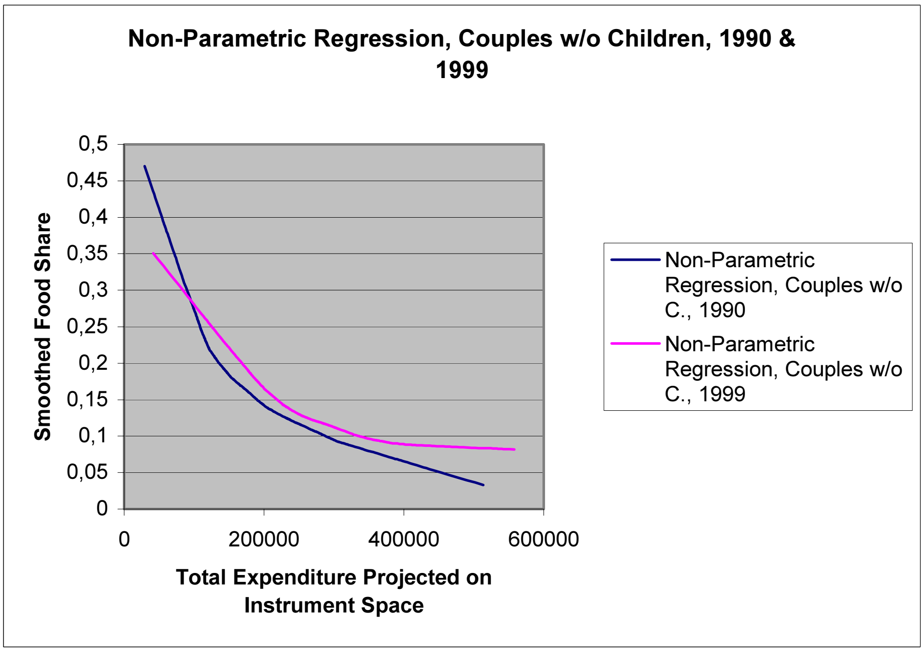
**Figure 3. Non-parametric Engel curves for Food, Single-person Households, Norway, 1990 and 1999**




Notes: For 1990 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:248, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares 2.45, Equivalent No. of Parameters:3.58, Residual Standard Error: 0.10. For 1999 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:170, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares 0.96, Equivalent No. of Parameters: 4.13, Residual Standard Error: 0.076. The instrument space for the regression of total expenditure on instruments consisted of the following variables combined linearly: Net Income after Taxes, Age of Main Person, Mortgage Payment, Mortage, No. of Earners, No. Boats, No. of Cars, No. of Stoves, No. of Refrigerators, No. of Freezers, No. of Washing Machines, No of Dry Tumblers, No of TVs, No. of Videos, and No. of Labor Hours. The 1999 instrument space consists of the same instruments, except Labor Hours (too many missing) and in addition: No. of Microwave ovens, No. of Combined Refrigerators and Freezers, No. of Video cameras, No. of Electric Sewing Machines, and No. of PCs.

Figure 3 shows that in 1990 a single-person household that wanted a standard of living commensurate with a food share of 0.20 had predicted total expenditures of 66 500 kroner in total. In 1999, a household that wanted such a standard of living had predicted total expenditures of 87 800 kroner in total. Thus, households behave as if the costs of maintaining a standard of living commensurate with a food share of 0.20 had increased 32 percent. For the more common 0.15-standard, households in 1999 have 44 percent higher predicted total expenditures. For the luxurious 0.12-standard, expenditures have increased by 26.4 percent. These differences tell us at least two things. First, there may be important differences in changes in the costs-of-living at different levels of standards. Second, there is variability in the data, and thus in our estimates of costs-of-living. For example, a few rich households in 1999 stretched the curve out to the right. This shows the power of non-parametric approaches. In most functional specification, such outliers would have affected estimated coefficients, possibly tempting us to draw unjustified conclusions unless we treated the data with winsorization techniques and other ways of handling outliers. In the appendix, I include an example of how the non-parametric sketch follows from the collection of pairs of food's share and predicted total expenditures.

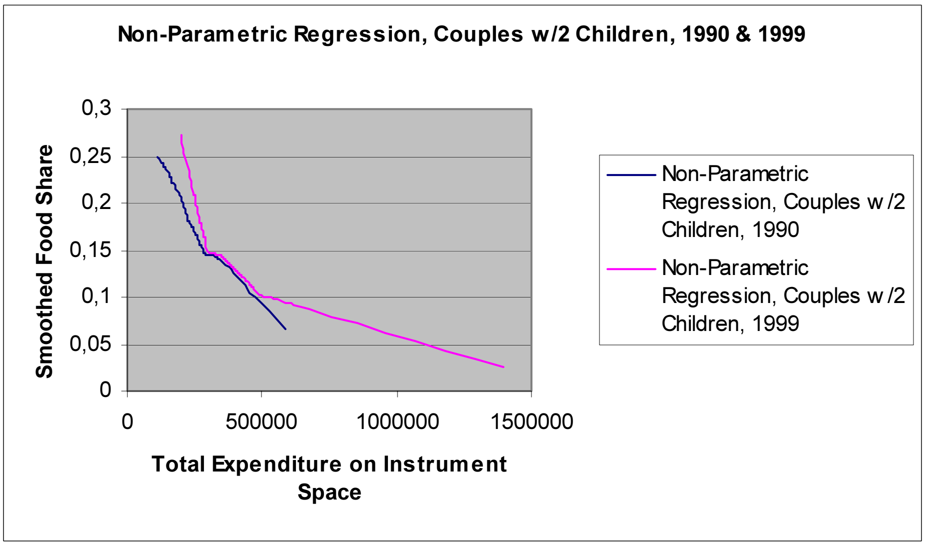
**Figure 4. Non-parametric Engel curves for Food, Couples without Children, Norway, 1990 and 1999**




Note: For 1990 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:313, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares 3.38, Equivalent No. of Parameters:3.91, Residual Standard Error: 0.10. For 1999 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:252, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares 1.13, Equivalent No. of Parameters: 3.90, Residual Standard Error: 0.068. The instrument space for the regression of total expenditure on instruments consisted of the following variables combined linearly: Net Income after Taxes, Age of Main Person, Mortgage Payment, Mortage, No. of Earners, No. Boats, No. of Cars, No. of Stoves, No. of Refrigerators, No. of Freezers, No. of Washing Machines, No of Dry Tumblers, No of TVs, No. of Videos. The 1999 instrument space consists of the same instruments and in addition: No. of Microwave ovens, No. of Combined Refrigerators and Freezers, No. of Video cameras, No. of Electric Sewing Machines, and No. of PCs.

Figure 4 shows that in 1990 a household consisting of a couple without children that wanted a standard of living commensurate with a food share of 0.25 would have predicted total expenditures of 108 500 kroner in total. In 1999, a household that wanted such a standard of living would have expenditures at 125 400 kroner in total. Thus, households behave such that expenditures associated with maintaining a standard of living commensurate with a modest material standard of living reflected by a food share of 0.25, increased by 15.6 percent. For the 0.20-standard, households are found to behave such that the associated level of predicted total expenditures increased by 24.2 percent. For the higher 0.15-standard, expenditures appear to increase by 14.7 percent.

**Figure 5. Non-parametric Engel curves for Food, Couples with Two Children, Norway, 1990 and 1999**




Notes: For 1990 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:182, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares: 1.66, Equivalent No. of Parameters:4.20, Residual Standard Error: 0.097. For 1999 Non-Parametric Local Regression I obtained the following key statistics: No. obs.:257, No. fitting points: 17, Smoothing Parameter:0.60, Residual Sum of Squares 1.17, Equivalent No. of Parameters: 4.58, Residual Standard Error: 0.068. The instrument space for the regression of total expenditure on instruments consisted of the following variables combined linearly: Net Income after Taxes, Age of Main Person, Mortgage Payment, Mortage, No. of Earners, No. Boats, No. of Cars, No. of Stoves, No. of Refrigerators, No. of Freezers, No. of Washing Machines, No of Dry Tumblers, No of TVs, No. of Videos. The 1999 instrument space consists of the same instruments and in addition: No. of Microwave ovens, No. of Combined Refrigerators and Freezers, No. of Video cameras, No. of Electric Sewing Machines, and No. of PCs.

Figure 5 shows that in 1990 a household consisting of a couple with two children that wanted a modest material standard of living commensurate with a food share of 0.25 would be observed to have (predicted) total expenditures of 172 600 kroner. In 1999, a household that wanted such a standard of living would be observed with (predicted) total expenditures at 238 000 kroner. Thus, households behave such that expenditures associated with a standard of living commensurate with a food share of .25 increase by 37.9 percent. For the 0.18-standard, households behave such that total expenditures increase by 18.3 percent. For the more luxurious 0.15-standard, total predicted expenditures are observed to increase by 5.9 percent. Again, these differences tell us at least two things. First, there may be important differences in changes in the costs-of-living at different levels of standards. Second, there is variability in the data, and thus in our estimates of a common costs-of-living.

There is of course a noticeable improvement in standards. For example, for couples with two children the 1990-median standard was seen at a share of 0.174. In 1999, it was found at a share of 0.137. The median family seems to improve material standards considerably over the decade.

Notice also that Figures 3, 4, and 5 imply estimates on equivalence scales as. For example, in order to purchase the 0.15-standard in 1999, single-person households needed approximately 120 000 kroner. Couples without children needed approximately 216 000 kroner, and couples with 2 children needed approximately 298 000 kroner. Thus, to obtain the same standard of a food share at 0.15, couples without children would require 1.8 times the expenditure of a single-person household, and couples with two children would require 2.5 times the expenditure of a single-person household. These numbers thus yield an estimate on equivalence scales of magnitude 0.8 adult-units for an additional adult and 0.35 adult-units for each additional child.

Moreover, observe that the above numbers were not corrected for the effect of cheaper food. Above, we saw that in the parametric version, given Hamilton's estimate of coefficient magnitude and given the slightly cheaper Norwegian food, the costs-of-living increases would be circa one twenty-fifth larger without the relative price effect. Thus, if one finds that the total expenditures associated with a given standard increases by, say, 35 percent over the decade, this effect includes both a price-constant costs-of-living effect and a relative-price-effect. Since the latter reduces costs-of-living, and is present in household behavior, the estimate of 35 on price-constant costs-of-living is a lower bound. Cost increases without cheaper food would be approximately 36.5.

**Table 3. Costs-of-Living Increases As Observed by Household Behavior and the Non-Parametric Local Regression Technique, Selected Material Standards, Norway, 1990-1999, Lower Bounds (Not Corrected for Cheaper Food)**

| **Material Standard of Living** | **Increases in Costs-of-Living as Inferred from Household Behavior, For Different Household Types, 1990-1999** | | |
|---|---|---|---|
| | **Singles** | **Couples w/o Children** | **Couples w/ 2 Children** |
| **0.20** | 33.1% | 24.1% | 25.9% |
| **0.15** | 43.3% | 14.8% | 6.4% |
| **0.13** | 38.2% | 12.6% | 4.6% |
| **1990-Median** | 0.146, 43.2% | 0.171,18.7% | 0.174, 15.5% |

In Table 3 I have collected costs-of-living increases for different standards and different types. It highlights that there are differences between and within types of households. Thus, analysts of costs-of-living should allow sufficient flexibility in specifications to capture the cost-development of different ways of solving material needs. For example, singles behave such that the median 1990-standard of 0.146 has associated total expenditures that are 43 percent higher in 1999 than in 1990. On the other hand, couples with two children behave such that the median 1990-standard of 0.174 has associated total expenditures only 16 percent higher in 1999 than in 1990. Couples without children lie in between at 19 percent. Notice, then that the CPI overstates costs-of-living for one type of household and understates costs-of-living for another type. In addition, we observe big differences within types of household among different standards. For example, within the segment of couples with two children households behave differently: Households with a modest standard of living, given food's share, increase their total expenditures more than do households at higher standards of living (with lower food's share). The differences between different living standards are smallest within the singles-group, but large in the segments containing couples without children and couples with two children.

For completion, I include results in the appendix on a parametric regression using Hamilton's specification that involves the definition of food being expanded to include food away from home. No substantial deviations from the major findings were detected, so I leave it uncommented.

# 5. Discussion and Speculation

I speculate that soaring housing prices are an important factor in causing from-behavior-inferred costs-of-living to rise faster than the CPI. I find four sources for this suspicion, three related to prices and one related to weights of prices. First, costs of housing services for all consumers are based upon Surveys of Renters. The rationale is that renting reflects the user price of housing, for renters and for owners. However, when most households purchase a home and consume the service stream from their purchase, it is crucial that rents reflect general user costs. This may not always be the case, especially when capital markets are imperfect. Røed Larsen (2004) shows that in the life-span of the House Price Index, 1992-2003, housing prices rose 143 percent while rental prices rose only 36 percent. Second, consumers may self-select into those who choose to rent and those who desires to purchase. Then renters' costs may not accurately represent owners' costs. Renters are much fewer than owners in Norway. Third, renters may adjust to increasing housing prices by downgrading their standard. Surveys of Renters sample renters, and track the rent of the housing object for 13 months, before a new sample is selected. Even if the survey tracks the object for 13 months, and normalize two samples in after their common 1-month period, the collection of objects may change when renters downgrade. If increases in prices for different rental objects are non-uniform this creates bias, even when the normalization corrects level differences; see Røed Larsen (2004). Fourth, the weights derived for the consumer price of housing are derived from Consumer Expenditure Surveys. But these surveys track cash flows, not latent consumption. This is not an acute problem for non-durables. But it is for durables. Households that own their own homes and have paid the mortgage appear with zero housing outlays and thus zero housing consumption. This underestimates the weights for housing since only paid interest and maintenance appear. Imputed housing consumption for owners would reduce bias (and are performed in 2000 onwards), but are difficult because they require good estimates and involve many out-of-sample predictions. In Norway, imputations were not made in the period 1990-1999.

Thus, one likely source of the discrepancy between costs-of-living and CPI lies in the housing market. Purchases of homes represent both consumption and investment, and it is a challenge for official measurements of inflation to disentangle which part should go into the CPI. It is possible that in periods with housing booms increases in costs-of-living for many sub-segments of the population exceed increases in CPI. Suspicion of this emerges from the two negative coefficient estimates of year dummies in Table 2. These estimates were for years 1991 and 1992, the same time housing prices fell. Thus, in this period, I find -- for the full model -- that CPI overstates, not understates, costs-of-living. This is then in accordance with Hamilton. However, coefficients change sign at the same time the housing boom started. I performed a Hamilton-regression on the sub-sample of early purchasers, i.e. households in which the ratio of mortgages to net income was between zero and unity. For the subgroup of house owners the results in costs-of-living were opposite those of the whole sample. Estimates of dummy coefficients were negative. Thus, for this subgroup, Engel curves consistently drifts to the left, not right, indicating that costs-of-living increase *less* than CPI.

Moreover, the period 1988-1993 was one in which housing prices fell. If housing prices were the key determinant of the discrepancy between increases in costs-of-living and the CPI in the period form 1993 onwards, then we would assume regression results for the period 1988-1993 to be different from those for 1993-1999. I performed an identical Hamilton regression on the period 1986-1994, and results were different than for 1990-1999, even if they were inconclusive. Out of 8 dummy coefficients, 5 were negative and 3 positive. T-values were small, and dummy coefficient estimates were not statistically significant. Again, it seems as if it is the rise in housing prices since 1993 that explains the downward bias in CPI.

Ultimately, constructing a scalar that is thought to capture all price effects implies assigning weights to prices of subgroups and specific items. Since different households purchase different goods in different amounts, the aggregate CPI cannot represent price increases precisely for all types of households -- neither can any scalar representation. Thus, this article's general finding that households behave in a way such that maintaining a given standard is associated with a 35 percent increase in expenditures, may simply be attained from another way of combining prices. It puts larger weight on goods and services that have had a large price increase. To control, however, that the results is not merely a figment of sampling scheme, I perform similar Hamilton-regressions with and without correction weights that are designed to control for sampling probability. The pattern remains unaltered. This is another reason why it is interesting to study the experiences within sub-groups of the population, and examine how costs are distributed. As we have seen, that distribution is quite asymmetrical over household types.

I performed robustness checks of different functional forms and omitted variables. I also used winsorization to check for influential outliers. I do not report these results. Let it suffice to say that the general pattern is robust. As can be seen below, the appropriate functional form seems to be close to the logarithmic and experiments with third order polynomials confirmed this. Linear models under-performed. Including and excluding several determinants and possible preference shifters such as wealth proxies, income class (lower, middle, upper), age, number of earners in household, numbers of hours worked, region, and urbanization of residential area were tested. The main results were intact. I report some of these results in an appendix. In particular, I include regression results in which food consumed away from home is included. I also checked whether the pattern was sensitive to choice of income definition. I performed regressions with wage income, total gross income, and net income after tax, rents, and payments of interest and principal. The pattern was not sensitive to such choices, and I do not report the results.

# 6. Concluding Remarks and Policy Implications

There may be important differences between the development in costs-of-living and the CPI. The discussion has revolved around the differences between a cost-of-good index and a cost-of-living index. The former uses a basket of goods; the latter a given standard of living. Scholars have frequently cited three sources for why the CPI overstate of costs-of-living: quality improvements, new goods, and substitutions. But goods may disappear and quality may deteriorate. Some goods may not appear properly in the basket. Less focus of attention has been put on the possibility that CPI may sometimes understate costs-of-living if some parts of the consumption basket do not reflect what consumers consume. Housing is notoriously difficult to measure, because it is both a consumption and an investment good, so a boom in housing prices may escape CPI-measures and involve an understatement of costs-of-living, depending on how housing prices are included in the CPI. It is thus an empirical question which way the bias goes, and it may be different for different economies and for the same economy at different times. In addition, this article shows -- in accordance with theory -- that it is different for different types of household and different material standards of living.

I find, using Hamilton's econometric method, that households in general behaved as if costs-of-living increased about 35 percent in the 90s. During the same time interval, CPI increased by 22 percent. I show, using a combination of an errors-in-variables model, segmentation, and a non-parametric approach that singles behave in a manner such that total expenditures associated with given standards rose much faster than for other groups, and much more than the CPI. Couples with two children and couples without children increase their total expenditures at given standards only moderately, i.e. at or below the CPI increase. This article shows that within groups there are different magnitudes in the expenditure increases for different levels of material standards of living. Poorer standards appear to require faster growth of expenditures than do higher standards.

Different households will experience different increases in prices. This shows up both in theoretical scrutiny and empirical studies. Since the CPI is one scalar indicator of a variety of prices, it cannot capture everybody's experience at once. As a result, the question is which weights to put on which prices. This article shows that, most likely, there is a large difference is price experiences across the spectrum of households. The question of whether to believe the 35 percent increase in costs or the 22 percent increase in the CPI may be resolved by looking at the price experience for different types of households. Singles have a different experience than couples. Owners face different cost development than do renters.

Since many important features of an economy revolves around prices, policymakers are well advised to heed the evidence showing discrepancies between the CPI and costs-of-living. Ultimately, one possibility is to consider indexing wages, tax brackets, and subsidies and transfers to other nominal anchors than the CPI or to different indices for different groups and standards. Of course, the CPI remains an important indicator of the effects from changes in the monetary base and the stock of money, but it may deserve supplementary indices when costs-of-living are involved. Using empirical regularities such as Engel's Law may prove to provide fertile soil for developing more precise studies into costs-of-living indices. In particular, following Røed Larsen (2004) we observe that substituting an interest-payment principle for a rental-equivalence principle in the computation of prices for home-owners increases CPI by a factor larger than one and one half. Thus, whether central bankers under an inflation target regime uses an interest-payment principle or a rental-equivalent principle becomes crucially important for the speed of their target. This article may hint that consumers actually behave consistent with a interest-payment principle so that current CPI increases are too low.

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# Data

I use observations on household purchase expenditures from the Norwegian consumer expenditure surveys in the period from 1990 to 1999 as my main data source. In total, 12815 households were observed over period 1990-1999; each household for a 14-day period. The surveys are conducted continuously by Statistics Norway. Every 14-day period of the year, 1/26 of households report their purchase expenditures in diaries. Sample sizes are typically around 1200 households per year. The sampling scheme is a two-stage stratified random sample. Response rates vary around 60 percent. The commodities are classified into a large array of different items when official surveyors code the expenditures from the households accounting books into pre-assigned groups. Standard aggregation levels are 9, 37, 150 and 488 commodity groups.

This data set also includes information on other household characteristics. Most importantly, income after tax is available. In addition, data include household size and composition, region of residence, vocation of main income earner, number of hours worked for main income earner, and ownership on a number of household durables such as cars, boats, refrigerators, washing machines, stoves, television sets, video recorders, and microwave ovens.

For verification, validation, and comparison I use three other data sets, but do not report all results. First, I use similar CES data sets for the period 1986-1993 in order to compare estimates over periods. Second, in doing so, I use information on income from tax registers. This allows incorporation of several types of income in order to investigate sensitivity to choice of income. Third, I use information from tax registers in the sub-period 1993-1998, which was only available for that sub-period, again to investigate sensitivity to choice of income. This allowed performing analyses using wage income, total income before taxes, and income after tax, interest, rent, and mortgage principal in addition to analyses using total income after taxes.

# Background Results

**Table B1. Food and expenditures at café, canteen, cafeteria, restaurant, and bars share (of net income) on log(net income), year dummies, household size and composition, and other determinants of material standard (extended model), Norway, 1990-1999**

| Variable | Estimate (t-value) | Cumulated Bias Using Hamilton's $\gamma$ (Range: $\gamma$ +/- $\sigma_{\gamma}$) |
|---|---|---|
| Intercept | 4.93 (64.4) | |
| Log(Income) | -0.418 (-60.8) | |
| Number of Adults | 0.110 (21.6) | |
| Number of Children | 0.037 (14.8) | |
| Dummy, 1991 | -0.0221 (-1.88) | -0.051 (-0.052--0.050) |
| Dummy, 1992 | -0.0154 (-1.33) | -0.034 (-0.036--0.032) |
| Dummy, 1993 | 0.0038 (0.32) | 0.015 (0.011-0.020) |
| Dummy, 1994 | 0.0095 (0.81) | 0.029 (0.025-0.033) |
| Dummy, 1995 | 0.0054 (0.45) | 0.020 (.0.015-0.025) |
| Dummy, 1996 | 0.0120 (1.01) | 0.035 (0.031-0.040) |
| Dummy, 1997 | 0.0226 (1.86) | 0.060 (0.056-0.064) |
| Dummy, 1998 | 0.0385 (3.08) | 0.096 (0.093-0.098) |
| Dummy, 1999 | 0.0478 (3.82) | 0.117 (0.115-0.119) |
| Number of Cars | 0.0193 (4.65) | |
| Number of Boats | 0.0272 (4.47) | |
| Mortgage Payment | 7.35e-7 (7.01) | |
| Mortgage | 9.07e-8 (9.46) | |
| Main Persons Age | -0.00036 (-1.69) | |
| Number of Inc. Earners | 0.0494 (11.7) | |
| Number of VCRs | 0.0225 (4.30) | |
| Number of Refrigerators | 0.0089 (1.75) | |
| | | |
| Adjusted $R^2$ | 0.242 | |
| F-value, Pr>F | 205.65, <.0001 | |

Note: 12816 households, 23 observations deleted due to missing values.

# Fitted Non-Parametric Engel Curves

**Figure C1. Example of Non-parametric Engel curves for Food and Point Observations, Singles, Norway, 1999**

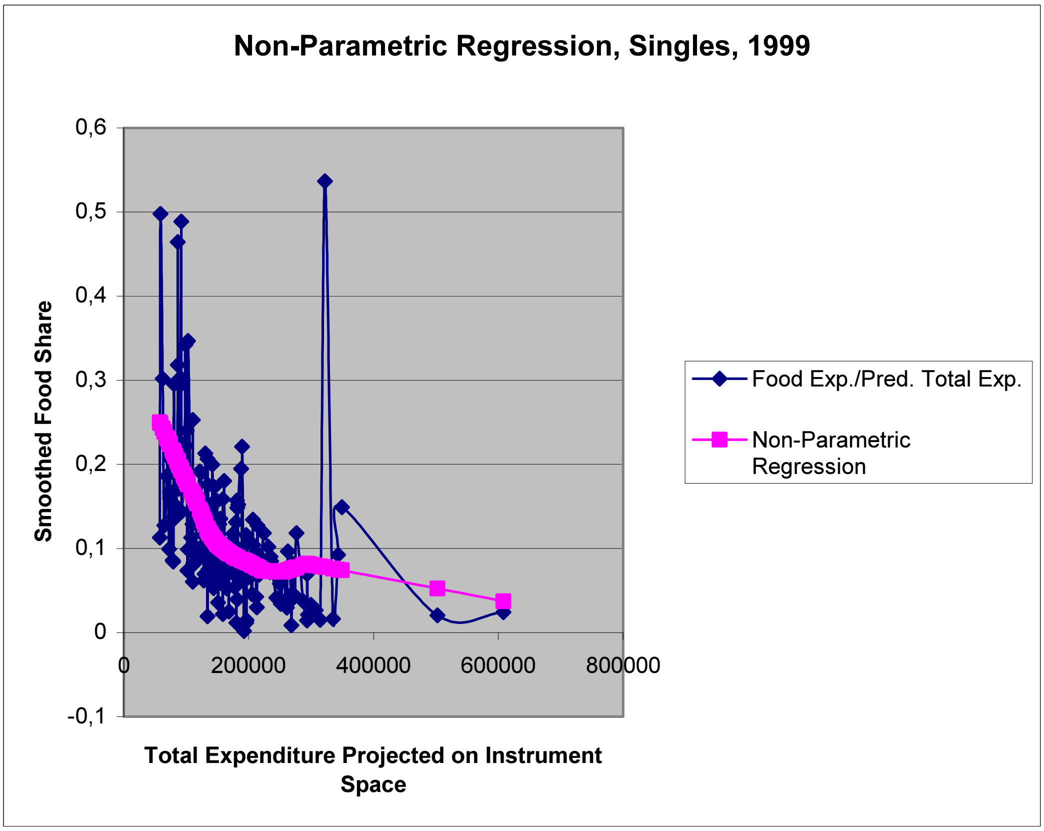

**Table D1. Hamilton Regression. Households with Mortgage/Net Income between 0 and 1 (Early Entrants to the Housing Market), 1990-1999**

| **Variable** | **Estimate (t-value)** |
|---|---|
| Intercept | 1.363 (31.3) |
| Log(Income/CPI) | -0.104 (-27.7) |
| Number of Adults | 0.0294 (13.2) |
| Number of Children | 0.0228 (18.9) |
| Dummy, 1991 | 0.0010 (0.16) |
| Dummy, 1992 | -0.0018 (-0.29) |
| Dummy, 1993 | -0.0128 (-2.08) |
| Dummy, 1994 | -0.0157 (-2.58) |
| Dummy, 1995 | -0.0166 (-2.67) |
| Dummy, 1996 | -0.0179 (2.90) |
| Dummy, 1997 | -0.0184 (-2.98) |
| Dummy, 1998 | -0.0257 (-3.99) |
| Dummy, 1999 | -0.0209 (-3.17) |
| | |
| Adjusted $R^2$ | 0.270 |
| No. of Households | 3034, 3 missing, 3031 used |

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