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Consumption Inequality in Norway in the 80s and 90s

Abstract:
Overall consumption inequality in Norway does not rise in the first half of the 90s. However, the inequality in the distribution of consumption among single-person households increases while it decreases among families. There is supporting evidence that the tax reform of 1992 contributed to reduce consumption inequality. These results emerge from a novel estimation procedure of consumption for each household and the subsequent measurement of consumption inequality among households. This article proposes a latent variable model that simultaneously estimates latent total household consumption and the variance of total consumption over households in order to investigate trends of consumption inequality in Norway in the late 80s and early 90s. The model makes use of both expenditure and non-expenditure indicators of latent total consumption in a variance minimizing way. We compute inequality measures, including the Gini index and the coefficient of variation, for consumption in the period 1986-1995, and investigate the development of consumption inequality for the population as a whole and for different household types.

Keywords: Consumption inequality, distribution, household consumption, latent variable model, standards of living, tax reform

JEL classification: D12, D31, D63, H24

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1. Introduction

It is widely believed among Scandinavian economists and policymakers that income inequality in Norway increased in the 90s and several studies have aimed to map such income inequality trends in Norway. This article shows that the picture may be more complicated, and that qualifications need to be made. Evidence based on consumer data shows that overall consumption inequality does not rise even if income inequality does. This puzzling divergence between income and consumption inequality arises from using a new model of household consumption, and is especially pertinent to the tax and income and welfare inequality debate. This article attempts to resolve parts of that puzzle and demonstrates the usefulness of studying consumption inequality development within population segments. An important finding is that while consumption inequality among single-person households increases, consumption inequality among families decreases. Thus, the resulting overall experience for the whole population depends crucially on the method for comparing households of different size and composition.

Policymakers, economists, and the public show keen interest in distributional questions in general and in the ramifications of tax reforms in particular, and this article seeks to stimulate that interest by presenting evidence from a rigorous model of latent total consumption that improves upon earlier models based on total purchase expenditure. A debate on the success of the tax reform emerged some years ago in the wake of the tax reform, and it is still ongoing. Our results are relevant to that debate, and lend some support to claiming that the tax reform actually succeeded in reaching distributional goals. Moreover, the findings in this article on consumption supplement the findings from the investigation of income. For example, Epland (1997) finds that the income inequality for 1986-1995 increased. We shed light on that claim, and put forward evidence that overall consumption inequality does not rise. However, there is an intriguing correspondence between what Aaberge et al. (2000) find and this article's results. While they document quite stable income distributions between 1986 and 1994 but, however, detect a tendency of inequality increase for the last two years in the period, we notice a similar possibility in overall consumption inequality for the years 1994 and 1995. Furthermore, Fjærli and Aaberge (2000) observe that rising income inequality to some extent can be explained in changed dividend policy induced by the 1992 tax reform. This article extends the list of explanations by examining how consumption inequality trends can be decomposed into trends among sub-segments of the population. The different experiences of different household types contradict, however, Aarbu and Thoresen (2001) who investigate income responses to the Norwegian tax reform of 1992 and suggest that income growth among the tax reform beneficiaries is not much different from

others. In summary, we join both a trend and a tax reform debate by presenting evidence from an important source, inequality in the distribution of consumption, and we pay particular attention to what goes on between 1991 and 1993.

Our argument revolves around the measurement of consumption inequality instead of income inequality. We do this because a household projects its perception of its economic position and financial opportunity onto its level of consumption. Ultimately, it is the economic positions and financial opportunities of households, and the distribution of such positions and opportunities among households, we are interested in when we analyze distributional issues. Of course, income is one important message-carrier. However, knowing the level of household consumption will usefully assist analysis, so it is an additional source of information. According to the life cycle theory and permanent-income hypothesis, a household's belief in an improved long-term economic position will lead to an increase in consumption because permanent income has increased. Conversely, an unforeseen worsening of the economic position will result in consumption contraction. Households act in this manner to smooth utility over time and avoid big differences in standards of living between periods. Thus, according to theory consumption mirrors long-term standards of living. Standards of living, and inequality in the distribution of standards of living, are highly interesting to economists and policymakers because of their relevance to equity concerns.

Inequality studies, however, often focus attention on wages and income. It may be a wise choice for at least three reasons. First, wages and income are observable variables in a way latent consumption is not. Second, countries often collect and offer large datasets of wages and income. Sometimes registers contain all observations of the population of working adults. Third, the abundance of data and the similarity in yearly data set construction facilitate reasonable comparisons between years. However, wages and income are only instruments to consumption and therefore only relevant as a basis for studying the difference in economic opportunity indirectly by their status as prominent utility tools and inasmuch as it reflects the long-term economic position. Moreover, the much-commented distinction between permanent and transitory income obfuscates the interpretation of the findings. The prevalence of failures to report income and the existence of corresponding tax evasions contaminate income variables with certain biases and level errors. This problem is especially acute when income variables are collected from self-delivered tax reports, as is often the case in Nordic studies. Comparing income inequality measures between countries is then understandably hard.

The advantages and disadvantages of income studies allow observers of welfare inequality to look at consumption studies as valuable supplements more than substitutes. Inequality studies of consumption are appealing to economists because of the direct connection between consumption and utility extraction and, again, because a household's total consumption reflects the household's views on its economic position in a way income cannot. Consumption levels are interpretable as material standards of living and consumption studies include demographic information that may be utilized to study the development of material welfare inequality for sub-segments of the population. Moreover, consumption data may supply information on standards of living when income misreporting and tax evasion occur. In addition, inequality studies of consumption may potentially be easier to compare between countries than income studies because the obstacle of different income definitions is replaced by in some ways a smaller hindrance of comparing material standards of living. But since total consumption in a household is latent it must be estimated. The estimation of latent total household consumption represents a challenge.

In the empirical literature, earlier inequality inspections of consumption have required estimates of latent total consumption in a household. For example, Cutler and Katz (1992) investigated income and consumption inequality, and were in need of estimates of latent total household consumption. They simply used total purchase expenditure as an estimate of total consumption, but made some ad-hoc modifications in order to get closer to the true consumption level of each household. Pendakur (1998) inspected consumption inequality in Canada in the period 1978-1992 and used another modification of total purchase expenditures that he called imputed consumption since it, in his own words, "may give a better indicator of well-being than total expenditure because lumpy expenditures are smoothed out". Sabelhaus and Groen (2000) asked whether permanent-income theory could explain consumption patterns. To test their ideas, they needed measures of consumption, and used several combinations of cash-expenditures, one of which excluded durable goods because "those purchases are volatile and partly represent investment". However, exclusion amounts to assigning zero-weights, and we shall see below in our model that it may be unnecessarily drastic. Theil and Moss (1999) decomposed consumption into subcategories before measuring inequality within the subcategories and were able to control for the unequal contribution of each category. We shall extend this literature on consumption inequality by presenting and employing a theoretically based model of consumption, estimate latent consumption for each household in a variance-minimizing fashion, and discuss how the resulting estimates and time-series of inequality measures illuminate important policy matters.

The problem with using purchase expenditure as an indicator of consumption is the wedge between purchase and consumption. For example, food is purchased, stored, and not in all consumed immediately. A car may be bought at one occasion but it still allows extraction of transportation services for a long period. Holiday trips are purchased infrequently but its enjoyment may exceed the time of the purchase. Stock build up, seasonality, and durable goods pose well-known problems for estimating latent total consumption, especially when purchase expenditures most often are recorded for only a brief period of time. However, despite the measurement errors, total purchase expenditure in a household is an unbiased estimator for latent total consumption in a household as long as the errors are zero-mean random variables. Statistical agencies and other students of consumption often use this average of manifest purchase expenditure as an estimator of latent consumption. This article shows how to use a weighted sum of both expenditure and non-expenditure indicators of latent consumption in order to minimize the variance that stems from measurement errors. The idea is simple so let us include an outline. Dentist expenditures, medical care, and other big item outlays are done infrequently, and have correspondingly large error variances. Thus, an observer should put less emphasis on such expenditures when she estimates latent consumption in a household. In stead, expenditures that come with smaller error variances should be given more weight. We demonstrate how to weigh the different expenditures before summing them. In addition, we introduce and show how to incorporate informative non-expenditure indicators that may shed light on the magnitude of latent total consumption in a household.

Thus, we argue that observers can improve upon using total purchase expenditure as an estimator of latent total consumption. This article seeks to explore the gap between total purchase expenditure and total consumption rigorously by utilizing consumption patterns in combining and weighting indicators of latent total consumption. Moreover, we aim to show how modeling latent total consumption in a household may hold great potential for inequality studies. Essentially, the model is based on deriving optimum weights for indicators of consumption. Estimator precision is enhanced when accurate indicators are given large weights and inaccurate indicators are given small weights. The latent variable model we propose estimates accuracy through usage of the covariance matrix and a maximum likelihood estimation procedure. Increasing precision on estimates of household consumption entails increasing precision on estimates of the distribution of household consumption. Thus, the new method may allow sharp comparisons between years.

Let us say in advance where we are headed. The next section introduces the latent variable model. Section 3 presents the results from using that model on Norwegian Consumer Expenditure Surveys

(CES). Section 4 discusses the findings, the basis of the findings, and points toward future research. Section 5 concludes and highlights some policy implications. In an appendix we describe the data, the estimation procedure, and the bootstrap simulation method we use.

2. The Latent Consumption Model

Røed Larsen (2002) describes in detail how to use expenditure and non-expenditure indicators of consumption in the estimation of latent consumption in a household. It is adamant in studies of consumption inequality that the unobservable, latent total consumption in a household is modeled rigorously and estimated accurately or else observers are in no position to make necessary, sharp comparisons between years. In this article, we claim that the much-used total purchase expenditure and simple transformations of total purchase expenditure are too inaccurate measures of latent consumption to yield the required precision. Important changes in the distribution of consumption may be relatively small. Thus, potentially underlying time trends of consumption inequality may escape detection if an imprecise apparatus is used. Therefore, students of consumption inequality need to tackle the problem of measuring latent total consumption, here denoted ξ, before going on to study the inequality in the distribution of consumption among households and this article offers a contribution. Let us explain briefly the essential elements of the suggested model. It may be written compactly as in equations (1)-(7) below.

(1) $$y_{ih} = \alpha_i + \beta_i \xi_h + \gamma_i z_h + u_{ih}, \quad i \in I, \ h \in H,$$

(2) $$E\left(u_{ih} \middle| \xi_h, z_h\right) = 0, \quad i \in I, \ h \in H,$$

(3) $$E\left(u_{ih} u_{jk} \middle| \xi_h, \xi_k, z_h, z_k\right) = \sigma_i^2 \quad \text{when} \quad i = j, \ h = k; \quad = 0 \quad \text{otherwise;} \quad i, j \in I; \ h, k \in H,$$

(4) $$x_{rh} = \alpha_r + \beta_r \xi_h + \gamma_r z_h + u_{rh}, \quad r \in R, \ h \in H,$$

(5) $$E\left(u_{rh} \middle| \xi_h, z_h\right) = 0, \quad r \in R, \ h \in H,$$

(6) $$E\left(u_{rh} u_{sk} \middle| \xi_h, \xi_k, z_h, z_k\right) = \sigma_r^2, \quad \text{when} \quad r = s, \ h = k; \sigma_{rs}, \quad \text{when} \quad r \neq s, h = k; \quad r, s \in R; h, k \in H,$$

(7) $$E\left(u_{ih} u_{rk} \middle| \xi_h, \xi_k, z_h, z_k\right) = 0, \quad \text{for} \quad i \in I; \ r \in R; \ h, k \in H.$$

In the model represented by equations (1)-(7) y_{ih} is the observable purchase expenditure on commodity category i in household h, ξ_h is the unobservable (latent) total consumption in household h, z_h is a

vector of demographic attributes of the household, here number of children and number of adults in the household; x_{rh} is an observable income indicator of total consumption, and u denotes error terms with the described conditional distribution. The coefficient β_i is the Engel derivative of commodity i, and it denotes the marginal consumption of commodity i when total consumption increases by one unit and the size and composition of the household remain unchanged. The coefficients γ state the partial effects of changes in household size and composition, here by increasing the number of children and the number of adults in the household. The intercept is denoted α. The set I comprises eight main commodity categories, and the set R contains only net income r and gross income q.

The underlying idea of the econometric specification of the consumption model in (1)-(7) is that a household's latent total consumption has observable counterparts or indicators. One class of such indicators consists of purchase expenditures on goods, represented by equation (1). Another class of indicators contains income variables, represented by equation (4). For each of these indicators, one may solve for latent total consumption and obtain an unbiased estimator as in equation (8):

$$\hat{\xi}_h^j = \frac{y_{jh} - \alpha_j - \gamma_j z_h}{\beta_j}, \quad j \in I \cup R, \; h \in H, \tag{8}$$

that has a corresponding conditional variance σ_j^2 / β_j^2 . In equation (8) we let y_{jh} for short denote both purchase expenditures from the set I and non-expenditure variables from the set R. The model allows us to combine the indicators given by equation (8) in a way that minimizes the conditional variance and yet retains the property of unbiasedness. The reason observers may minimize conditional variance is that different indicators have different accuracy; thus by weighting each indicator differently one may reduce conditional variance. To see this, keep in mind that some purchase expenditures are inaccurate indicators of latent consumption. Examples are purchases of medical services and transportation services. Such items of expenditure are inaccurate because they may be undertaken infrequently, and then often with large money outlays. In other words, such purchase categories come with large variances of error terms because the relation between the expenditure magnitude and the magnitude of total consumption contains much noise. Other purchase expenditures are accurate indicators of latent consumption. These are typically items purchased regularly or purchased in a pattern of strict correspondence to latent total consumption. Put differently, when an observer reviews a household's purchase expenditures on these items the observer may infer with some precision what is the household's total consumption. The combination of all indicators properly weighted yields an unbiased, minimum-variance estimator of latent total consumption in a household:

(9a)
$$\hat{\xi}_h = \sum_i \omega_i \hat{\xi}_h^i + \sum_r \omega_r \hat{\xi}_h^r = \xi_h + \sum_i \omega_i \frac{u_{ih}}{\beta_i} + \sum_r \omega_r \frac{u_{rh}}{\beta_r},$$
$$s.t. \ \sum_i \omega_i + \sum_r \omega_r = 1, \quad i \in I, \ r \in R, \ h \in H,$$

which may be written in terms of observable variables as:

(9b)
$$\hat{\xi}_h = \sum_i \frac{\omega_i}{\beta_i} y_{ih} + \sum_r \frac{\omega_r}{\beta_r} x_{ih} - \left(\sum_i \frac{\omega_i \gamma_{ci}}{\beta_i} + \sum_r \frac{\omega_r \gamma_{ai}}{\beta_r} \right) c_h$$
$$- \left(\sum_i \frac{\omega_i \gamma_{ai}}{\beta_i} + \sum_r \frac{\omega_r \gamma_{ar}}{\beta_r} \right) a_h - \sum_i \frac{\omega_i \alpha_i}{\beta_i} - \sum \frac{\omega_r \alpha_r}{\beta_r}, \quad i \in I, \ r \in R,$$

in which c_h and a_h refer to the number of children and the number of adults in household *h*. The challenge lies in finding the right weights. It is tedious, but straightforward, to demonstrate how the weights ω in equations (9a,b) may be aligned to minimize conditional variance of the combined estimator; the appendix contains the resulting variance-minimizing weights. The next step involves the estimation of the relevant parameters. This article estimates the coefficients α, β, γ, variance σ_i^2, variance σ_r^2, and covariance σ_{rs} using the covariance matrix and a maximum likelihood procedure described briefly in the appendix and in more detail by Røed Larsen (2002). From the estimates the observer obtain optimum weights and may implement the estimator of latent total household consumption in equation (9b). The appendix includes estimates on parameters and weights and a numerical example of the estimator for the year 1993. Røed Larsen (2002) shows that for the year 1993 this estimator reduces variance with 44 per cent compared to the competing estimator, total purchase expenditure. Thus, the estimate of latent total household consumption uncovers the material standard of living more accurately than does total household purchase expenditure. The latent variable model also allows estimating the underlying variance of latent total consumption, σ_ξ^2 by using the covariance matrix, the use of which shall be explained below.

3. Measures of Consumption and Consumption Inequality

The individual estimates of latent total consumption for each household represented in the surveys from 1986 to 1995 together form an estimate of the distribution of latent total consumption among households in the population. There exists no consensus on how to best represent and summarize a distribution in a single scalar statistic. Merits of competing statistics will depend on the purpose of the investigation. Yet it may be necessary to compress the information contained in a distribution into more readily comparable measures in order to assess inequality time trends. This article uses several

measures of consumption inequality in order to map some important facets of inequality. The measures will be more or less interconnected depending on the underlying distribution of consumption. Since the measures capture different facets of the distribution, and since we do not know the properties of this distribution, we cannot ex ante say how or how much time trends of different measures may deviate from each other. In the event that all measures show identical trends we may be positioned to conclude robustly on the development of inequality. When the measures show contradicting trends we shall discuss the inherent message.

Sketching convincing time trends of the distribution of consumption among households is thus a complex task. In order to detect time trends we impose certain requirements on data and method that are not needed in the assessment of a cross-section level. The data sets must be comparable and span a substantial period of time, in addition to the standard requirements of holding high quality, exhaustively covering expenditure opportunities, and having been collected by random sampling. The estimation procedure must be adequate to uncover the underlying consumption pattern, summarize it in a few, interpretable parameters, be based in consumer theory, and handle measurement errors. We claim, and substantiate in the remainder, that the Consumer Expenditure Surveys fulfill such demands on data and that the proposed estimation method satisfies the methodological requirements.

When analyzing inequality issues, it is well known that adjustment for household size and composition is necessary. Before measuring the inequality in the distribution of consumption, we need to establish the consumption unit. In this article, we choose to deal with the unit problem by employing several techniques. First, we introduce the use of equivalence scales. The inequality measures introduced below are computed on consumption levels per equivalent consumer unit. Second, levels of consumption per equivalent consumer unit are weighted by sampling probability correction weights when we employ two of our measures. To ensure thorough comparison, one measure is computed using four different weighting regimes: i) sampling probability correction weights, ii) number of household members, iii) the product of sampling probability correction weights times the number of household members, and iv) none. In effect, we then look at several ways of adjusting for size and composition. However, the question of how to choose equivalence scales and weights can never be settled completely. Since the results to some extent are sensitive to those choices, any observer must examine in detail how the composition and size affects the inequality measures. We use the most direct approach, segmentation. This article analyzes consumption inequality of consumption per equivalent consumer unit *within* and *between* segments of different household types. Thereby we manage to control directly for size and composition effects.

The first technique involves an equivalent consumer unit in order to incorporate economies of scale within the household and to account for the different needs of a child and an adult; see Deaton and Muellbauer (1980) for an excellent exposition of the idea and method. Allow a brief explanation on how we do it. In essence, this article treats a consumption level of, say, *c* for a single adult as if it represents a somewhat less utility opportunity than a consumption level of *2c* for two cohabiting adults since the latter household may use the same bathroom, kitchen, television set etc. There is a massive literature on equivalence scales, and it is not without controversy. However, our purpose is not to contribute to the discussion of equivalence scales. In stead, we make use of the results because we need to account for household size and composition. Therefore, we state without further substantiation that we let the first adult in a household be represented by one equivalent unit and the next adult(s) by 0.7 of a unit. Children below 16 years of age are assigned 0.5 of an equivalence unit.[1] Thus, our unit of measurement is the consumption level per equivalent unit of a consumer within the household. In other words, we divide the estimated latent total consumption in a household on the number of equivalent units in that household. The resulting ratio is the first object of our scrutiny and the basis of the construction of inequality measures in our first table. The second stage of adjusting for size and composition revolves around weighting the level of estimated latent total household consumption per equivalent consumer unit. By using the whole repertoire of weighting schemes, we obtain measures that show the impact of demographic effects and thus are to some extent robust against demographic changes in the period of study. Notice that we do retain one unadjusted measure of consumption per equivalent consumer unit for comparison with the segmentation-results.

Again, equivalence scales and weighting schemes cannot to our satisfaction control for all demographic effects. As a remedy, we use the segmentation technique. This article first studies consumption inequality for specific sub-samples of the population such as singles, couples without children aged 16-44, and couples with children in which the youngest child is between 0-6. Then we study consumption levels between median agents of the different household types. We do this to ensure that demographic changes in the population do not mask inequality trends and to deal with a one-time change in sampling scheme discussed below.

Empirical analyses of inequality in distributions of income or consumption are normally based on the Lorenz curve. to summarize the detailed information provided by the Lorenz curve and to achieve

[1] This is a compromise of sorts between the two scales of Eurostat (1997), in which one scale assigns 1 unit to the first adult, 0.7 to other adults, and 0.5 to children below 13 years of age and another scale assigns 1 unit to the first adult, 0.5 o the other adults and 0.3 to children below 13 years of age.

rankings of intersecting Lorenz curves the standard approach is to employ the Gini coefficient and/or alternative measures of inequality. This article relies on the Gini coefficient and the coefficient of variation.

4. Empirical Results

We ask whether consumption inequality rose in Norway in the early 90s, as conventional wisdom has it. In addition, we pay particular attention to consumption inequality in the years 1991, 1992, and 1993 in order to shed light on the effects of the tax reform in 1992. In Table 1, we present empirical estimates on our measures of inequality. There is one striking tendency: consumption inequality does not increase in the period. All measures of inequality show a more compact distribution in 1995 than in 1986. All 1995 measures of inequality are below the average for the ten-year period. Put differently, we do not detect an increase in consumption inequality during the first half of the 90s. More specifically, there appears to be a peak of consumption inequality in 1991 and a bottom in 1992-1993. Perhaps there is a slight tendency of increase the last two years of 1994 and 1995. On the basis of Table 1, it seems tempting, perhaps even legitimate, to claim that time trends of Norwegian consumption inequality developed in a non-increasing fashion in the early 90s. This claim has bearing on the interpretation of welfare policies in general and tax policies in particular and because of that, the finding may potentially have influence on the assessment of the ongoing Nordic debate on taxes and inequality. It is necessary, however, to avoid stretching the data and not to draw speedy conclusions. We shall study the measures below in more detail and offer subtle points of qualification.

First, observe in Table 1 that the Gini index is 0.303 in 1986 and 0.255 in 1995, and that the adhering standard deviations are estimated[2] to be sufficiently small to sustain a claim that the sample reduction most likely mirrors a population reduction. The coefficient of variation using the household as unit was 0.562 in 1986 and only 0.498 in 1995. The coefficient of variation using the individual household member as unit was 0.908 in 1986 and 0.861 in 1995. The coefficient of variation computed by the product weights of sampling probability correction times household members was 0.294 and 0.274 in 1986 and 1995, respectively, while the coefficient of variation using only sampling weights was 0.191 and 0.187. These are arresting statistics. At first sight, the evidence does not invite any support for stating that consumption inequality rose in the period. Moreover, the downward discontinuities observed around the time of the tax reform implementation are intriguing.

[2] How to estimate the standard deviation of the empirical Gini coefficient is shown in Aaberge (2001).

Table 1. Inequality Measures of Estimated Latent Total Household Consumption Per Equivalent Consumer Unit, 1986-1995

			Inequality Measures		
	Gini Index (St. Dev.)	**Coefficient of Variation, All Weights**	**Coefficient of Variation, Sampling Prob.**	**Coefficient of Variation, Individual Level**	**Coefficient of Variation, Household Level**
Weights:	**Sampling Probability Correction**	**Sampling Probability Correction*Household Members**	**Sampling Probability Correction**	**Household Members**	**None**
Year					
1986	0.303 (0.0055)	0.294	0.191	0.908	0.562
1987	0.296 (0.0059)	0.323	0.207	0.901	0.550
1988	0.301 (0.0057)	0.304	0.200	0.890	0.555
1989	0.284 (0.0060)	0.315	0.208	0.841	0.527
1990	0.292 (0.0060)	0.313	0.207	0.857	0.541
1991	0.307 (0.0070)	0.322	0.218	0.931	0.602
1992	0.285 (0.0070)	0.269	0.179	0.904	0.523
1993	0.259 (0.0072)	0.259	0.174	0.846	0.488
1994	0.274 (0.0077)	0.269	0.185	0.858	0.491
1995	0.255 (0.0092)	0.274	0.187	0.861	0.498
Mean	0.286	0.294	0.196	0.880	0.534

Source: Consumer Expenditure Surveys 1986-1995, Statistics Norway. Notes: Latent total household consumption was first estimated for each household in the cross-section for each year using the method outlined above. Estimated latent total household consumption was then divided on the number of equivalent consumer units in the household. Inequality measures were computed on the resulting vector of estimated latent total household consumption per equivalent consumer unit. The Gini index was computed by using sampling probability correction weights. The computation of the coefficient of variation was done in four ways, three weighted and one un-weighted. For the first two weighted calculations of the coefficient of variation (weights sampling probability correction*household members and household members) the weights were readjusted to sum to unity in order to facilitate interpretation.

The conclusion must be qualified. The tendency of non-increasing consumption inequality needs detailed examination because there do exist caveats. One major caveat is the well-known problem involving demographics. As for example Cutler and Katz (1992) point out, adjusting for household composition and size is important. We shall see below that in our problem it becomes acutely important since different types of households experience different tendencies. The overall tendency is then a matter of relative strength between sub-tendencies, which is the rationale behind weighting for equivalent consumer units, household members, and sampling probabilities.

Let us pause for a moment to contemplate this. Imagine that over the period single-person households experience increased consumption inequality while families experience decreased consumption inequality. The resulting overall tendency of summary measures of inequality will then show decreased consumption inequality to the extent family households dominate in the population. Using weights for sampling probability correction put enhanced emphasis on *singles* because they are underrepresented in the sample, thus such weights increase a tendency towards observing increasing inequality. On the other hand, using weights for household size, for example by counting individual members of household instead of households, put enhanced emphasis on *families* because they are counted as many times are there are family members. Thus, such weights entail a tendency towards observing decreasing inequality. The question then becomes how to weigh. In the literature, observers routinely use the combinatory weight only, the product of sampling probability correction times household members; see Cutler and Katz (1992) and Pendakur (1998). Potentially, this may mask two different and important tendencies if small and large households have different consumption inequality experiences. This article shall deal with the problem explicitly and in two ways. First, we present in Table 1 all four permutations of computing the coefficient of variation, thus singling out the different tendencies. Second, we present in Table 2 the results of the useful technique of segmentation, e.g. decomposing the sample into different household types and examining the trends without needing to account for household composition and size.

Let us turn to Table 1. The statistics seem to contain a possible accentuated drop from 1991 to 1992. That discontinuity is both encouraging and disturbing. It is encouraging because it may hint of a successful tax reform put in effect in January 1992. One explicit purpose of the tax reform was to make the tax system work more redistributively, i.e. progressively, and thus reduce inequality by widening the tax base through the disallowance of certain tax deductions and shifting the emphasis from net to gross incomes. It is disturbing because there was a change of sampling scheme in the Consumer Expenditure Survey, starting January 1992[3]; the same time as the new tax regime was implemented. Possibly then, our results arise from confounding two factors with very different interpretation. Therefore, we shall inspect the 1991-1992 drop and the development of statistics between 1991 and 1993 more closely in order to substantiate that our results are more than figments of data collection. In Table 1, we have used different inequality measures with different forms of weighting, and in the following we shall exploit the differences and observe how different apparatus allows us to look at different aspects of inequality development.

[3] The CES sampling of households changed in 1992 from being address-based to being person-based. Since large households contain more persons the change implied an increase in the sampling probability of large households. Sampling probability correction weights are computed in order to compensate for such sampling effects.

Further, this article investigates the possibilities of disentangling the two level effects of tax reform and sampling change and differentiating between a level effect and a trend effect in inequality development. We approach the problem from several angles. First, we shall utilize the difference between a one-time drop and a longer time trend in order to argue that the sampling change cannot cause both. Second, we shall investigate the impact on interpretation from our employment of correction weights that readjust sampling probabilities in the computation and weaken the disturbance from the sampling change. Third, we shall make use of a non-parametric bootstrap pooling technique to check whether the null hypothesis of constant population properties in 1992 and 1993 can be rejected or not since the sampling change cannot be attributed any discontinuities since it affects both those years similarly. Doing so we thus manage to isolate the tax effect. Fourth, we shall examine the results from segmentation with keen interest to distinguish level effects from trend effects. We may do so in an attempt at controlling for demographic effects without resorting to equivalence scales, correction weights, and individual consumption level assignments.

First, since the sampling scheme change was implemented once, it cannot affect the time series more than once. Time trends before and after the sampling scheme change cannot be caused by the change; only a shift of level in the year 1992 can. To complicate matters, the same can be argued for the completion of the tax reform; it should only affect consumption levels once the content of the reform was revealed to consumers, most likely at the time of tax reporting in 1992. However, since it may take some time for consumers to realize and experience to full extent the ramifications on disposable income from the tax reform, we may observe that consumers adjust consumption to the new tax environment in the subsequent years. Therefore, what happens in the year 1993 is very interesting and we shall study the two years 1992 and 1993 through simulations of the distribution of one of the inequality measures below. Let us therefore distinguish between the two types of hypotheses, a general *trend* hypothesis and a shift or *level* hypothesis. The statement that consumption inequality increased in the 80s and 90s is a trend hypothesis, and can be analyzed without the interference of a one-time sampling scheme effect. This trend hypothesis is relevant to the assessment of general welfare policies. The statement that consumption inequality dropped in 1992 is a shift hypothesis, and cannot be analyzed without the interference of the sampling change effect. This shift or level hypothesis has specific relevance to the evaluation of tax policy change. Did the reform work progressively or did it not?

Let us first study the trend hypothesis closely. In Table 1, three out of five measures of consumption inequality show less inequality in 1995 than in 1992 and the remaining two measures do not show a

large increase. In fact, there appears to be some stability in the inequality development until 1995. This is indicative of non-increasing inequality. The measures in the period 1992-1995 are sufficiently close in magnitude that we cannot reject the hypothesis of constancy. Put differently, there may be no change in consumption inequality in the period 1992-1995. The exclusion of an upward-sloping trend does not warrant any acceptance of a downward-sloping trend. From Table 1, we should so far hesitate before concluding that the tax reform was successful in reducing consumption inequality. On the other hand, we are increasingly convinced that there is insufficient evidence for claiming that there is an upward-sloping consumption inequality trend during first half of the 90s.

While there does not appear any clear pattern before the tax reform of 1992 except for a possible peak in 1991, and while there is only inconclusive evidence of a downward-sloping trend after 1992, there is little doubt that our measures depict a clear reduction *in* 1992 and *in* 1993. All five measures show a decrease from 1991 to 1992 *and* from 1992 to 1993. Some events that took place just before 1992 may have caused inequality, and therefore measures of it, to drop. But from this article's analysis it is still uncertain whether the event is one of data collection or one of tax reform. Notice, however, that the continued reduction between 1992 and 1993 cannot be caused by the sampling change. In the remainder we shall maintain a belief in both a tax effect and the absence of an upward-sloping consumption inequality trend. Let us proceed to study in increasing detail what happened around 1992 and the next few years.

One approach to differentiate between the sampling and tax effects is to perform a hypothesis test of the difference between the measures of 1992 and 1993. To reiterate, while the change between 1991 and 1992 may be due to sampling change, tax reform, or both, the change between 1992 and 1993 cannot be due to sampling change since both the 1992-sample and the 1993-sample were collected in identical fashion. The change between 1992 and 1993 can of course be due to tax reform, general trend, or both. But the general trend is only plausible if it continuous until 1995. If it does not, we are left with a tax effect. In consequence, we believe that if the change between 1992 and 1993 seems real but the subsequent trend dubious then what we observe is a late tax effect. If the change between 1992 and 1993 seems real and the subsequent trend clear then what we observe may be a general trend. Since the former shed light on the tax reform and the latter on general welfare policy it is of some interest to be able to differentiate between the two. Above we have argued, and below we shall continue to argue, that the latter seems somewhat unlikely. What remains then is the hypothesis test of whether the change observed between 1992 and 1993 reflects a change of population property. It is possible, and perhaps plausible, that a statistically significant change is a late tax reform effect.

First, estimations of standard deviations of the Gini Index are tabulated in parenthesis in the second column of Table 1; see Aaberge (2001) for the estimator of the standard deviation. They are sufficiently small to support the notion of a statistically significant drop in inequality between 1992 and 1993. The Gini coefficient is 0.285 in 1992 and 0.259 in 1993, a reduction of 0.026. This difference is on the order of 3.7 standard deviations, which clearly lead to a rejection of constancy.

We also simulate the difference between two inequality measures in order to estimate the distribution of such measures. In the appendix we explain how this can be done without parametric assumptions through usage of the non-parametric Monte Carlo bootstrap. The results are tabulated in Table 2. We are particularly interested in knowing how often a difference as large as 0.035 occurs in simulated samples from identical parent distributions. If it is seldom, then we may reject the hypothesis that a difference of 0.035 is likely even when there is no population property change. If it is often, then we may not reject the hypothesis. In Table 2, column five, we see that a difference of 0.035 lies close to the 95th percentile of the simulated distribution of the inequality measure when the simulations were performed 1000 times. We infer that a difference of 0.035 occurs only infrequently when there is constancy in distribution properties. In other words, rejecting the hypothesis of constancy between 1992 and 1993 entails making a mistake only about five out of one hundred times. Put differently, the chance of committing a type-I-error is approximately five percent. Conventionally, such a low probability of type-I-error results in a rejection. Thus, the inequality measures in Table 1 for the coefficient of variation supports a claim of reduced consumption inequality from 1992 and 1993. This reduction cannot be a figment of data collection since samples of both years were collected in the same fashion.

Table 2: Bootstrap Simulation of the Distribution of the Difference between Household CoV for Two Years, 1992 and 1993

Simulated Difference of Sample CoV from Same Population, Base Year	Number of Simulated Differences	Mean, Simulated Differences	Standard Deviation, Simulated Differences	95th Percentile of Simulated Differences
$\Delta(CoV_1\text{-}CoV_2)$, 1992	1000	0.000520	0.0182	0.0329
$\Delta(CoV_1\text{-}CoV_2)$, 1993	1000	0.000068	0.0220	0.0382

Source: Consumer Expenditure Surveys 1986-1995, Statistics Norway. Note: See the appendix for details on the non-parametric bootstrap simulation procedure.

Using sampling probability readjusting correction weights may lessen the impact of a sampling change. Since a correction weight also must be estimated it is no panacea. This article thus also presents an inequality measures not based on correction weights. The employment of correction

weights, in concert with the other techniques discussed above, enhances the support for stating that consumption inequality is non-increasing. In Table 1, it is the juxtaposition of multitude of approaches and their unequivocal non-increasing tendency that makes us maintain that consumption inequality did not rise in the first half of the 90s.

Let us now focus attention on the dynamics within sub-segments of household types and continue our scrutiny of the year 1992, and use the technique known as segmentation. We look at specific segments of the sample that are identical in household composition and size. This is a device that may more adequately take care of what the use of equivalence scales and sampling probability correction weights attempt. The results are presented in Table 3.

Table 3: Consumption Inequality for Some Household Types, Coefficient of Variation of Household Consumption, 1986-1995

Year	Household Types				
	Singles, 16-44y	**Couples w/o C., 16-44y**	**Couples, w/o C., 45-64y**	**Couples w/C., youngest 0-6y**	**Couples w/C., youngest 7-19y**
1986	0.343	0.345	0.544	0.479	0.447
1987	0.376	0.335	0.491	0.475	0.504
1988	0.385	0.380	0.453	0.475	0.452
1989	0.384	0.421	0.486	0.482	0.443
1990	0.407	0.397	0.509	0.500	0.371
1991	0.386	0.497	0.589	0.503	0.457
1992	0.413	0.433	0.503	0.440	0.443
1993	0.491	0.381	0.464	0.440	0.434
1994	0.465	0.375	0.423	0.432	0.430
1995	0.551	0.479	0.406	0.454	0.422

Source: Consumer Expenditure Surveys 1986-1995, Statistics Norway. Note: Latent household consumption was first estimated for each household in the cross-section for each year. We computed the coefficient of variation on the resulting vector of household consumption per equivalent consumer unit.

We manage to isolate consumption trends and discontinuities from the one-time sample scheme change in 1992. The table uncovers an interesting phenomenon: The inequality trends are not uniform over household types.

We observe that for the group "singles, aged from 16 to 44" the inequality in consumption seems to increase over the period. Likewise, the group "couples without children, aged 16 to 44" experiences an

upward sloping trend in consumption inequality, even if it is not as pronounced as the one for singles. For the three other groups investigated there seem to be decreasing trends, or at least non-increasing trends, of consumption inequality. Thus, the non-increasing overall consumption inequality trend obtained above seems to occur because the effect of increasing inequality observed in the group "singles" do not off-set the opposite effect in other groups. To policymakers, this divergence among sub-segments is worthwhile examining.

Notice that decreasing inequality is especially noticeable for the group "couples without children, aged 45-64". This group is particularly interesting because popular belief holds it to be very well-off since households in this group often enjoy two incomes, do not have children-related expenses, and are at the peak of their earning potential. Since rich households in this group used to be able to have large and many-itemized tax deductions, and since the tax reform of 1992 targeted such deductions, we were ex ante interested in observing how that household type experienced the early 90s. We find that inequality among households in this group falls for each year after 1991, a striking finding. This may mean that upper-tail and well-off households reduce their consumption levels and/or that lower-tail and less well-to-do households increase their consumption levels or both. In any event, column four in Table 3 thus supports a claim that the tax reform fulfilled one of its goals.

How can we interpret the other findings? The large increase in consumption inequality among singles needs understanding, further research, and perhaps policy-attention. Let us mention briefly a few possibilities. Costs of housing for this group are high since they cannot enjoy and utilize economies of scale. In fact, the costs of housing for this group have received comments and scrutiny in Norway recently from the governmentally appointed committee, Boligutvalget (The Housing Commission) that studied and reported such costs and documented its increase in NOU (2002). Remember, that the group "singles" may be the most heterogeneous. The group includes students living on student loans and career-oriented executives. Allow a few speculations that may be tested in further research. The internationalization of Norway has increased salaries among executives at the same time that larger groups of the Norwegian society have sought tertiary education. If at effect, these factors would probably increase inequality among the singles more than in other groups because of the heterogeneity of singles.

But one thing is the distribution of material standards of living *within* one group another thing is the relative development of standards of living *between* groups. In Table 4, we observe that the medians of different household types improve their consumption per equivalent consumer units compared to

"singles", a phenomenon possibly related to the inequality development in column two of Table 3 since increased inequality within the group singles may go hand-in-glove with a relative falling-behind other groups, yet another matter policymakers have voiced concern over recently.

Table 4: Between-group Trends in Estimated Latent Total Household Consumption Per Equivalent Consumer Unit, 1986-1995

Year	Ratios of Medians, Household Types			
	Median Couple w/o C. (16-44) on Median Young Single	Median Couple w/o C. (45-64) on Median Young Single	Median Couple w/C. (0-6y) on Median Young Single	Median Couple w/C. (7-19y) on Median Young Single
1986	0.894	0.691	0.496	0.520
1987	1.007	0.811	0.611	0.595
1988	0.899	0.721	0.531	0.589
1989	0.937	0.805	0.600	0.653
1990	1.045	0.860	0.621	0.638
1991	0.956	0.799	0.608	0.629
1992	0.906	0.828	0.644	0.623
1993	0.920	0.895	0.715	0.686
1994	0.930	0.974	0.707	0.739
1995	0.917	0.827	0.607	0.594

Source: Consumer Expenditure Surveys 1986-1995, Statistics Norway. Note: Latent household consumption was first estimated for each household in the cross-section for each year and then divided on the number of equivalent consumer units in the household. The median was then identified for each household type, and put in relation to young singles.

In Table 4, two main features need commenting. First, the significance of the computed consumption *level* per equivalent unit for different household types is open to debate since it obviously is a function of and sensitive to choice of equivalence scales. Second, time trends need not be sensitive to such choices when computations are done in similar fashion each year. Errors about the level will cancel when levels are compared with each other within the group. Thus, time trends *of* levels may allow interpretation even if the levels themselves do not. Thus, we put most emphasis on the observation that other groups appear to improve material standards of living relative to single households, possibly partly reflecting the problem singles have in reaping benefits from the economies of scale in housing.

5. Discussion

Consumption inequality is a rich field for study. Explorations may take many forms and have different scopes. We have introduced a rigorous modeling of the level of latent total household consumption.

Our method of estimation may be extended along several lines so let us suggest a few. First, one may model the purchase expenditure and income indicators of consumption non-linearly. This may entail some estimation challenges since the maximum likelihood procedure that utilizes the covariance matrix may not be easily modeled to include higher order terms, but the challenges may be overcome. Second, indicator precision may be enhanced through considering inclusion of more terms such as age, region of residence, occupation, and education in the model. Third, more indicators can be employed. For example, we use only eight main categories of consumption and two income variables as indicators of latent total consumption. Others can be thought of, e.g. financial wealth and property value, in addition to the obvious possibility of disaggregating consumption categories. Using them, the question of measurement error may become especially pertinent since they may be severely misreported.

Measuring consumption inequality involves projecting an estimate of the consumption distribution down to a few scalar measures that capture only a few aspects of the distribution. We have used some well-known inequality measures, but we have not shed light on consumption levels among the poor households. Rather than studying specific parts of the distribution we have concentrated our effort on interpreting the whole distribution. We did not probe deep into the study of sub-segments of the population. When we did, this article limited scrutiny of sub-segments to the development among and between different household types. Household types such as singles, couples without children, and couples with children are target for specific policies in Norway, and policymakers are keen on knowing how the groups fare. Moreover, the intra-household allocation of welfare levels was assumed uniform over members. It may not be. The economies of scale in household production of welfare were attempted incorporated in the analysis by the use of equivalence scales. However, inequality measures may be quite sensitive to the choice of such scales as Aaberge and Melby (1998) argue. This is another reason why the merits of the segmentation approach used above must be emphasized. An advantage of segmentation is exactly that, it controls for size and composition. However, the overall interpretations are complicated since the number of dimensions is increased. A balance must be struck, and this article sought it by using several supplementary techniques. Future research may extend investigation into such issues and the related ones, e.g. cohort-differences or urban-rural inequality matters.

6. Concluding Remarks and Policy Implications

Consumption inequality does not increase in Norway in the early 90s. This is a puzzling result given the evidence from income inequality studies. It is also contrary to popular belief. In light of the other

evidence, it is potentially an important finding since policymakers have been and still are curious to finding out how consumption is distributed among members of society given their mandate from the populace to secure economic opportunity for all and avoid big discrepancies in consumption levels between the poor and the rich, the young and the old, the rural and the urban households. Moreover, this article supports Fjærli and Aaberge (2000) who question the belief in rising income inequality and show the influence of changing income definitions. In addition, we find that the consumption inequality development is not uniform over household types. Single-person households experience increasing inequality of consumption at the same time families experience decreasing or non-increasing inequality of consumption.

Especially intriguing is the two-time discontinuities of consumption inequality that we register in our measures at the same time and immediately after the tax reform was implemented. One of the proclaimed goals of the tax reform was to broaden the tax base and make it more progressive by disallowing deductions that may have favored rich households. It is possible, perhaps plausible, that the effects show up in this article's consumption measures. Our results cannot without careful elaboration be interpreted in concert with findings from income studies. It is certainly puzzling, but perhaps somewhat disturbing, that there are differences between income and consumption inequality studies. The discrepancy between the two approaches of inequality examination is a challenge for researchers to bridge. It may be due to measurement errors, conceptual confusion, or inappropriate time frames. But it may not. Possibly the bridge can be constructed using two pillars of thought, the notions of Ricardian equivalence and life cycle consumption. Empirical discrepancies between income and consumption inequality may be related to the impression of permanence of new tax rules and the perception of shifting balances of permanent and transitory income. The divergence may also simply stem from different weighting of different population segments. This article has documented the non-uniformity of inequality developments, and the resolution to differences between income and consumption measures may lie therein.

We have highlighted the advantages of consumption measures, and suggested that consumption inequality studies are valuable supplements to, not substitutes of, income studies. Consumer Expenditure Surveys (CES) allow studies of consumption directly. Consumption is a main ingredient of household utility construction and therefore invites for direct rather than roundabout interpretations. Consumption also reflects a household's knowledge about its economic position in a way income cannot. Consumption surveys may capture elements of the material standards of living that escape income registers because of the prevalence of misreported income due to a tax evasion motive. Such

measurement errors abound, especially in registers based on self-reported, for-tax-purposes income. Consumption inequality may also be more readily available for international comparisons than income inequality can because the obstacle of income definition differences may be larger than the hindrance of different notions of material standard of living. Moreover, CES data invite observers to focus attention on both formal and informal structures of households, perhaps more precisely than do income studies. Since CES data are collected in the same manner, exhaustively cover all expenditures, and are sampled randomly observers can follow not only consumption patterns but also consumption inequality developments over large time periods. These strengths make consumption inequality measures worthwhile and highly informative indicators of the distribution of opportunities in the society.

This article argues that household consumption is a latent variable that must be estimated. While earlier studies have used total purchase expenditure or simple transformations thereof, this article shows how observers may employ a rigorous model in which total consumption is latent but can be observed indirectly through indicators. Since some indicators are accurate and others inaccurate, a minimum-variance unbiased estimator of latent total consumption is derived by assigning large weights to indicators with small error variance and small weights to indicators with large error variance. The resulting estimate of latent total household consumption has much reduced variance, and thus the cross-section estimate of consumption inequality is sharper. This allows fine year-to-year comparisons of inequality that are adamant to the examination of the early 90s. Ultimately, rigorous models of consumption are useful supplements to income studies in acquiring knowledge about how benefits and burdens are distributed among individuals and households in society.

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Consumption Data

The Norwegian Consumer Expenditure Surveys contain observations of household samples from 1975 to 1995; see e.g. Statistics Norway (1990) for a detailed description of account books, interviews, and classification. The surveys are conducted continuously every year by Statistics Norway, with 1/26 of households reporting each 14-day period of the year. The samples contain expenditure and other information on more than one thousand households[4] each year, and the samples include information on many socio-economic variables of each household. The sampling scheme is a two-stage stratified, random sample with a small sub-sample of a two-year panel. The response rate is typically above 60 percent. The 1993 sample contained 1308 observations out of a population of about 1.5 million Norwegian households. Our income data were obtained from tax records from Norwegian tax registers for the period 1986-1995. The income data contain the variables gross income (pension-earning income before tax) and net income (pension-earning income after tax). Halvorsen and Wangen (1999) document the income sources.

For this study, all nine main categories were employed as expenditure indicators, but the categories Food and Beverages and Tobacco were bundled together into one category. Aasness (1990) and Aasness et al. (1993) present reasons why such an aggregation is useful in order to avoid unreasonable zero-covariance assumptions needed for identification. In the profession, there exists no unified theory for how to aggregate goods. Classification is, to a certain extent, arbitrary. This is regrettable, but cannot stop us from undertaking rigorous empirical scrutiny of consumer expenditures. We emphasize the importance of making reasonable, well-argued assumptions and this article uses the conventional categories of aggregation.

Identification, Estimation, and Optimization

The latent variable model we have suggested can be estimated in several ways and by using many statistical packages. There is a large literature on properties of latent variable models, their identification, and optimum estimation. We use the SAS (1990, p.249) CALIS structure summarized in equation (10) that builds on models, identifiable and estimable, introduced and explored early by Keesling (1972), Wiley (1973), and Jöreskog (1978). See Goldberger (1972) for an early, and excellent, treatment of such models in economics. The broad structure of latent models is:

[4] There are about 1.8 million households in Norway.

(10) $$\eta = B\eta + T\xi + \varsigma, \qquad y = \lambda_y \eta + \varepsilon, \qquad x = \lambda_x \xi + \delta.$$

In the notation of equation (10), B, T, λ are coefficient matrices; η and ξ are vectors of endogenous and exogenous latent variables, respectively; x and y are vectors of manifest variables; and ζ, ε, and δ are errors.

There are several software packages available that handle latent variable models, and model programming varies somewhat in how to incorporate summing-up conditions such that Engel coefficients, β, sum to unity, and demographic coefficients, γ, and constant terms, α, sum to zero for the consumption part of the chosen indicators. For example, Jöreskog developed the LISREL system to perform such estimations. The SAS CALIS system we used offered several optimization choices and straightforward programming. Our SAS code and details of estimation results are available at requests.

Initially, we ran single-equation two-stage-least-square estimations with several instruments prior to the latent variable estimation in order to be able to specify initial values for the coefficients that would ensure rapid convergence with a minimum number of iterations. The employed estimates were obtained by using the maximum likelihood method and the Marquardt-Levenberg optimization algorithm. Details can be found in Røed Larsen (2002) and by correspondence with the author.

Optimum Weights of Indicators of Latent Total Household Consumption

Røed Larsen (2002) demonstrates how to derive optimum weights for each indicator of latent total household consumption. For completion, this article includes the expressions in equation (11)-(13).

(11) $$\omega_i = \frac{\beta_i^2}{\sigma_i^2}\left(\sum_i \frac{\beta_i^2}{\sigma_i^2} + \frac{\sigma_q^2\beta_r^2 - 2\sigma_{rq}\beta_r\beta_q + \sigma_r^2\beta_q^2}{\sigma_r^2\sigma_q^2 - (\sigma_{rq})^2}\right)^{-1}, \quad i \in I;\ r \neq q;\ r,q \in R,$$

(12) $$\omega_r = \frac{\sigma_q^2\beta_r^2 - \sigma_{rq}\beta_r\beta_q}{\sigma_r^2\sigma_q^2 - (\sigma_{rq})^2}\left(\sum_i \frac{\beta_i^2}{\sigma_i^2} + \frac{\sigma_q^2\beta_r^2 - 2\sigma_{rq} + \sigma_r^2\beta_q^2}{\sigma_r^2\sigma_q^2 - (\sigma_{rq})^2}\right)^{-1}, \quad i \in I;\ r \neq q;\ r,q \in R,$$

(13) $$\omega_q = \frac{\sigma_r^2\beta_q^2 - \sigma_{rq}\beta_r\beta_q}{\sigma_r^2\sigma_q^2 - (\sigma_{rq})^2}\left(\sum_i \frac{\beta_i^2}{\sigma_i^2} + \frac{\sigma_q^2\beta_r^2 - 2\sigma_{rq} + \sigma_r^2\beta_q^2}{\sigma_r^2\sigma_q^2 - (\sigma_{rq})^2}\right)^{-1}, \quad i \in I;\ r \neq q;\ r,q \in R.$$

Examples of Parameter Estimates, Indicator Weights, and Consumption Estimator

We include an example of estimates for the year 1993 and tabulate the results in Table A1.

Table A1. Estimated Engel Coefficient and Indicator Weights for 1993

Good Category or Income Type	Estimated Engel/income coefficient	Estimated Weight
Food, Beverages, and Tobacco	0.0850	0.0654
Clothing and Footwear	0.1128	0.1411
Rent, Fuel, and Power	0.1702	0.0946
Furniture and Household Equipment	0.1283	0.1832
Medical Care	0.0222	0.0065
Transportation	0.1985	0.0551
Recreation and Education	0.1489	0.0698
Other Goods and Services	0.1342	0.1809
Sum	1.0001	0.7966
Net Income	0.7664	0.0097
Gross Income	1.0081	0.1936
Sum		0.9999

The resulting estimator of latent total household consumption for the year 1993 is given in equation (14).

$$\begin{aligned}\hat{\xi}_h &= 0.77y_{1h} + 1.25y_{sh} + 0.56y_{3h} + 1.43y_{4h} + 0.29y_{5h} + 0.28y_{6h} + 0.47y_{7h} + 1.35y_{8h} \\ &\quad + 0.01x_{1h} + 0.19x_{2h} - (4615 + 1949)c_h - (-2116 + 12916)a_h - (-17971) - (-20465), \ h \in H.\end{aligned} \tag{14}$$

We observe from Table A1 and equation (14) that different purchase expenditures y_i and income variables x_r are given much different weights, indicating the importance of assigning weights according to accuracy or magnitude of estimated error variance relative to magnitude of outlay. The subscript numbers in equation (14) refer to row number in Table A1. We find that the estimator entails multiplying the expenditures on Clothing and Footwear, Furniture and Household Equipment, and Other Goods and Services by a factor larger than unity because the model implies that these are accurate indicators of latent total consumption.

The Non-Parametric Monte Carlo Bootstrap Simulation Technique

The following simulation algorithm generates an estimate of the distribution of a difference between two inequality measures when the null hypothesis is true, i.e. that the two inequality measures come from two populations with identical inequality properties.

1. Under the null there is no difference between the distributions of two populations since under the null the samples stem from the same population. To simulate this, draw two samples of size n_t from the observed sample of households from year t. Draw one household at the time with replacement.
2. Compute the coefficient of variation for each sample of size n_t.
3. Calculate the difference between the two coefficients of variation.
4. Perform step 1 to step 3 1000 times.
5. The 1000 simulated differences between two coefficients of variation represent an estimate of the distribution of a difference between two sample coefficients of variation from the same population.