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JEL Codes: D12, D13, O12.

Keywords: Engel curves, intrahousehold inequality, heterogeneity, separability, Senegal.

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# Unpacking Household Engel Curves

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Philippe De Vreyer

Sylvie Lambert

Martin Ravallion<sup>1</sup>

*Acknowledging that decision making does not happen at the household but at the individual level, can household Engel curves be safely estimated based solely on household level data? Answering this question implies to consider the intra-household Engel curves (IECs) and to assess how estimates of such IECs relate to standard household Engel curves estimates. Aggregating the IECs to household level reveals confounding factors in standard household Engel curves, including intra-household inequality. A unique data set for Senegal is used to estimate IECs. Large discrepancies are found between the standard estimates of Engel curves and the consistently aggregated IECs. The main source of the discrepancy is a household fixed effect on intra-household spending behavior, which is only partially offset by differences in intra-household inequality. Results suggest that income elasticity of food consumption might be overestimated by as much as 43% by the standard household Engel curve estimation.*

**Keywords:** Engel curves; intrahousehold inequality; heterogeneity; separability; Senegal

**JEL:** D12, D13, O12

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<sup>1</sup> Philippe De Vreyer is Professor of Economics at Paris Dauphine-PSL university; his email address is philippe.devreyer@dauphine.psl.eu. Sylvie Lambert (corresponding author) is director of research at INRAE, Professor at the Paris School of Economics, and Professor at Ecole Normale Supérieure – PSL University; her email address is sylvie.lambert@psemail.eu. Martin Ravallion was Edmond D. Villani Professor of Economics at Georgetown University and former director of the Development Research Group at the World Bank. He passed away on Christmas Eve 2022. Sylvie Lambert is grateful for the financial support of the EUR grant ANR-17-EURE-0001. For helpful comments and discussions, the authors thank Tanguy Bernard, François Bourguignon, Caitlin Brown, Isabelle Chort, Vassilis Hajivassiliou, Franco Peracchi and participants at the workshop on “Family and Development” at the University of Bordeaux, the Development Seminar at Stanford University and the Martin Ravallion Symposium on Poverty and Inequality in Calcutta. We are also grateful for the constructive comments of the two reviewers. A supplementary online appendix is available with this article at the World Bank Economic Review website. The data underlying this article will be shared on reasonable request to the corresponding author.

## 1. Introduction

Ernst Engel (1857) famously studied household budgets for 200 working class Belgian families. He discovered that the proportion of income devoted to food decreases as total household spending increases—a property now referred to as Engel’s Law. Since then, “Engel curves” for budget shares have been widely used and much studied across the world, consistently confirming Engel’s Law.<sup>2</sup> Engel curves have a wide range of applications, including in assessing policies related to agriculture, taxation, trade, industrial organization, housing, and in the measurement of poverty and inequality. Estimating Engel curves to assess the income elasticity of food demand is still widely used to evaluate the effectiveness of social programmes aimed at reducing poverty and improving the nutritional status of poor households. Moreover, in the past decade, a booming literature has used estimation of Engel curves for assignable goods as a basis for identification of individual resources shares from household level data (see for example Dunbar et al. 2013, Bargain et al. 2018, Lechene et al; 2022, Calvi et al, 2023).

While there have been methodological and computational advances in the specification and estimation of Engel curves, a common and persistent feature has been the reliance on household aggregates that Engel pioneered, along with a degree of imposed homogeneity in the Engel curves of household’s members. Homogeneity assumptions allow only limited variability in the parameters between and within households. However, many spending decisions are made by individuals rather than collectively.

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<sup>2</sup> At the centenary of the publication of Engel’s major work on household budgets, Houthakker (1957) provided estimates across 30 countries largely confirming Engel’s Law, though noting that the income elasticity of demand for food tended to be higher in poorer countries. Houthakker reported one estimate for India (from the city of Bhopal) of an elasticity of about unity, which was the only exception he found to Engel’s Law.

This paper addresses the question of whether household level Engel curves can give an accurate depiction of household demand behavior, when consumption decisions are taken at a disaggregated level within the household. It examines intra-household Engel curves (IEC) and their relation with standard household level Engel curves. The idea is to aggregate IECs at the household level and compare the result to the usual household Engel curves, revealing some neglected but potentially confounding sources of unobserved heterogeneity. Leveraging a unique dataset from Senegal that provides consumption data at a disaggregated level within the household, this paper estimates both IEC and standard EC, and demonstrates that the Engel coefficient obtained in the latter case is severely biased.

Three potential sources of heterogeneity are explored. First, latent household effects may affect individual demand behavior. Household members are not merely autonomous individuals living under the same roof; they come together selectively and influence one another's behavior through shared consumption and collaboration (including working together). Furthermore, some aspects of the household and shared local environment can have a powerful influence on individual choices, either through individual preferences, which are to some extent formed within a household, or through household- or location-specific constraints (such as differential prices faced or quality consumed by households of different social class or income level). This influence of the household on individual choices is well documented in the consumer behavior literature outside economics.<sup>3</sup> Relatedly, any household specific measurement error on consumption expenditure would be a source of bias. For the present purpose, those various sources of heterogeneity can be

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<sup>3</sup> On the influence of the family and other group memberships on individual preferences and consumer behavior see the surveys by Solomon et al. (2006, Chapters 10 and 11) and Arnould et al. (2005).

encompassed in a household effect on individual Engel curves. This effect cannot be accurately accounted for in estimations based on household-level cross-sectional surveys.

Second, there are differences in individual demand parameters within households. This has received some attention. It is known that Engel's Law may cease to hold at the household level when income gains are assigned to people with different consumption patterns and different preferences over how the extra money should be spent. Attanasio and Lechene (2010, 2014) argue that this could explain why the household food share did not fall despite the income gains for targeted households participating in Mexico's famous PROGRESA program, which provided cash transfers, paid to women. This arrangement for payment appears to have shifted the household Engel curve for food among PROGRESA participants.

Third, there is heterogeneity in the extent of inequality within households. The existence of intra-household inequality is known to be a source of bias in the measurement of poverty and global inequality.<sup>4</sup> Intra-household inequality can also bias estimates of empirical consumer demand functions estimated from household aggregate data. Furthermore, intra-household inequality may drive part of the differences in individual demand parameters within the household.

There is no clear reason why these sources of heterogeneity should be statistically ignorable when estimating standard household Engel curves. Latent heterogeneity in demand behavior may well be correlated with total household spending or income. For instance, latent heterogeneity in preferences regarding children's welfare may be related to the share of expenditure dedicated to food, clothing and education and correlated to the level of household expenditure. In turn, human capital is likely to be positively correlated with household consumption or income. Another

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<sup>4</sup> Contributions include Haddad and Kanbur (1990), Findlay and Wright (1996), Lise and Seitz (2011), Bargain et al. (2018), De Vreyer and Lambert (2021).

example pertains to the household's social standing in the local community. Perceptions of the obligations that accompany a higher social status can affect spending patterns; for example, one might feel compelled to show off with a TV, or have ample food prepared in case of unannounced visits. Such "status-seeking" behavior is expected at a certain level of total spending, but is also likely to be correlated with that spending.

A similar point can be made regarding intra-household inequality. On a priori grounds, it would be difficult to defend the assumption that this latent inequality is statistically ignorable. One might expect that the extent of intra-household inequality varies with mean consumption or income (and possibly other covariates of household demands). The sign of such correlation will depend on the context. Kanbur and Haddad (1994) show that a (positive or negative) correlation between intra-household inequality and household income can arise from a model of Nash-type intra-household bargaining for resources allocation. In the data, the correlation happens to be positive: richer households display a more unequal intra-household allocation of resources.<sup>5</sup>

The upshot of these observations is that household Engel curves estimation may be biased by these confounders. Testing this conjecture is the aim of this paper. To do so, it investigates whether two methods of estimating Engel curves—one using standard household aggregates and the other estimating IECs with (rather rare) consumption data at a disaggregated level within the household to—are reasonably consistent with each other. It provides explanations for inconsistencies that are uncovered.

Past research on Engel curves has been constrained by the lack of data on spending within the household and by the fact that income or total expenditure is rarely exogenous so that reliable

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<sup>5</sup> In the data, the Intra-household Theil index is positively related to the level of household expenditure per capita. On average, the index equals 0.034 in the first quartile of household expenditure and climbs up to 0.078 in the last quartile. See De Vreyer and Lambert (2021).

estimations might be difficult to obtain. Almås et al. (2023), as well as Bellemare et al. (2024) use exogenous variation in income linked to the randomized evaluations of cash transfers programs to obtain unbiased estimates. They both report lower estimates than those obtained for non-experimental studies. This paper exploits a unique data set for Senegal to estimate IECs. The data can be used to assign total spending within the household. Leveraging this information allows for both latent household-level effects and intra-household inequality to be accounted for, addressing the concerns raised above. Estimated IECs are then aggregated to derive the implied household estimation. Results are then compared to the estimation of the more familiar aggregate Engel curves, which does not require detailed sub-household consumption data. The comparisons offer new insights into the structure of the error term of the household Engel curve, enabling potential sources of bias to be explored.

Similar to the literature on collective household models, this paper postulates that individual preferences matter and interactions between household members lead to an aggregate demand curve. The common assumption of Piglog type cost-functions is made, that leads to the standard Working Leser Engel curves. Also considered is a quadratic specification for the Engel curves that would follow from a QUAIDS demand system, such as that found in Calvi et al. (2023) for example. In a way similar to Dunbar, Lewbel & Pendakur (2013) or Calvi et al. (2023), these individual demand functions are aggregated up to the household level to derive from this exercise a household level Engel curve. In both cases, as well known from the literature for the Piglog specification and explicitly derived in the Calvi et al. (2023) online appendix, the household level Engel curve resulting from this aggregation has a functional form similar to the individual level ones.

For the purpose of this paper, the focus is put primarily on the longstanding Working-Leser (WL) specification for budget shares that is linear in log total spending.<sup>6</sup> It is assumed that the WL model holds at the individual level and then aggregates up to the household level. Through this process, a WL specification is derived, that can be estimated with standard household-level data. It is shown that the error term of this model contains a component for latent heterogeneity, as well as a component that reflects inequality within the household. In the special case of common Engel parameters within the household, a Theil-T index for intra-household inequality is the relevant inequality related omitted variable. Predictions of the aggregate demand responses to changes in household income are thus conditional on how changes in spending are distributed within households. The possibility that the level of intra-household inequality varies with total spending thus emerges as a confounding factor in estimating household Engel curves.

When aggregating IECs up to the household level, results are significantly different from those obtained by only using the aggregate data to estimate the household Engel curves. The conditions required for consistent estimation of Engel curves using standard household data are convincingly rejected. The components of bias are partly offsetting, as the bias due to correlated differences in the extent of intra-household inequality works in the opposite direction to that due to latent household effects on spending behavior.

The remaining of this paper is organized as follows. The next section 'unpacks' the household Engel curve and demonstrates how its estimation on commonly available household level consumption aggregates can be biased by intrahousehold heterogeneity when there are

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<sup>6</sup> Working (1943) advocated this functional form, which Leser (1963) found to fit better than some options. On the consumer expenditure function (and hence indirect utility function) implied by such Engel curves see Muellbauer (1975). For an overview of this model and alternatives see Phlips (1983) and Lewbel (2008). However, robustness to allowing budget shares to be nonlinear in log total spending per capita with a quadratic specification has also been tested. Results presented in appendix C are hardly sensitive to this variation.

multiple decision makers in the household and heterogeneous Engel curves. In section 3, data are presented and some descriptive statistics are provided. Section 4 shows the Engel curve estimation results obtained when using either aggregate or intra-household consumption measures. In section 5, the two main sources of bias are investigated when estimating Engel curves with household level consumption aggregates. Section 6 concludes.

## 2. Un-packing the household Engel curve

Consider a situation where the household includes several decision makers over budget allocations. These decision makers take decisions regarding their own consumption as well as that of their dependents. In order to avoid cluttering the notation, the presence of dependent members will be ignored in this theoretical section, but it will be taken into account in the empirical application.

Each decision maker is assigned to one of a number of possible types (male head, wife, other adult...), with fewer types than people. Engel parameters are allowed to vary within households but a key identifying assumption is that they vary between types but not within.<sup>7</sup> The unique assignment of persons to types is given by a pre-determined discrete function  $t(i, j)$ , which returns the designated type for each person  $i=1, \dots, n_j$  in household  $j=1, \dots, m$ .

The IEC for consumption by decision maker  $i$  (of type  $t(i, j)$ ) in household  $j$  for a private good of type  $k$  ( $=1, \dots, K$ ) takes the form:

$$S_{ij}^k = \alpha_t^k + \gamma_t^k \ln Y_{ij} + \eta_j^k + \varepsilon_{ij}^k \quad (i=1, \dots, n_j; j=1, \dots, m; t = t(i, j)) \quad (1)$$

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<sup>7</sup> A homogeneity assumption of this sort is common for identification purposes in the literature on intra-household resource allocation. See, for example, the empirical implementation of the collective model in Dunbar et al. (2013).

where  $S_{ij}^k$  is the share of person  $i$ 's total expenditure  $Y_{ij}$  devoted to good  $k$  and  $\eta_j^k$  is a household effect. To avoid cluttering the presentation, equation (1) omits cell characteristics as control variables. These will be incorporated during the estimation stage. The data are assumed to include multiple observations for a given type, such that (1) is estimable. Notice that (1) allows the Engel parameters  $(\alpha_{t(i,j)}^k, \gamma_{t(i,j)}^k)$  to vary within households.

It is assumed that the endogeneity concerns about  $Y_{ij}$  in (1) are adequately addressed by including household fixed effects that soak up any latent differences between households. For instance, it may be conjectured that the head uses the allocation across household members to influence spending patterns in desired ways. The household fixed effect will pick up differences in the preferences of the heads of household.

However, there remain threats to identification. The first threat is measurement error in the survey-based spending allocations. In the empirical implementation (as detailed in section 3), household data are collected from several respondents to obtain within-household allocation of expenditure, and each of these respondents is exposed to measurement error. These data are then aggregated to obtain household expenditure. If the data collected at the intra-household level suffer from classical measurement error, the aggregation should dampen the overall measurement error at the household level. Classical measurement error generates the usual attenuation bias in the estimated Engel coefficients, in a more pronounced way for IEC estimates.<sup>8</sup> The possibility that estimates of individual Engel curves based on (1) will be biased due to such measurement errors cannot be ruled out, as is the case with most other studies for developing countries.<sup>9</sup> The second

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<sup>8</sup> This suggests that IEC estimates should be more biased towards zero than household level ones. It will be seen in the results that, on the contrary, estimated IEC coefficients are of a much larger magnitude than what is obtained when the data is used to estimate the coefficients of standard household level Engel curves.

<sup>9</sup> Two exceptions are Almås, Haushofer and Kjelsrud (2023) and Bellemare, Kandpal and Thomas (2024) who use a randomized controlled trial to generate a defensible instrumental variable.

threat is that in households where the head is the main source of income, and as such allocates resources among members, individual decision makers with a strong preference for (say) clothing may search out and find some extra “private” income source to complement the allocation from the head, again generating  $Cov(\varepsilon_{ij}^k, \ln Y_{ij}) \neq 0$ . However (as will be seen), even if  $Cov(\varepsilon_{ij}^k, \ln Y_{ij}) = 0$ , new sources of bias in the household Engel curves emerge when aggregating up.

**Aggregation to household-level:** Neither  $S_{ij}^k$  nor  $Y_{ij}$  are typically observed. When only household level aggregates are available, to derive the estimable household-level Engel curves from (1) one can proceed by first eliminating the (unobserved) intra-household values of  $Y_{ij}$  by re-writing (1) as:

$$S_{ij}^k = \alpha_{t(i,j)}^k + \gamma_{t(i,j)}^k \ln \bar{Y}_j + v_{ij}^k \quad (2)$$

Here  $\bar{Y}_j$  is total household expenditure per capita and the new error term is:

$$v_{ij}^k \equiv \gamma_{t(i,j)}^k \ln \delta_{ij} + \eta_j^k + \varepsilon_{ij}^k \quad (3)$$

where  $\delta_{ij} \equiv Y_{ij}/\bar{Y}_j$  is the relative expenditure for person  $i$  in household  $j$ . In other words, this is individual  $i$ 's resource share, multiplied by household size. Next, aggregating the budget shares at the household level for good  $k$  yields:

$$S_j^k = \frac{1}{n_j} \sum_{i=1}^{n_j} \delta_{ij} S_{ij}^k = \alpha_j^k + \gamma_j^k \ln \bar{Y}_j + v_j^k \quad (4)$$

Here the household-level Engel-curve parameters are related to the unpacked IEC parameters as follows:

$$\alpha_j^k \equiv \frac{1}{n_j} \sum_{i=1}^{n_j} \delta_{ij} \alpha_{t(i,j)}^k; \quad \gamma_j^k \equiv \frac{1}{n_j} \sum_{i=1}^{n_j} \delta_{ij} \gamma_{t(i,j)}^k \quad (5)$$

Notice that the household parameters are implicitly weighted more heavily on household members with larger resource shares. Note further that equation (5) is parallel to equations 5 and 8 in Dunbar et al. (2013), as the Engel coefficient at the household level is the sum of each type Engel coefficient weighted by their resource share. The error term of the household Engel curve in (4) is:

$$v_j^k = \sum_{i=1}^{n_j} \delta_{ij} v_{ij}^k = T_j^k + \eta_j^k + \sum_{i=1}^{n_j} \delta_{ij} \varepsilon_{ij}^k \quad (6)$$

where:

$$T_j^k \equiv \frac{1}{n_j} \sum_{i=1}^{n_j} \gamma_{t(i,j)}^k \delta_{ij} \ln \delta_{ij} \quad (7)$$

Henceforth,  $T_j^k$  will be referred to as the “ $\gamma$ -weighted Theil index” for good  $k$ .<sup>10</sup> The corresponding ordinary Theil index applied to measuring intra-household inequality is:<sup>11</sup>

$$T_j \equiv \frac{1}{n_j} \sum_{i=1}^{n_j} \delta_{ij} \ln \delta_{ij} \quad (8)$$

To aid interpreting (6) consider the special case of homogeneous Engel coefficients within the household ( $\gamma_{t(i,j)}^k = \gamma_j^k$  for all  $i$ ). Then,  $T_j^k$  in (6) can be replaced by  $\gamma_j^k T_j$ . Greater intra-household inequality (measured by the Theil index) will lower the budget share devoted to goods of type  $k$  if they are a necessity ( $\gamma_j^k < 0$ ) and the opposite if they are a luxury ( $\gamma_j^k > 0$ ). Under Engel’s Law, the budget share devoted to food will be lower in more unequal households.

Household Engel curves in the form of (4) are still not the standard estimable Engel curves, which have constant-parameters as follows:

$$S_j^k = \alpha^k + \Gamma^k \ln \bar{Y}_j + \mu_j^k \quad (9)$$

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<sup>10</sup> Note that the weighted Theil index is not bounded below by zero, as in the unweighted index, given that the  $\gamma$ ’s can be negative.

<sup>11</sup> See Theil (1967). For further discussion of the properties of this index see Bourguignon (1979).

Here:

$$\alpha^k \equiv \frac{1}{m} \sum_{j=1}^m \alpha_j^k; \quad \Gamma^k \equiv \frac{1}{m} \sum_{j=1}^m \gamma_j^k \quad (10)$$

while the error term in (9) is:

$$\mu_j^k \equiv T_j^k + \eta_j^k + \alpha_j^k - \alpha^k + (\gamma_j^k - \Gamma^k) \ln \bar{Y}_j + \sum_{i=1}^{n_j} \delta_{ij} \varepsilon_{ij}^k \quad (11)$$

Following equation (9), the standard formula for the total spending elasticities of household demand for WL Engel curves is:

$$\frac{\partial \ln Y_j^k}{\partial \ln \bar{Y}_j} = 1 + \frac{\Gamma^k}{S_j^k} \quad (12)$$

(Here  $Y_j^k$  denotes household  $j$ 's total consumption of good  $k$ .) Note, however, that (in the model) this standard formula is only valid when all individuals gain in proportion to their current allocation of the household's total consumption, in which case the effect of the income gain on the intra-household inequality term in (7) can be set to zero. This assumption is not made in the empirical work, but it will help in interpreting the results.

**Conditions for consistent estimation using only household-level data:** As usual, the key assumption needed for consistent estimation of the household Engel curve in (9) is that  $Cov(\mu_j^k, \ln \bar{Y}_j) = 0$ . The same orthogonality condition is of course required with other regressors. From (11), it can be seen that there are three potential sources of bias when estimating the Engel curve using standard household data, corresponding to the sources of heterogeneity described in the Introduction: (i) correlated heterogeneity in the  $\gamma$ -weighted Theil indices ( $T_j^k$ 's); (ii) correlated household effects (the  $\eta_j^k$ 's); and (iii) systematic heterogeneity in the IECs, such that  $Cov[(\gamma_j^k - \Gamma^k) \ln \bar{Y}_j], \ln \bar{Y}_j] \neq 0$ . Given that the specification allows for a household effect on the IEC,  $\gamma_j^k$  can

be treated as orthogonal to  $\ln \bar{Y}_j$  in (11), leaving the  $\eta_j^k$ 's to pick up this source of bias in the Engel curve when estimated on household data only.<sup>12</sup>

Thus, two specific orthogonality conditions stand out as problematic. The first is a familiar exogeneity condition,  $E(\eta_j^k | \ln \bar{Y}_j) = 0$ . The second is that  $E(T_j^k | \ln \bar{Y}_j) = 0$ . If both hold then OLS is valid when applied to (9). In the special case of constant Engel parameters ( $\gamma_{t(i,j)}^k = \Gamma^k$  for all  $i,j$ ) this requires that the intra-household Theil index is orthogonal to household total spending. This latter condition makes explicit another reason to require the hypothesis of independence between intra-household inequality and total household expenditure (as postulated in the literature on intra-household resource allocation based on Engel curves estimations, see e.g. Dunbar et al. 2013).

### 3. Data and descriptive statistics

The data are provided by the Pauvreté et Structure Familiale (Poverty and Family Structure, henceforth PSF) survey conducted in Senegal in 2006/2007.<sup>13</sup> The survey is described in detail in De Vreyer et al. (2008). The PSF is a nationally representative survey covering about 1800 households spread over 150 clusters drawn randomly from the census districts stratified in 3 strata

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<sup>12</sup> This follows from the law of iterated expectations: conditioned on household expenditure and the fixed effect, the covariance is equal to zero, and then taking the expectation gives the claimed result.

<sup>13</sup> The PSF survey stems from the cooperation between a team of French researchers and the National Statistical Agency of Senegal. Momar Sylla and Matar Gueye of the Agence Nationale de la Statistique et de la Démographie of Senegal (ANSD) on the one hand and Philippe De Vreyer, Sylvie Lambert and Abla Safir (World Bank) designed the survey. The data collection was conducted by the ANSD thanks to the funding of the IDRC (International Development Research Center), INRA Paris and CEPREMAP.

according to the urbanization level, so as to insure a geographically representative sample. The survey describes a population of which the majority (52%) live in rural areas.

Senegalese households are large, with eight members on average in the PSF. The families are typically multigenerational. Polygamous unions are common, with 25% of married men and 39% of married women engaged in such unions, which mostly comprise a husband and two wives (only 20% of polygamous unions have more than two wives).

The survey collected details on each household's structure and budgetary arrangements. Households were divided into "cells", each of them including an adult decision maker and his or her dependents. The following rule was used to form cells: the head of household and unaccompanied dependent members, such as a widowed parent or children whose other parent does not live in the same household, are grouped together. When the household head is a man, each wife of the head and her children make up a separate group. Finally, any other family nucleus, such as a child of the household head with their spouse and/or children, forms a separate cell. By definition, cells contain only one decision maker, so that they are units within the household for whom the assumption of a unitary behavior is most likely to hold. There is one exception to this rule, when the household contains a monogamously married man who is not the household head. This man would form a single cell with his wife and their children.<sup>14</sup> There are 440 such "non-unitary" cells, in 338 households.

With such a rule for the division of the household into cells, nuclear households contain 2 cells, that of the head and that of his wife and children. The number of cells is higher in complex households (extended or polygamous for example). Single cell households are those of people

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<sup>14</sup> Note that all polygamous men are treated like the household head, i.e. they and their wives are in separate cells.

living alone, such as men in temporary work migration, or living with dependent only, such as lone mothers with their children. Enumerators saw this as a natural way to divide households and had no difficulty organizing the survey in this way and collecting the data accordingly.

For the purpose of this study, the sample is reduced to households comprising at least two cells, which reduces the sample size to 1425 households and 3956 cells. Of those, about 45% (640) are nuclear households, containing 2 cells, that of the monogamous head and that headed by his spouse. The cell of the household head can include unaccompanied dependent such as a widowed parent or children from a previous marriage. A narrower definition of “nuclearity” limits the set of nuclear households to those that include only the husband, wife, and their children. The sample contains 404 households (28%) meeting this definition.

A series of robustness exercises is conducted, varying the sample used. First, estimations are repeated without the 338 households containing “non-unitary” cells. This reduces the sample to 1088 households and 2659 cells. Second, to assess whether the results are driven by polygamous households, the analysis is also repeated on the two samples of nuclear households (640 “complex” nuclear households and 404 “strictly” nuclear households).

Consumption expenditure are recorded in several parts: first, all common expenditures within the household (housing, electricity bills etc.) are collected, generally from the household head who is typically in charge for those expenses. Regarding food expenditure, interviewing each woman in the household about the meals she’s in charge for preparing, a detailed account is made of who shares which meal and how much money is specifically used to prepare this meal.<sup>15,16</sup> Since

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<sup>15</sup> The “DQ”, i.e. “dépenses quotidiennes,” is the name the Senegalese give to the amount of money a woman has at her disposal to buy fresh ingredients for the meals of the day.

<sup>16</sup> Food expenditure includes the value of home-produced food.

all household members who participate in the meal eat out of the same dish, food expenditure for a given meal are supposed to be equally shared among them. Then private consumption, other than food at home, is collected at the cell level (such as clothing, mobile phone, transportation, food outside the home), by directly interviewing the cell's head. What is measured here is the value of the consumption accruing to the cell, irrespective of who paid for it. For example, even if the household head pays for the education of his children, the corresponding expenses are affected to the cell to which children belong. Finally, expenditures that are shared between several cells, but not the whole household, are collected (e.g. the cost of transporting the children to school, when children belong to different cells). Hence, a measure of per capita consumption can be constructed at the cell level.

Thanks to these features of the data, a measure of consumption can be constructed at the level of household's cells, which is a level of granularity rarely available in household surveys, thus enabling the estimation of IECs<sup>17</sup>. Cell total private consumption is measured by the sum of the amount of expenditure specific to the cell, of its share of food-at-home and of its share of consumption shared with subsets of household' cells. Household's joint expenditure on utilities, durable goods and housing are considered "public" and are not included in cells private spending. For consumption purposes, cell heads are assumed to be the decision makers at the cell level.

When looking at total expenditure, inequalities within the household are evident.<sup>18</sup> The ratio between the expenditure of the richest and the poorest group within a household can be as

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<sup>17</sup> To our knowledge, there are two surveys in Bangladesh that also provide individual level consumption data. Household Income and Expenditure Survey (HIES) for the year 2004 collects individual consumption of private goods while *Bangladesh Integrated Household Survey* (BIHS), collected by IFPRI since 2013, provides individual food consumption for the past 24 hours. Note that Bangladesh is a context where households have a simpler structure than households observed in West Africa and in particular in Senegal.

<sup>18</sup> For further discussion of intra-household inequality in Senegal and its implications for the measurement of poverty see De Vreyer and Lambert (2021).

high as 5.3 even after trimming off the 5% most unequal households. Computing a Gini inequality index for the distribution of cash expenditure in the population, yields a value of 0.47 when the average per capita consumption level in each household is attributed to each person. By contrast, the index is 0.50 if instead everyone is attributed the per capita consumption in his cell (i.e. the sum of the per capita expenditure specific to the cell and of the cell's share of public household expenditure, distributed on a per capita basis). The Gini index of inequality in the distribution of the cell-specific component of cash expenditure (ignoring the joint consumption within the household) is 0.78. Note that the hypothesis of equal sharing of food taken at home might lead to underestimate intra-household inequality.

The cell-specific consumption data reveal a sizeable gender gap. Male headed cells have a per capita consumption 33% higher than that of female headed ones, and this difference is statistically significant at the 1% level ( $t=13.12$ ).

The remaining of this paper focuses on the estimation of Engel curves for private consumption. Consumption is split between six categories of goods and services: food taken at home, food taken outside, transport, clothing, education, and other goods and services<sup>19</sup>. Budget shares considered in this paper are defined as a share of total private expenditure.<sup>20</sup> Since food taken outside may be considered a recreation good, expenses on this item appear in a separate category rather than with other food expenditures. The Engel law is not expected to hold for this kind of food. Though being obviously a private consumption, expenditures on health do not enter

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<sup>19</sup> This latter category comprises leisure goods, newspapers or magazines, personal care, mobile phone and communication.

<sup>20</sup> 33 households (corresponding to 87 cells) have outlier values for budget shares for some goods (less than 10% of private expenditure spent on food, more than 70% spent on clothing or other goods, more than 80% on education or more than 53% spent on transportation). Excluding those 33 households does not affect the results.

in the scope of this paper, as they may not result from a free choice made by the consumer. Expenditures on health and public goods are assumed separable from private consumption.

Three types of cells are defined: those headed by a household head, those headed by a spouse of the head and those headed by any other member of the household (brother of the head for ex). Sample summary statistics on the main variables are shown in table 1. The table is divided into household (Table 1a) and cell level by type (Table 1b). Average household food share is 64.7%, though it ranges widely. The average size is 9 persons (larger than for the full sample given that single-cell households are excluded), ranging from 2 to 44. The average number of cells is 2.8 (with a maximum of 12). 36% of cells are those of the head, 37% of the spouse. 85.8% of household heads are male. Notice that spouses have a higher food share than heads (Table 1b).

TABLES 1a and 1b ABOUT HERE.

#### **4. Results comparing household and intra-household Engel curves**

The data are used to estimate Engel curves in two ways. The first entails estimating the IECs in equation (1) and then using equations (5) and (10) to get a “consistently aggregated IEC” estimation of  $\Gamma^k$ . The second is the standard method using only the household aggregate data, ignoring the fact that sub-household data are available, as in equation (9). Estimations are then compared.

*Estimates of intra-household Engel curves with household fixed effects (Table 2):* For the IECs (Equation 1), the regressions include (log) cell size and cell head’s age, age square and

education, as well as cell composition by age and gender.<sup>21</sup> In the household level regression (Equation 9), additional controls are (log) household size, age, sex and education of household head, household composition by age and gender, as well as urban and regional dummy variables (see Table 1a).

The top panel of Table 2 gives the estimates of  $\gamma_t^k$  separately for three types of cells: the household head and other members in his/her cell (type 1), head's spouses and their children (type 2) and cells headed by another household member (type 3). The next panel down gives test statistics of the difference between types. In the third panel, the row “ $\Gamma$  from hhold level regression” gives the coefficient obtained by the standard household level data analysis. In other words, this is an estimate of equation (9) treating  $v_j^k$  as a zero-mean error term orthogonal to the regressors. The row “ $\Gamma$  from IEC aggregation” is obtained by consistent aggregation from the cell-level Engel curves in equation (1). Here the means are computed at two levels: first, for each household, the weighted mean of the  $\gamma_t^k$  coefficients is computed, with weights equal to the budget share of each cell (equation (5)). Second, equation (10) is used to compute the average over the sample of households. Finally, the last row of this panel provides a test of the difference between the two estimates of  $\Gamma$ . Table 2 also gives the Hausman test, indicating that the fixed effects specification is to be preferred for the cell level Engel curves (against the null hypothesis that the random effect model is the correct specification).

***Comparison of household and intra-household estimates:*** Large discrepancies are found between the consistently aggregated IECs and standard estimates from only household aggregate

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<sup>21</sup> The complete results for all Engel curves are found in the Appendix B, tables B1.1 and B1.2

data, and this appears to be true for all the categories of goods. Differences in the coefficients are sizeable as well as statistically significant (Table 2, third panel).

Note that such a result cannot be attributed to the specific household structures found in Senegal. The same results hold when the sample is restricted first by withdrawing households containing non-unitary cells (appendix A, table A1), then by concentrating on “complex” nuclear households (table A2), and finally when considering only “strictly” nuclear households (table A3). In this latter case, in the education equation, although the point estimates are not very different from those of the main sample, the difference between the Engel coefficients obtained from the consistently aggregated IEC and that from the household level estimation are not significantly different anymore. This seems to be due mainly to more imprecise estimates due to smaller sample size. Same is true for the last category of good considered “other goods and services”.

TABLE 2 ABOUT HERE

A further insight into the extent of the discrepancies is found in Figure 1, which provides the cell-based density functions of the Engel parameters across households (equation (5)) for each category of spending. It is notable how tight the distributions are around their means. When these densities are compared with the results from the standard household-level specification it can be seen that for every category, the latter are well outside the bulk of the density function of Engel parameters. Clearly, these are not small differences.

FIGURE 1 ABOUT HERE

For food-at-home, Engel's Law holds either way, although the cell analysis indicates a far steeper decline in the food-at-home share as total consumption rises; indeed, the estimated Engel parameter is 2.4 times greater when the cell data are used and the estimates aggregated up to the household level. At the mean budget share for food of 0.647, this difference would reduce the implied income elasticity of demand for food (assuming inequality neutrality) from 0.82 (using household data only) to 0.57 (using cell data). Interestingly, this conclusion is qualitatively similar to that reached by the papers that leverage exogenous income variation to obtain unbiased estimates of income elasticity of the demand for food. Both Almås et al. (2023) and Bellemare et al. (2024) reevaluate this elasticity downwards compared to those obtained with non-experimental data.

Given that the issue of who receives a transfer payment has been prominent in the literature, and in light of the findings of Attanasio and Lechene (2010, 2014) (as discussed in the Introduction), it is of interest to take advantage of the ability to estimate separately Engel curves for several types of household members and to consider the effects on the budget share devoted to food-at-home by a household comprising two adults in the following stylized cases:

Case 1: Total spending by the head increases in the amount  $\Delta = dY_H$  with no change in the spending done directly by the spouse. The share of the head's spending going to food ( $S_H^F$ ) changes by  $\gamma_H \Delta / Y_H$  and the share of total household spending devoted to food ( $S^F$ ) changes by  $dS^F = (S_H^F - S^F + \gamma_H) \Delta / Y$ .

Case 2: This is the reverse: the spouse's total spending increases in the amount  $\Delta = dY_S$  and (similarly to Case 1) there is no change in the spending done directly by the head. The share of the spouse's spending going to food ( $S_S^F$ ) changes by  $\gamma_S \Delta / Y_S$  and the share of total household spending devoted to food changes by  $dS^F = (S_S^F - S^F + \gamma_S) \Delta / Y$ .

Summary statistics show that heads have a lower food share than spouses, namely 56.7% and 71.8% respectively (Table 1b), with a household food share of 64.7% (Table 1a). Thus, Case 1 changes the household food share by  $-0.35\Delta/Y$  while it changes by  $-0.21\Delta/Y$  for Case 2. The food share falls less when the spending gain is for the spouse. Given the similarity in their Engel parameters, the difference in the impact on aggregate food share between the two cases ( $0.14\Delta/Y$ ) is almost entirely due to the difference in individual food shares between the head and the spouse (at mean points,  $S_H^F - S_S^F = -0.15$ ).

## 5. Sources of bias in standard household Engel curves

Recall that the model points to two main sources of bias in the standard household-level Engel curves, namely the confounding differences across households in either the household effects (the  $\eta_j^k$ 's), and the  $\gamma$ -weighted Theil index ( $T_j^k$ 's). In this section the data are used to see which confounder matters most, to better understand the sources of bias in standard household Engel curves.

Since the data allow the estimation of IEC coefficients, the estimated parameters can be used to build estimated values of  $\gamma$ -weighted Theil index for each household. Estimated values of household fixed effects can also be obtained using the Stata predict command.

In a first step, one or both of the two confounders are added to a standard household Engel curve. Table 3 presents the results in lines 2 to 4, as well as, for comparison purposes, the original household level estimation (First line, that repeats line “Γ from hhold level regression” from table 2) and the aggregated IEC coefficients (last line, repeating the corresponding line from table 2). Results suggest that the household effects are the main source of the discrepancies between the standard household-level estimates of the Engel curve parameters and aggregated IEC coefficients.

The gaps are much reduced when household fixed effects are controlled for, while the impact of controlling for the  $\gamma$ -weighted Theil index is much smaller and goes in the other direction.<sup>22,23</sup>

Given the role of the household fixed effect, the analysis explores the possibility of reducing the bias in the standard household level estimation by controlling for a fuller array of household characteristics. The data available in the survey can be used to control for the type of the household: nuclear monogamous, nuclear polygamous, extended polygamous households (at least one cell is headed by an adult who is neither the head nor one of his spouses) or other extended households. In addition, the number and the mean characteristics of cells (cell head's age, education and gender, and cell composition by age and gender) can be controlled for. Disappointingly, adding this precise description of the household does hardly affect the estimated Engel coefficient and hence does not permit to correct for the bias (5<sup>th</sup> line). Similarly, very little is gained by adding survey cluster fixed effect to control for the context that might create a set of constraints to consumption common to all household members (6<sup>th</sup> line). *In fine*, at the household level, it was not possible to find any alternative way to control for the unobservable part of the household fixed effect.

TABLE 3 ABOUT HERE

To corroborate the finding that household effects are indeed the main source of discrepancies, similar results to the standard household Engel curve should be obtained if the  $\eta_j^k$ 's

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<sup>22</sup> In Appendix B2, tables B2.1 to B2.4 show the full set of controls. As shown in Table B2.5, using the intra-household Theil index directly rather than the  $\gamma$ -weighted Theil gives very similar results.

<sup>23</sup> Given this result, the potential underestimation of intra-household inequality due to the assumption of equal sharing for food-at-home is unlikely to drive a significant overestimation of the bias.

are ignored when estimating cell-based Engel curves. The results of the comparison between standard household level Engel curves estimation and the consistently aggregated IEC, when IEC are estimated by OLS, ignoring the  $\eta_j^k$ 's in (1) confirm intuition (Table 4): IEC estimates are consistently closer to the household level ones than those presented in Table 2. Consider for instance the food eaten at home Engel curve, for which the estimate of  $\Gamma$  in Table 4, based on the cell-model, falls to -0.105, which is fairly close to the household-based estimate (-0.114), and not significantly different.<sup>24</sup>

TABLE 4 ABOUT HERE

The total bias in estimates of the Engel parameters can be decomposed into the bias due to the  $\eta$ 's and that due to the  $T$ 's.<sup>25</sup> To assess the relative weight of these two sources of bias, it is useful to examine at how these confounders correlate with log of total expenditure and log of household size. The estimated coefficients of these two variables, obtained from regressions, for each category of goods, of the two confounders on all variables included in the Engel curve specification are shown in table 5. Results for the household effects are reported in the top panel of the table, while those for the  $\gamma$ -weighted Theil index can be found in the lower panel. There is a greater explanatory power (higher  $R^2$ ) for the  $\eta$ 's. Household total spending (in logarithm) and size are significant predictors of the household effects in all categories, but with opposite signs. The intra-household  $\gamma$ -weighted Theil index (lower panel of Table 5), correlates with log

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<sup>24</sup> Full results for the OLS regressions are presented in appendix B3.

<sup>25</sup> More precisely, the bias is the regression coefficient of  $v_j^k$  on  $\ln \bar{Y}_j$  ( $Cov(v_j^k, \ln \bar{Y}_j)/Var(\ln \bar{Y}_j)$ ), which is the sum of the regression coefficient of  $\eta_j^k$  on  $\ln \bar{Y}_j$  and that of  $T_j^k$  on  $\ln \bar{Y}_j$ .

household expenditure, but not significantly with log household size. Variations between consumption categories occur mainly between food-at-home, on the one side, and other categories, on the other. For the food-at-home Engel curve, the  $\eta_j^k$ 's are positively correlated with  $\ln \bar{Y}_j$  while the  $T_j^k$ 's are negatively correlated. On balance, the positive effect through the  $\eta_j^k$ 's is dominant. All other consumption categories also have offsetting components of the bias term, though here the sign pattern is reversed, with the  $\eta_j^k$ 's negatively correlated with  $\ln \bar{Y}_j$  while the  $T_j^k$ 's are correlated positively. For all categories of spending the dominant source of bias is the latent household effects in standard Engel curves.

Full regressions for the confounders are found in the Appendix B4. While in some cases the household effect was also correlated with the number of children, and the age, gender and education of the head, adding the extra covariates did not much reduce the (absolute value) of the coefficient on (log) total spending.

TABLE 5 ABOUT HERE

The sign of the bias is that of the product of the correlation between the omitted variable and the dependent variable, and of the correlation between the omitted variable and the explanatory variable of interest, here total expenditure. In the case of food-at-home, omitting the measure of inequality induces a bias downwards. This is explained by the coexistence of the negative correlation between the  $\boldsymbol{\gamma}$ -weighted Theil index, and total expenditure in these data (Table 5), and a positive correlation between the  $\boldsymbol{\gamma}$ -weighted Theil and food share in total household expenditure

(see Table B2.1).<sup>26</sup> The latter is to be expected since inequality implies that the preferences of the richest person in the household (likely to have a lower food share) are weighted more heavily than that of the poorest one (noting that a lower  $\gamma$ -weighted Theil implies higher inequality levels – see footnote xxvi).

Regarding the household fixed effect, the direction of the bias cannot be understood in an intuitive way, since it absorbs several unobserved household characteristics that could be correlated differently to budget shares. In the case of food-at-home, omitting the household effect induces an upward bias, while it generates a downward bias for all other categories of spending.

## 6. Conclusion

In light of inequalities and behavioral differences within households, traditional household-level empirical analysis of Engel curves no longer appears adequate. In fact, it may conceal considerable heterogeneity in parameters and resource allocation within households and this heterogeneity needs not be ignorable from the point of view of reliably estimating the household Engel curves.

This paper has postulated intra-household Engel curves that aggregate up to the widely-used Working-Leser form of the aggregate (household-level) Engel curve. By unpacking household Engel curves in this manner, the analysis identifies the necessary conditions for the standard household Engel curve parameter estimates to be unbiased in the presence of intra-household inequality and latent behavioral heterogeneity across households.

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<sup>26</sup> Since the  $\gamma$  coefficients are all found negative for food-at-home, the  $\gamma$ -weighted Theil index is negative for 1392 out of 1425 households. The largest absolute values are reached for the most unequal households. Hence, the negative correlation between the food-at-home  $\gamma$ -weighted Theil and total expenditure, reflects a positive correlation between this measure of the household total consumption and the standard Theil. For other consumption items, the  $\gamma$ -weighted Theil is found positive for virtually all households.

These ideas have been applied to a unique data set for Senegal in which household spending choices are identified at the sub-household level by exploiting the “cell” structure that is common in Senegalese households. This provides a rare window for understanding household Engel curves.

Two key lessons emerge. First, the data reveal large discrepancies between the standard household-level Engel curves and that obtained by aggregating up the intra-household Engel curves. For example, for the food-at-home share Engel curve, the coefficient on log total household spending is -0.11 using only household data but -0.28 when one estimates the Engel curve from the sub-household data and aggregates up to the household data. This is enough to reduce the income elasticity of demand for food (evaluated at mean food share) from 0.82 to 0.57. It is worth noting that this result holds when restricting attention to nuclear households. With a different empirical approach, the paper adds to this recent literature which, using experimental income variation to estimate income elasticity of demand for food, find that non-experimental data overestimate it.

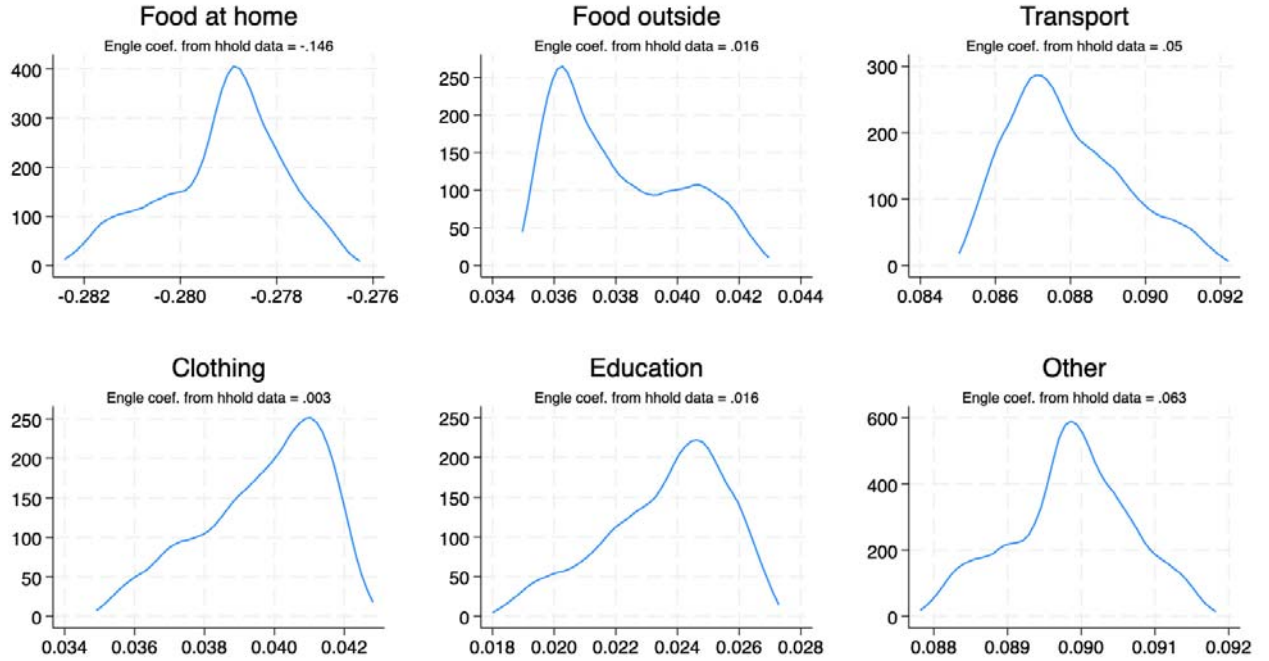
Second, the results show that, in the context of Senegal, the bulk of the gap between the two methods of estimating household Engel curves is accountable to the influence of household fixed effects on sub-household Engel curves. The channel of bias via intra-household inequality partially offsets that due to the latent household effects in standard Engel curves calibrated to only household-level data. Thus, only adding controls to reflect intra-household inequality may increase the bias in household-level Engel curves.

The paper demonstrates that estimating Engel coefficients from household data can be misleading. In particular, this should be a point of attention when using household level data to estimate intra-household resource shares on the basis of the estimation of assignable goods Engel

curves. It should be recognized that in some settings, the necessary orthogonality conditions for consistent estimations are unlikely to be met. Note however that in the case of Senegal, the estimations of Engle curves for clothing are not suffering from as large a bias as the one uncovered for other expenses. Although the paper does not provide evidence on how general this result could be, it supports the frequent selection of clothing as an assignable good.

While having individual consumption data would be ideal, such data are costly to collect and therefore very rare. The PSF data provide a useful alternative. In fact, this work shows that consumption data disaggregated at the cell level may address the issue: by factoring in a household latent effect and intra-household inequality, it yields more accurate estimations of Engel coefficients. Recovering such household fixed effects from panel data is unlikely to be helpful since no household remains exactly the same overtime (if only because the members are aging, impacting needs and preferences – see LaFave and Thomas, 2016). Beyond aging issues, in Senegal and more generally West African countries, households' structures change extremely quickly, definitely ruling out this possibility. An alternative solution is to use exogenous sources of income variations to instrument the total household income (see Almås et al 2023).

Figure 1: Kernel density functions for estimated Engel parameters for log total spending



Source: PSF data, authors' calculations. Epanechnikov kernel. At both ends of the distributions, the 1% most extreme estimates were dropped to make the density functions easier to view (30 observations).

Source: Pauvreté et Structure Familiale (PSF) survey data, authors' calculations.

Note: Epanechnikov kernel. The figure displays the distribution of cell-level estimated Engel parameters across households for each category of spending. On top of each graph, the value of the estimated Engel parameter from the standard household level specification is reported. At both ends of the distributions, the most extreme estimates (1%) have been removed to facilitate visualization of the density functions (30 observations).

**Table 1a: Summary statistics - household level**

Variable	N	Mean	Std. Dev.	Min	Max
Log(household exp. per cap.)	1,425	12.316	0.823	10.100	15.171
Food-at home (share in exp.)	1,425	0.647	0.198	0.045	0.999
Food-outside (share in exp.)	1,425	0.036	0.068	0.000	0.691
Transport (share in exp.)	1,425	0.066	0.103	0.000	0.848
Clothing (share in exp.)	1,425	0.071	0.075	0.000	0.889
Education (share in exp.)	1,425	0.026	0.060	0.000	0.825
Other goods (share in exp.)	1,425	0.154	0.128	0.000	0.912
Household's head is male	1,425	0.858	0.349	0.000	1.000
Head's age	1,425	51.682	13.828	20.000	93.000
Head's educ. 1 to 3 years	1,425	0.034	0.182	0.000	1.000
Head's educ. 4 to 5 years	1,425	0.102	0.302	0.000	1.000
Head's educ. junior school	1,425	0.075	0.264	0.000	1.000
Head's educ. $\geq$ High school	1,425	0.091	0.287	0.000	1.000
Head's educ. Koranic	1,425	0.302	0.459	0.000	1.000
Household size	1,425	9.060	5.167	2.000	44.000
Number of kids less than 5	1,425	1.429	1.423	0.000	10.000
Nb. males 5 to 14	1,425	1.201	1.295	0.000	9.000
Nb. males 15 to 24	1,425	0.880	1.185	0.000	10.000
Nb. males 25 to 59	1,425	1.239	1.010	0.000	8.000
Nb. males 60 and over	1,425	0.288	0.467	0.000	2.000
Nb. females 5 to 14	1,425	1.201	1.269	0.000	9.000
Nb. females 15 to 24	1,425	1.063	1.109	0.000	8.000
Nb. females 25 to 59	1,425	1.477	1.019	0.000	7.000
Nb. females 60 and over	1,425	0.282	0.514	0.000	4.000
Number of cells	1,425	2.790	1.194	2.000	12.000
Two cells: Head + SP	1,425	0.449	0.498	0.000	1.000
Two cells: Head + Oth	1,425	0.107	0.309	0.000	1.000
3+ cells: Head + n SP	1,425	0.098	0.297	0.000	1.000
3+ cells: Head + n SP + Oth	1,425	0.286	0.452	0.000	1.000
Other kinds	1,425	0.060	0.238	0.000	1.000
Dakar	1,425	0.326	0.469	0.000	1.000
Other urban	1,425	0.201	0.401	0.000	1.000
Rural	1,425	0.473	0.499	0.000	1.000
Diourbel	1,425	0.040	0.196	0.000	1.000
Fatick	1,425	0.081	0.274	0.000	1.000
Kaolack	1,425	0.068	0.252	0.000	1.000
Kolda	1,425	0.052	0.222	0.000	1.000
Louga	1,425	0.088	0.283	0.000	1.000
Matam	1,425	0.125	0.331	0.000	1.000
Saint-Louis	1,425	0.058	0.234	0.000	1.000
Tambacounda	1,425	0.048	0.213	0.000	1.000
Thies	1,425	0.068	0.252	0.000	1.000
Ziguinchor	1,425	0.039	0.193	0.000	1.000

Source: Pauvreté et Structure Familiale (PSF) survey data, sample of households with at least 2 cells, authors' calculations.

**Table 1b: Summary statistics - cell level**

Variable	Head					Spouses					Other				
	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
Log(Cell pc exp.)	1,425	12.543	0.939	9.029	16.417	1,482	12.110	0.818	9.681	15.461	1,049	12.154	0.802	9.850	16.049
Food-at home (share)	1,425	0.567	0.247	0.020	1.000	1,482	0.718	0.196	0.047	1.000	1,049	0.638	0.218	0.018	1.000
Food-outside (share)	1,425	0.054	0.113	0.000	0.767	1,482	0.016	0.047	0.000	0.514	1,049	0.038	0.091	0.000	0.777
Transport (share)	1,425	0.096	0.143	0.000	0.951	1,482	0.041	0.085	0.000	0.878	1,049	0.056	0.105	0.000	0.852
Clothing (share)	1,425	0.074	0.089	0.000	0.973	1,482	0.074	0.085	0.000	0.833	1,049	0.087	0.095	0.000	0.978
Education (share)	1,425	0.014	0.059	0.000	0.834	1,482	0.025	0.063	0.000	0.889	1,049	0.019	0.057	0.000	0.734
Other goods (share)	1,425	0.195	0.177	0.000	0.928	1,482	0.127	0.128	0.000	0.881	1,049	0.161	0.134	0.000	0.956
Cell's head is male	1,425	0.858	0.349	0.000	1.000	1,482	0.004	0.064	0.000	1.000	1,049	0.438	0.496	0.000	1.000
Cell head's age	1,425	51.682	13.828	20.000	93.000	1,482	39.322	12.722	15.000	96.000	1,049	34.864	13.479	13.000	98.000
Cell heads education:															
1-3 years	1,425	0.034	0.182	0.000	1.000	1,482	0.043	0.202	0.000	1.000	1,049	0.054	0.227	0.000	1.000
4 to 5 years	1,425	0.102	0.302	0.000	1.000	1,482	0.091	0.288	0.000	1.000	1,049	0.148	0.355	0.000	1.000
junior school	1,425	0.075	0.264	0.000	1.000	1,482	0.044	0.205	0.000	1.000	1,049	0.069	0.253	0.000	1.000
≥High school	1,425	0.091	0.287	0.000	1.000	1,482	0.036	0.187	0.000	1.000	1,049	0.055	0.229	0.000	1.000
Koranic	1,425	0.302	0.459	0.000	1.000	1,482	0.178	0.383	0.000	1.000	1,049	0.180	0.385	0.000	1.000
Cell size	1,425	2.231	1.889	1.000	15.000	1,482	4.169	2.110	1.000	12.000	1,049	3.377	1.758	1.000	14.000
Nb. Children ≤5	1,425	0.048	0.256	0.000	3.000	1,482	0.721	0.845	0.000	4.000	1,049	0.838	0.835	0.000	4.000
Nb. males 5 to 14	1,425	0.178	0.513	0.000	4.000	1,482	0.682	0.869	0.000	5.000	1,049	0.418	0.748	0.000	4.000
Nb. males 15 to 24	1,425	0.288	0.712	0.000	9.000	1,482	0.445	0.808	0.000	4.000	1,049	0.173	0.485	0.000	5.000
Nb. males 25 to 59	1,425	0.792	0.700	0.000	4.000	1,482	0.123	0.436	0.000	5.000	1,049	0.429	0.538	0.000	4.000
Nb. males 60+	1,425	0.261	0.446	0.000	2.000	1,482	0.005	0.069	0.000	1.000	1,049	0.030	0.169	0.000	1.000
Nb. females 5 to 14	1,425	0.145	0.463	0.000	4.000	1,482	0.724	0.877	0.000	5.000	1,049	0.406	0.702	0.000	4.000
Nb. females 15 to 24	1,425	0.168	0.481	0.000	4.000	1,482	0.516	0.713	0.000	4.000	1,049	0.482	0.553	0.000	3.000
Nb. females 25 to 59	1,425	0.196	0.502	0.000	5.000	1,482	0.848	0.501	0.000	4.000	1,049	0.536	0.527	0.000	2.000
Nb. females 60+	1,425	0.162	0.380	0.000	2.000	1,482	0.077	0.274	0.000	2.000	1,049	0.054	0.243	0.000	2.000

Source: Pauvreté et Structure Familiale (PSF) survey, sample of households with at least 2 cells, authors' calculations

**Table 2: Intrahousehold Engel Curve fixed effects estimates**

	Food at home	Food outside	Transport	Clothing	Education	Other goods / services
$\gamma$ for head's cell	-0.276 (0.006)	0.039 (0.004)	0.093 (0.005)	0.034 (0.004)	0.017 (0.003)	0.092 (0.006)
$\gamma$ for spouses' cells	-0.280 (0.007)	0.035 (0.005)	0.086 (0.006)	0.043 (0.005)	0.027 (0.004)	0.089 (0.007)
$\gamma$ for other cells	-0.283 (0.008)	0.043 (0.005)	0.085 (0.006)	0.040 (0.005)	0.028 (0.004)	0.087 (0.008)
t stat. spouses vs. head diff.	-0.660	-1.100	-1.577	2.169	3.289	-0.497
t stat. other vs. head diff.	-1.036	0.776	-1.486	1.183	3.091	-0.678
$\Gamma$ from hhold level regression	-0.114 (0.007)	0.005 (0.003)	0.057 (0.004)	0.000 (0.003)	0.005 (0.002)	0.047 (0.005)
$\Gamma$ from IEC aggregation	-0.279 (0.006)	0.038 (0.004)	0.088 (0.005)	0.040 (0.004)	0.024 (0.003)	0.090 (0.006)
t stat. hhold vs cell reg. diff.	18.917	-6.827	-5.067	-7.596	-4.954	-5.639
Chi2 Hausman test for f.e. (p-value)	911.288 (0.000)	149.917 (0.000)	194.893 (0.000)	199.064 (0.000)	159.591 (0.000)	177.092 (0.000)
Number of households	1,425	1,425	1,425	1,425	1,425	1,425
Number of cells	3,956	3,956	3,956	3,956	3,956	3,956

Source: Pauvreté et Structure Familiale (PSF) survey, sample of households with at least 2 cells, authors' calculations.

Note: Standard errors are between parentheses. In the top part of the table, the first three lines display the estimated coefficient of cell's log expenditure in cell level Engel curves ( $\gamma$ ), for each cell type (equation (1)). Cell characteristics are cell head's sex, age, age squared and education; log cell size, cell composition by age and gender. In these regressions, household fixed effects are removed. The next two lines display the values of the student t-statistic used to test for equality between the cell  $\gamma$ -coefficient of spouses and the cell  $\gamma$ -coefficient of the head, on the one hand, and between the cell  $\gamma$ -coefficient of other cells and the cell  $\gamma$ -coefficient of the head, on the other. In the middle part, the first line displays the value of the log household per capita expenditure  $\Gamma$ -coefficient in a household level Engel curve estimation (equation (9)), and the next line the estimated value of the consistently aggregated  $\Gamma$ -coefficient (from equations (5) and (10)). The next line reports the value of the student t-statistic used to test for equality between the two  $\Gamma$ -coefficient estimates. Household level control variables are household head's sex, age, age squared and education; log household size, household composition by age and gender; regional and urban/rural dummies. The first line at the bottom of the table shows the chi-squared statistic value for the Hausman test of fixed versus random effects in cell-level regressions. Full results in appendix B1.

**Table 3: Impact on the Engel coefficient of the two confounders**

	Food at home	Food outside	Transport	Clothing	Education	Other goods/services
No extra covariate	-0.114 (0.007)	0.005 (0.003)	0.057 (0.004)	0.000 (0.003)	0.005 (0.002)	0.047 (0.005)
(1) $\gamma$ -weighted Theil only	-0.093 (0.006)	0.003 (0.003)	0.047 (0.004)	-0.007 (0.003)	0.005 (0.003)	0.043 (0.005)
(2) Fixed effect only	-0.299 (0.002)	0.036 (0.001)	0.100 (0.002)	0.047 (0.001)	0.030 (0.001)	0.095 (0.002)
(1) + (2)	-0.284 (0.002)	0.035 (0.001)	0.094 (0.002)	0.043 (0.001)	0.030 (0.001)	0.093 (0.002)
Household structure & mean cell charac. as controls	-0.112 (0.007)	0.007 (0.003)	0.056 (0.004)	0.000 (0.003)	0.003 (0.003)	0.046 (0.005)
With district fixed effects	-0.122 (0.007)	0.007 (0.003)	0.055 (0.005)	0.004 (0.004)	0.007 (0.003)	0.050 (0.006)
Consistently aggregated from IEC	-0.279 (0.006)	0.038 (0.004)	0.088 (0.005)	0.040 (0.004)	0.024 (0.003)	0.090 (0.006)

Source: Pauvreté et Structure Familiale (PSF) survey, sample of households with at least 2 cells, authors' calculations.

Note: Standard errors are between parentheses. The table shows the values of the log household per capita expenditure coefficient in a household level Engel curve estimation (equation (9)). The first line shows the results obtained when the expenditure share for a given class of items is regressed on log household expenditure, with controls for commonly observed household characteristics (household head's sex, age, age squared and education; log household size, household composition by age and gender; regional and urban/rural dummies - as in table 2,  $\Gamma$  from hhold level regression). Lines 2 to 4 show the values of the coefficient when the  $\gamma$ -weighted Theil is added to the regressors (line 2), or the fixed effect (line 3) or both (line 4). Other control variables in these regressions are the same as in the first line. Line 5 displays the results when, on top of commonly observed household characteristics, controls built from cell level data are added: number of cells, mean cell characteristics (head's sex, age and education; cell composition by age and gender), and household structure composition (4 dummies variables, with the reference being nuclear households with two cells, those of the head and its spouse. Other categories are: other kinds of 2-cells households; 'nuclear' polygamous households, that is households with more than two cells, that of the head and those of its spouses; other polygamous households, that is households with more than three cells, with at least one of the cells not headed by a spouse of the head (head's cell excluded) ; and other types of households). Line 6 shows the estimated coefficients when district fixed effects are added (all the regional and urbanization dummies are dropped). The last line displays the values obtained when the coefficient is built by consistently aggregating estimates of the cell level Engel curves following equation (10) (same as table 2,  $\Gamma$  from IEC aggregation). In cell level regressions, control variables are cell head's sex, age and age squared; education; log cell size, cell composition by age and gender. In these regressions household fixed effects are removed. Full results in appendix B2, tables B2.1, B2.2, B2.3 and B2.4.

**Table 4: Intrahousehold Engel Curve OLS estimates**

	Food at home	Food outside	Transport	Clothing	Education	Other goods / services
$\gamma$ for head's cell	-0.142 (0.006)	0.023 (0.003)	0.060 (0.003)	0.000 (0.003)	0.002 (0.002)	0.056 (0.004)
$\gamma$ for spouses' cells	-0.077 (0.007)	0.007 (0.003)	0.028 (0.004)	-0.000 (0.003)	0.013 (0.002)	0.030 (0.005)
$\gamma$ for other cells	-0.108 (0.008)	0.019 (0.004)	0.037 (0.005)	-0.002 (0.004)	0.011 (0.002)	0.044 (0.006)
t stat. spouses vs head diff.	7.100	-3.742	-6.072	-0.170	3.918	-3.971
t stat. other vs head diff.	3.320	-0.911	-3.956	-0.518	2.900	-1.665
$\Gamma$ from hhold level regression	-0.114 (0.007)	0.005 (0.003)	0.057 (0.004)	0.000 (0.003)	0.005 (0.002)	0.047 (0.005)
$\Gamma$ from IEC aggregation	-0.105 (0.004)	0.015 (0.002)	0.040 (0.002)	-0.000 (0.002)	0.009 (0.001)	0.041 (0.003)
t stat. hh vs cell reg. diff.	-1.116	-2.793	3.391	0.213	-1.431	0.872
Nb of households	1,425	1,425	1,425	1,425	1,425	1,425
Number of cells	3,956	3,956	3,956	3,956	3,956	3,956

Source: Pauvreté et Structure Familiale (PSF) survey, sample of households with at least 2 cells, authors' calculations.

Note: Ordinary Least Square estimates, standard errors are between parentheses. In the top part of the table, the first three lines display the estimated coefficient of cell's log expenditure in cell level Engel curves ( $\gamma$ ), for each cell type (equation (1)). Cell characteristics are cell head's sex, age, age squared and education, log cell size, cell composition by age and gender. The next two lines display the values of the student t-statistic used to test for equality between the cell  $\gamma$ -coefficient of spouses and the cell  $\gamma$ -coefficient of the head, on the one hand, and between the cell  $\gamma$ -coefficient of other cells and the cell  $\gamma$ -coefficient of the head, on the other. In the bottom part, the first line displays the value of the log household expenditure  $\Gamma$ -coefficient in a household level Engel curve estimation (equation (9)), and the next line the estimated value of the consistently aggregated  $\Gamma$ -coefficient (from equations (5) and (10)). The next line reports the value of the student t-statistic used to test for equality between the two  $\Gamma$ -coefficient estimates. Household level control variables are household head's sex, age, age squared and education; log household size, household composition by age and gender; regional and urban/rural dummies.

**Table 5: Regressions for the two confounders**

	Food at home	Food outside	Transport	Clothing	Education	Other goods/services
<b>Household effects in cell Engel curves</b>						
Log(HH exp.)	0.1812 (0.0062)	-0.0318 (0.0028)	-0.0399 (0.0036)	-0.0428 (0.0028)	-0.0183 (0.0017)	-0.0482 (0.0047)
Log(HH size)	-0.3017 (0.0184)	0.0234 (0.0083)	0.0784 (0.0105)	0.0631 (0.0082)	0.0270 (0.0050)	0.1098 (0.0139)
$R^2$	0.5805	0.1648	0.2513	0.2915	0.1570	0.2281
<b>Intra-household Theil indices (<math>\gamma</math>-weighted)</b>						
Log(HH exp.)	-0.0138 (0.0015)	0.0020 (0.0002)	0.0047 (0.0005)	0.0016 (0.0002)	0.0008 (0.0001)	0.0046 (0.0005)
Log(HH size)	0.0021 (0.0043)	-0.0003 (0.0006)	-0.0006 (0.0015)	-0.0003 (0.0005)	-0.0002 (0.0003)	-0.0006 (0.0015)
$R^2$	0.0962	0.0990	0.0972	0.0932	0.0945	0.0965
Nb of observations	1,425	1,425	1,425	1,425	1,425	1,425.

Source: Pauvreté et Structure Familiale (PSF) survey, sample of households with at least 2 cells, authors' calculations.

Note: Ordinary Least Squares estimates, standard errors between parentheses. Top panel shows the coefficients of the regression of the household fixed effects on log(total household expenditure) and log (household size), while the bottom panel does the same for the  $\gamma$ -weighted Theil. Other covariates in household level regressions are urbanization and regional dummies, together with age, age<sup>2</sup>, sex and education of household's head; household composition by age and gender. Weighted Theil and household fixed effects are estimated from cell level regressions with 3959 observations. Covariates in these regressions are: log(total cell private expenditure) ; log(cell size) ; age, age<sup>2</sup> , sex and education of cell's head ; cell composition by age and gender.

## References

- Almås, Ingvild, Johannes Haushofer and Anders Kjelsrud. 2023. "The Income Elasticity for Nutrition: Evidence from Unconditional Cash Transfers in Kenya." NBER WP 25711, National Bureau of Economic Research, Cambridge, MA.
- Arnould, Eric, Craig Thompson. 2005. "Consumer Culture Theory (CCT): Twenty Years of Research." *Journal of Consumer Research* 31(4): 868–882.
- Attanasio, Orazio P., and Valérie Lechene. 2010. "Conditional Cash Transfers, Women and the Demand for Food." Working Paper no. 10/17, Inst. Fiscal Studies, London.
- \_\_\_\_\_, and \_\_\_\_\_. 2014. "Efficient Responses to Targeted Cash Transfers." *Journal of Political Economy* 122(1): 178-222.
- Bargain, Olivier, Guy Lacroix, and Luca Tiberti. 2018. "Validating the Collective Model of the Household using Direct Evidence on Sharing." Partnership for Economic Policy Working Paper No. 2018-06, Nairobi.
- Bellemare, M. F., Kandpal, E., & Thomas, K. 2024. "Income and the Demand for Food among the Poor." Center for Global Development Working Paper 701, London and Washington, DC.
- Bourguignon, François. 1979. "Decomposable Income Inequality Measures." *Econometrica* 47: 901-920.
- Calvi, R., J. Penglase, D. Tommasi and A. Wolf. 2023. "The More the Poorer? Resource Sharing and Scale Economies in Large Families", *Journal of Development Economics* 160 (January): 102986.
- De Vreyer, Philippe, and Sylvie Lambert. 2021. "Inequality, poverty and the intra-household allocation of consumption in Senegal." *World Bank Economic Review* 35(2): 414-435.
- De Vreyer, Philippe, Sylvie Lambert, Abba Safir and Momar B. Sylla. 2008. "Pauvreté et Structure Familiale, Pourquoi une Nouvelle Enquête ?", *Stateco* 102, 261-275.
- Dunbar, Geoffrey R., Arthur Lewbel and Krishna Pendakur. 2013. "Children's Resources in Collective Households: Identification, Estimation, and an Application to Child Poverty in Malawi." *American Economic Review* 103(1): 438-71.
- Engel, Ernst. 1857. "Die Productions- und Consumtionsverhältnisse des Königreichs Sachsen." *Zeitschrift des statistischen Bureaus des Königlich Sächsischen Ministerium des Inneren* 8–9: 28–29.
- Findlay, Jeanette, and Robert E. Wright. 1996. "Gender, Poverty and the Intra-Household Distribution of Resources." *Review of Income and Wealth* 42(3): 335-351.

- Haddad, Lawrence, and Ravi Kanbur. 1990. "How Serious is the Neglect of Intra-Household Inequality?" *Economic Journal* 100: 866-881.
- Houthakker, H. S. 1957. "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law." *Econometrica* 25:532-551.
- Kanbur, Ravi, and Lawrence Haddad. 1994. "Are Better off Households More Unequal or Less Unequal?" *Oxford Economic Papers* 46(3): 445-458.
- LaFave, D. and D. Thomas. 2016. "Farms, Families, and Markets: New Evidence on Completeness of Markets in Agricultural Settings," *Econometrica*, 84:1917-1960.
- Lechene, Valérie, Krishna Pendakur, and Alex Wolf. 2022. "Ordinary least squares estimation of the intrahousehold distribution of expenditure." *Journal of Political Economy* 130.3 : 681-731.
- Leser, C. E. V. 1963. "Forms of Engel Functions." *Econometrica* 31: 694- 703.
- Lise, Jeremy, and Shannon Seitz. 2011. "Consumption Inequality and Intra-household Allocations." *Review of Economic Studies* 78(1): 328-355.
- Muellbauer, John. 1975. "Aggregation, Income Distribution and Consumer Demand." *Review of Economic Studies* 42(4): 525-543.
- Phlips, Louis, 1983. *Applied Consumption Analysis*. Amsterdam: North-Holland.
- Solomon, Michael, Gary Bamossy, Soren Askegaard, and Margaret Hogg. 2006. *Consumer Behavior: A European Perspective*, Third Edition, Harlow, Essex: Prentice Hall.
- Theil, Henri. 1967. *Economics and Information Theory*, Amsterdam: North-Holland.
- Working, H. 1943. "Statistical Laws of Family Expenditures." *Journal of the American Statistical Association* 38: 43-56.