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Thresholds for Time and Income Poverty in Households: Evidence from Joint Distributions

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Thresholds for Time and Income Poverty in Households: Evidence from Joint Distributions

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Abstract

Time poverty is a key yet conceptually contested dimension of household living standards. Both univariate and bivariate measures remain debated because there is no clear consensus on how to define and quantify socially necessary unpaid work, the time that money cannot substitute for, across household types and income levels. Existing approaches typically adjust monetary poverty lines for unpaid work responsibilities or rely on average unpaid work time, while assuming a fixed substitutability between time and money. Such measures fail to capture the joint constraints that shape household living standards. Using household-level data from the 2017 and 2019 Panel Study of Income Dynamics (PSID), the analysis supports setting 60 percent of the median as the threshold for socially necessary unpaid work in single-adult households without children and applying equivalence scales for other household types. The bivariate relative poverty line (BRPL) framework further defines nonlinear bundles of unpaid household work and food expenditure that mark the threshold for living above the poverty line. The results show that 10.1 percent of one- and two-adult households fall below the BRPL despite not being poor according to univariate measures, underscoring the importance of jointly considering time and money in assessing household living standards and poverty.

Keywords: Bivariate relative poverty line, time and income poverty, unpaid work, time poverty, living standards

JEL classification: C46, D13, I3, J22

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1. Introduction

Time poverty is typically defined as a stand-alone measure on the individual (rather than household) level and is often specified either in absolute or relative terms based on the amount of time devoted to leisure, discretionary time, and personal care (Goodin et al. 2005; Bardasi and Wodon, 2010; Aloè 2023, Dorn et al. 2024). However, like income poverty, time poverty can also be defined on the household level, and this poses greater conceptual difficulties. In this context, the time devoted to unpaid work is relevant, especially since such work directly affects household living standards, including the time spent caring for young children or adults requiring assistance. Income poverty and time poverty can, in principle, be measured separately, and the very concept of necessary thresholds implies that time and income are not perfectly substitutable. However, income and time are likely substitutable to some extent within a certain range. As previous researchers have noted, "more rigor must be applied to measuring the underlying time of interest and the choice of thresholds against which that sum of time is judged" (Williams et al., 2016:279).

Here, a brief review of research on household time poverty sets the stage for an empirical exploration of two closely related issues—the socially necessary threshold of unpaid work for which monetary expenditures cannot provide adequate substitutes and the conceptualization of bundles of unpaid work time and expenditures above this threshold. Most empirical estimates of time and income poverty, which are often based on Vickery (1977), adjust the income poverty line by adding a replacement cost wage to represent deficits in unpaid work time (Vickery, 1977; Zacharias et al., 2012; Ilkkaracan et al., 2021; Aloé, 2023; Rodgers, 2023). While this approach has merit for analyzing households close to or below the poverty line who work long hours, it does not guide us toward estimates of the bundles of time for unpaid work and money income that place a household above or below a joint time and income poverty line. In this analysis, we use a data-driven approach to estimate the bundles for unpaid work time and expenditure to avoid falling into poverty.

The contribution of this paper is twofold. First, we provide new empirical evidence for the United States on the socially necessary unpaid work time that monetary resources cannot substitute for. We identify empirically grounded thresholds and show that the arbitrarily defined or mean-based thresholds commonly used in the literature can misclassify households' unpaid work-time deprivation. Second, using the bivariate relative poverty line (BRPL) framework developed by Dorn et al. (2024), we estimate expenditure and unpaid work time bundles directly from the joint empirical distribution. Unlike CES-based approaches such as Merz and Rathjen (2014), which rely on subjective well-being to estimate utility functions and explicitly model substitutability through a parameter quantifying trade-offs between time and income, the BRPL derives insights on these trade-

offs from the data. Without relying explicitly on utility-based assumptions, this approach infers how constraints in one dimension co-occur with constraints in the other, without imposing a fixed substitution rate between time and money across households. In doing so, it provides an empirical response to Sen's (1976, 1987) critique of the utility approach by grounding poverty assessment in the actual distribution of resources rather than in individual utility. The BRPL identifies minimum bundles of unpaid work time and expenditure that lie above the non-substitutable univariate thresholds and allow households to meet basic living standards. Using the joint distribution preserves the original units of time and expenditure without collapsing them into a single metric and captures the nonlinear, context-specific patterns that characterize real-world living conditions.

Using household data from the 2017 and 2019 Panel Study of Income Dynamics (PSID), we estimate thresholds for socially necessary unpaid working time for both one- and two-adult households. Our findings indicate that, conditional on household structure, 60% of the median provide a solid estimate for the minimum level of non-substitutable housework. For one-adult households without children, this corresponds to roughly six hours per week. For two-adult households, however, direct estimates are less reliable because higher values likely include joint measurements of household work and shared activities, such as cooking together. To compare household types fairly, we recommend using the one-adult threshold as a baseline and applying equivalence scales to estimate socially necessary unpaid work for larger households. Our results indicate that establishing socially necessary minima for unpaid childcare work is particularly challenging. Childcare time lacks a clear pattern, likely due to varying interpretations of direct and supervisory care hours as well as the unmeasured contributions of unpaid childcare by family members and friends. The analysis, therefore, focuses on unpaid household work and food expenditure. In the second part of the analysis, the study applies the BRPL approach to estimate the bundles of expenditure and unpaid work time required to live above the poverty threshold line. The results indicate that these time–money bundles are nonlinear and that 10.1 percent of households fall below the BRPL while remaining above both univariate poverty thresholds, rendering them invisible to conventional poverty assessments.

The paper is organized as follows: Section 2 reviews the conceptual foundations of measuring time poverty, with a focus on the socially necessary threshold for unpaid household and childcare. Section 3 presents the pooled 2017–2019 PSID data to analyze expenditures and time use across different household types. Section 4 empirically estimates minimum thresholds for unpaid housework and childcare and evaluates statistical measures (mean, median, mode) by household structure. Section 5 introduces and applies the BRPL and defines bundles of time and money to define the bivariate poverty threshold line. Section 6 summarizes the conclusions.

2. Time Poverty, Money, and Substitutability

Claire Vickery established the analytical framework used in most household-level measures of time poverty, which includes attention to unpaid work (Vickery, 1977; Zacharias et al., 2012, 2019). Her approach was motivated by the concern that a certain amount of unpaid work time was necessary to convert money income into actual consumption. The U.S. poverty lines devised in the 1960s, which have been based on estimates of the cost of a "low-income budget" for food items such as rice and beans, which require considerable preparation time, disregarded this constraint. Vickery (1977) concluded that U.S. poverty lines were, as a result, set too low; households with little time for unpaid work, such as single mothers of young children employed full-time, need more income to avoid poverty effectively. Subsequent research has shown that Vickery's analysis provides a useful way to factor "time to do the chores" into measures of poverty in the U.S. (Douthitt, 2000). The time constraints associated with virtually mandatory employment make life especially difficult for single parents in the U.S. (Albelda, 2011).

Vickery's analytical framework includes a minimum money income threshold, E_0, that prevents households from falling into poverty only if they also have sufficient capacity to devote unpaid work time (U_1) on the household level, as indicated by point A in Figure 1. The total time available to a single adult household for unpaid work is U_t, determined by subtracting hours of employment plus the minimum quantity of time necessary for leisure and personal care from the total time available. Moreover, all households require a minimum amount of time, U_0, that they must devote to unpaid work. At U_0, they require a minimum income of at least E_1 to escape poverty, as indicated by point B in Figure 1, where the difference between E_1 and E_0 compensates for the difference between U_0 and U_1.[2]

We set aside the issue of minimum time for leisure and personal care, which must be specified on the individual level. Instead, we focus on the relationship between unpaid household work and expenditures on the household level. In Vickery's model, unpaid labor time can help the household reach the standard of living defined by the income poverty line, but beyond that point, it has no effect. Time in excess of U_1 does not lower the poverty line, E_0. Interestingly, this asymmetry imposed by Vickery is inconsistent with current measures of extended income, which assume that every additional hour of unpaid work contributes equally to household consumption and living standards. The bold black line between E_1 and U_1 indicates the poverty threshold line in

[2] See Dorn (2025) for a more exhaustive theoretical discussion on measuring time and income poverty.

the bivariate space of time for unpaid work and income. Households located above E_1 but below U_0 are unidimensional time-poor, while those below E_0 but above U_1 are unidimensional income-poor.

This inconsistency between the implications of studying time and income poverty in theory and the practice of calculating extended income in empirical research highlights the importance of substitutability. Unpaid work beyond U_1 probably does not contribute essentially to avoiding deprivation, and unpaid work can never fully compensate for extremely low money income. Obviously, a person cannot cook without a stove or clean the house if they live on the street. On the other hand, unpaid work can contribute to consumption and living standards within a certain range and to a certain extent. For instance, providing unpaid childcare often saves households money they would otherwise spend on care services. Similarly, purchasing food away from home reduces cooking time. While the extent of substitutability between time and money is not unbounded, it affects household consumption and living standards in ways governed by the exact dynamics of substitution that operate within these boundaries.

Therefore, the substitution line as sketched in Figure 1 considers thresholds that limit substitutability and also identifies an area – between points A and B – where substitutability is possible. This substitutability is represented by a downward-sloping curve that is convex to the origin, indicating an isoquant or indifference curve that reflects diminishing marginal rates of utility for both inputs. Alternatively, substitution could be shown by a straight line, creating a region of linear substitutability. This region can be constrained by thresholds of socially necessary money income and unpaid work time, as in Figure 1 (indicated by E_1 and U_1), or it can extend to a range between U_t and E_t, as in extended income measures.

Empirical applications of Vickery's model typically measure time and income poverty by linearly adjusting the monetary poverty threshold when households lack sufficient time for unpaid work (Vickery, 1977; Zacharias et al., 2012; Ilkkaracan et al., 2021; Aloé, 2023; Rodgers, 2023). In these methods, assuming the household is at the income poverty line and falls short of the necessary unpaid work hours, the focus shifts to how much extra money would be needed to purchase market substitutes that compensate for this shortfall. Although this produces an adjusted monetary poverty line, it does not address the broader issue of determining the combination of unpaid work time and financial resources required for a household to escape poverty. This bundle of time for unpaid work and money for expenditure is likely non-linear, reflecting that the marginal contribution of additional time or money—and how much one can substitute for the other—varies once minimum levels for each are reached.

For simplicity, consider a unitary household that combines both, market income and unpaid labor, and consumes all income received. In Figure 1, the vertical axis shows consumption measured in terms of money

expenditures. The horizontal axis shows time spent on unpaid work. Leisure time is assumed to be given externally, and any productive time not used for unpaid work is dedicated to paid work. The hypothetical minimum thresholds for money income and unpaid work time are E_0 and U_0, respectively.

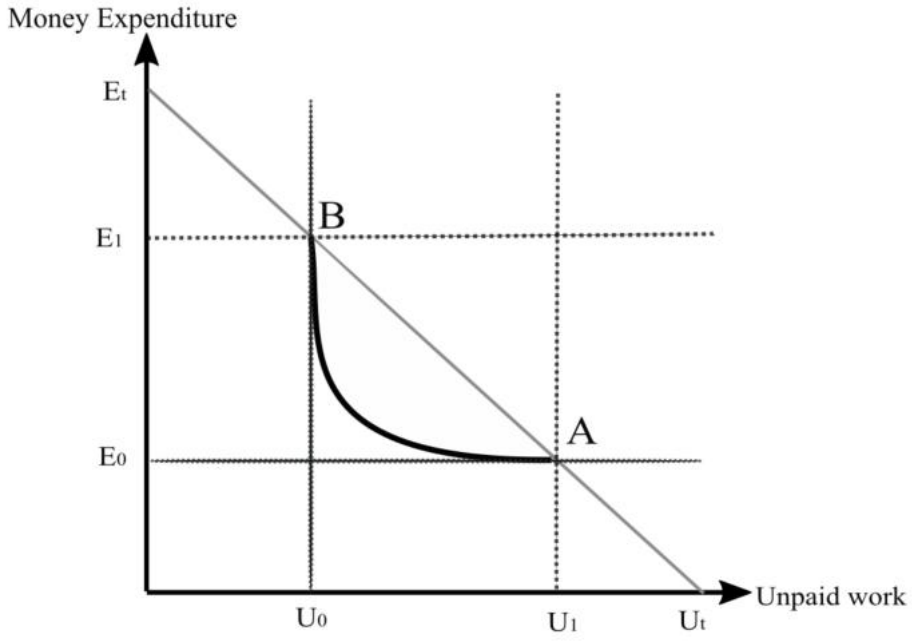

Figure 1: Possible Shapes of Tradeoffs between Earnings and Unpaid Work Time[3][4]

A household below both thresholds (the square defined by E_0 and U_0) is doubly constrained, lacking sufficient money to substitute for unpaid work time or sufficient unpaid work time to substitute for money. In this region of Figure 1, time and money are complements rather than substitutes, though it is unclear how households can improve their position, and, in the absence of assistance, they may well be stuck. A household below the money threshold (E_0) but above the unpaid work time threshold (U_0) gains no improvement by increasing unpaid work time and must prioritize earning more money. Conversely, a household below the unpaid work time threshold (U_0) but above the money threshold (E_0) gains no improvement by earning money, only by increasing unpaid work time. Put in everyday language, a household with an inadequate money income may not be able to purchase the childcare needed to engage in paid employment. Likewise, a household with inadequate time for unpaid work may be unable to prepare nutritious meals or adequately care for and supervise children or

[3] An alternative approach models the time–money trade-off as a concave-to-the-origin frontier derived from a marginal productivity function, where concavity reflects diminishing marginal productivity of each input. While this can describe the valuation of unpaid work across the income distribution, it is not well-suited to defining poverty thresholds. Since this paper constructs a bivariate poverty line above socially necessary minima of money and time, we do not pursue the concave formulation further. Still, the very notion of socially necessary unpaid work implies that it contributes to household consumption and living standards, and is thus subject to diminishing marginal productivity, much like a production possibilities frontier.

[4] The author created all Figure 1 using Inkscape (version 1.4.3.).

other dependents. The area of potential tradeoffs between money and time lies above both, the money as well as the time threshold.

In this area, choices are constrained by the wage rate and the cost of purchasing substitutes for unpaid work. E_t represents the money expenditures available to the household if all time is devoted to paid work, and no time to unpaid work, ignoring possible thresholds. U_t represents the maximum amount of unpaid work time if no time is spent on market work and all consumption is produced by unpaid work, again ignoring possible thresholds. A possible linear tradeoff is depicted between money and unpaid work, connecting E_t and U_t. The wage, a measure of opportunity cost or replacement cost, represents the slope of this line. The higher the wage, the higher E_t will be, and the steeper the negative slope of the line connecting E_t and U_t. Assuming linearity and taking the specified thresholds into account, the range of efficient feasible choices, if trade-offs are constant, lies on the portion of the grey line between B and A in Figure 1.

The level of thresholds determines the range of possible substitutability between time and money, and their very existence challenges the assumption of perfect substitutability. However, the shape of the line connecting A and B is also at issue. If the axes in Figure 1 were interpreted as alternative inputs into the production of the same service, we would expect the line connecting B and A to be convex to the origin, rather than linear, reflecting an isoquant (or an indifference curve) as indicated by the bold black curve. In other words, at a high level of money income, the decision-maker would be willing to sacrifice a relatively large amount of money for a small additional amount of time. Alternatively, we could argue that the marginal productivity or merit of additional unpaid work hours is exceptionally high when they are closely above the threshold.

Both Vickery's empirical application and later developments, such as the Levy Institute Measure of Time and Income Poverty (LIMTIP), focus solely on households at the income poverty line, valuing unpaid work time lost due to long working hours (Vickery, 1977; Zacharias et al., 2012; Aloè, 2023; Rodgers, 2023). The question then becomes: How much extra money would be needed to buy market substitutes for every missing hour of unpaid work? This creates a constant trade-off rate between time and money, representing the adjusted income poverty line, as shown by the straight gray line between points A and B in Figure 1. In this case, each missing hour of unpaid work is valued at the hourly wage necessary to hire a substitute, indicating a consistent trade-off between time and money. These approaches acknowledge thresholds, but assume linear substitution between points A and B. Therefore, they do not represent a general poverty frontier but rather an adjustment to the income poverty line for a specific group of time-poor households. In this context, the replacement cost method helps estimate the budget required to compensate for unpaid work that remains unmet.

In contrast, a general bivariate time and income poverty threshold aims to determine the minimum

necessary bundle of unpaid work hours and monetary income needed for a household to be above both time and income poverty. This threshold applies across the entire joint distribution of time and money, without focusing only on households at the income poverty line. It acknowledges that the trade-off between time and money is likely nonlinear because the marginal contribution of each input—and the scope for substitution—varies depending on how far a household is from the respective minimums.

After introducing the data in Section 3, Section 4 builds on this distinction and first evaluates the minimum socially necessary unpaid work time, which is often set arbitrarily and requires a clear conceptual basis. In the second part, we estimate the shape of the poverty threshold above the socially necessary minima of unpaid work and monetary expenditure. We use the bivariate relative poverty line approach to determine the full set of unpaid work and expenditure poverty bundles for the entire population, based on household composition. By applying an empirical method to the joint distribution of unpaid work time and income, we can directly calculate the combinations of time and money needed to stay above the poverty line, removing the need to assign a monetary value to time.

3. Data

We use pooled data from the 2017 and 2019 Panel Study of Income Dynamics (PSID), which is one of the few U.S. data sets that includes data on both unpaid housework and childcare (including supervisory time) for up to two adults per household, as well as household-level expenditures. We focus exclusively on one- and two-adult households without other cohabiting adults, but include households with any number of children. Our dataset comprises all adults aged 18 to 65 who live in households with no more than one adult and report at least one hour of unpaid work in a typical week. Our analysis assumes that everyone does some unpaid work, even if it is only managing others.[5]

In our analysis, we focus on the components of unpaid work and household expenditure that are interchangeable. While a significant portion of household expenses—such as rent, utilities, and transportation—are not interchangeable, the PSID provides data on services that can be substituted, like food expenditures and family care. For food expenditure, we include the value of food stamps, which are not accounted for in the food expenditure variable. This value is particularly interesting, as recipients are restricted to buying staple foods, which in turn require more time to prepare into meals ready to eat. Total food expenditure ranges from 13 percent (first quartile) to 25.7 percent (third quartile), with a median of 18.5 percent and an average of 20.3 percent of total annual household expenditure. To estimate the necessary money and unpaid work bundles, we

[5] All empirical analyses are conducted using the statistical weights provided by the PSID.

restrict unpaid work to unpaid household services and shopping, presumably including a significant share of errands, cooking, and food expenditure (including food at home, food away from home, and delivered food). We cannot further distinguish unpaid household services. Additionally, we analyze expenditures on childcare and time spent on childcare. 32.4 percent of one-adult with children and 35.8 percent of two-adult households with children report having childcare costs.

The PSID asks respondents how much time they devote to unpaid housework in a typical week. Estimates for unpaid housework, such as cleaning and cooking, are roughly consistent with measures from the American Time Use Survey (ATUS) (Insolera et al., 2019; Gautham & Folbre, 2024). However, estimates for childcare significantly exceed measures of active childcare from the ATUS in corresponding years. Still, they are roughly consistent with ATUS measures that include what the ATUS terms a secondary activity, having a child under the age of 13 "in your care" while engaged in another activity (Insolera et al., 2019). This can be construed as a measure of supervisory care. Table 1 reports summary statistics for our main variables of interest.

Table 1: Mean values and standard deviation for time and money expenditures

Category	Single-adult households	Two-adult households
Unpaid household work (per week)	9.8h (8.7)	24.4h (15.4)
Shopping (per week)	3.4h (4.2)	7.5h (6.5)
Unpaid household work and shopping (per week)	13.2h (10.7)	31.9h (18.5)
Unpaid childcare (per week)	12h (33.3)	42.2h (64.6)
Total household expenditure on food, including food stamps value (per year)	$6,349 (4,891)	$11,378 (6,124)
Household expenditure on childcare (per year)	$3,895 (4,096)	$6,838 (6,671)

Note: Standard deviations are in parentheses. The dataset comprises adults aged 18-65 in one- and two-adult households. Household expenditures are reported in $ per year, and unpaid work variables are reported in hours per week. Household expenditures on childcare are reported only for households with positive childcare expenditures.

Our dataset shows that a significant proportion of adults with children report more than 112 hours of unpaid childcare per week, indicating supervisory care. In 15% of two-adult households with children, at least one adult reports over 112 hours of unpaid childcare, while in 12.8% of such households, at least one adult

reports 168 hours of unpaid childcare. In one-adult households with children, 21.8% of households report more than 112 hours, and 18.2% report 168 hours of unpaid childcare. These figures reflect a potential issue in how respondents interpret the definition of unpaid childcare, be it supervisory or direct care. Adults reporting many unpaid childcare hours are likely describing time constraints arising from the responsibility of being on call and available to provide direct care to children under 13.

4. Empirical Explorations

In the empirical section, we address two main questions. First, what do the data imply about the social minimum of unpaid work? Second, how do the joint bundles of unpaid work time and money income that lie above this threshold vary across the population? The housework measure combines two PSID categories: hours devoted to housework and hours spent shopping[6], while unpaid childcare hours are analyzed separately.

4.1. Minimum Thresholds

Most efforts to estimate the threshold for socially necessary unpaid work have relied on time-use data documenting average or median amounts of time devoted to unpaid tasks. Vickery stated each household must spend at least 14 hours a week "managing the household and interacting with its members if the household is to function as a unit" (Vickery, 1977:46). Variations on this assumption have been widely adopted. For instance, Zacharias et al. (2012) assume that each adult household member must spend 7 hours a week on socially necessary unpaid work, independent of household composition (Zacharias et al., 2012:24; Aloé, 2023). More attention has been devoted to socially necessary leisure time, and it has often been specified in relative terms, set, for instance, at 50% and 70% of the median (Harvey & Mukhopadhyay, 2007).

As noted above, we focus on patterns of unpaid housework and childcare, setting the issue of leisure thresholds aside. We compare median, mean, and modal values, the 60% of the median value (as the most commonly applied relative income poverty measure) and the most commonly assumed minimum threshold of 7 hours per adult person (Zacharias et al., 2012) or 14 hours per household (Vickery, 1977). The aim is to identify the statistical measure that best serves as a commonly understood threshold. Relative estimates, grounded in population distributions, provide a clearer and more accurate understanding of unpaid work needs in households compared to informed guesses, such as those presented in Vickery (1977) and Zacharias et al. (2012).

[6] Questions on housework and shopping in the PSID: In a typical week, how many hours [do you/does [he/she]] spend) Shopping, for example, buying groceries or clothes, or shopping online? For this analysis we are not looking at elder care.
In a typical week, how many hours (do you/does [he/she]) spend doing housework, for example, cooking, cleaning, and other work around the house?

We conduct separate threshold analyses for housework (including shopping) and childcare across four household types: one- and two-adult households, each distinguished by whether they include at least one child under age six. Housework is estimated for all household types, while childcare is analyzed only for those with young children. This distinction captures structural differences in unpaid working time driven by household composition.

4.1.1. Housework and shopping

Among those living in one-adult households without children, the mode of time devoted to housework and shopping is 6 hours per week (see Figure 3). As 60% of the median and the mode coincide, and given the high density around the mode, we argue that these indicators are the most suitable measures for establishing minimum thresholds for this household type. Both are slightly below the weekly 7 hours assumed by Zacharias et al. (2012) and well below Vickery's (1977) 14 hour estimate for at least one adult. Using either the mode or 60% of the median as a measure for a minimum threshold provides an advantage over earlier assumptions by grounding the threshold in the actual distribution of time-use data. These measures reflect the central tendency for the majority of the population, capturing typical behavior rather than relying on informed guesses. By anchoring the threshold in empirical evidence, we can more accurately define a realistic and context-sensitive benchmark. This approach ensures that minimum thresholds are both representative and practical, thereby reducing errors that could arise from over- or underestimation due to arbitrary assumptions.

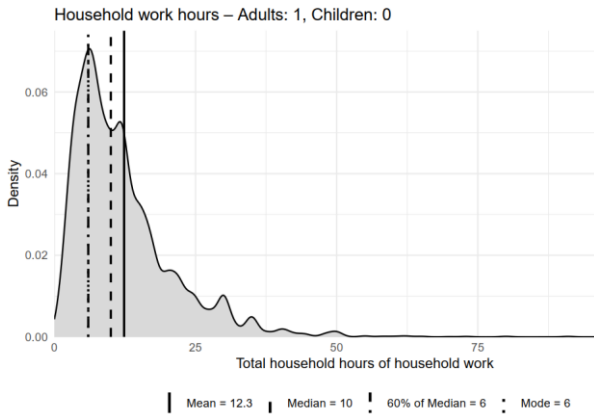

Figure 3: Total hours of housework, including shopping for adults between 18-65 in one-adult households with no children

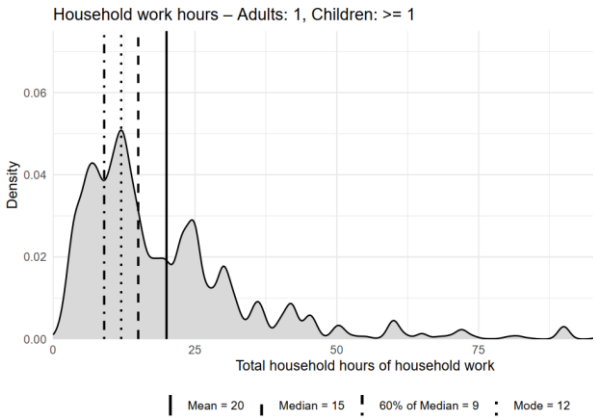

Figure 4: Total hours of housework including shopping for adults age 18-65 in one-adult households with at least one child under 6

For one-adult households with at least one child under 6, relative statistics do not coincide. The mode is 12 hours, while 60% of the median is 9 hours. This suggests that single adults with at least one child under 6 require a minimum of three to six additional hours of housework compared to single adults without children, considering the divergence of the mode and 60% of the median thresholds. The distribution of housework in single-adult female and male households with at least one child under 6 shows a narrow range, with a median of 15 hours, indicating that at least 50% of this population does not need more than 15 hours of unpaid work.

Note that the estimates for the four household types are considerably lower than the 14 hours a week that Vickery (1977) reported. Her estimate was based on an informed guess. At her point in time, the time devoted to housework in the U.S. was considerably higher than it is nowadays, due to increased automation, ready-made meals, and other factors. In addition, the time use data she relied on were both methodologically poor and considerably out of date.

For two-adult households, we examine total hours spent on housework and how these hours are distributed by household composition. For two-adult households without children (Figure 5), 60% of the median is 15.6 hours, whereas for households with at least one child under 6 (Figure 6), it is 18.6 hours. Similar to single female adults, 60% of the median is roughly 2 hours more for households with a child under 6 compared to those without children. In both cases, the mode and 60% of the median exceed Vickery's (1977) estimate of 14 hours. The distribution and modal value are higher for households with children. Table 2 summarizes all relative measures for the households studied.

Table 2: Relative statistical measures for unpaid household work and shopping for one and two-adult households

Dataset	Child	Mean	Median	60% of Median	Mode
One adult	0	12	10	6	6
One adult	at least one under 6	20	15	9	12
Two adults	0	29	26	16	17
Two adults	at least one under 6	36	31	19	24

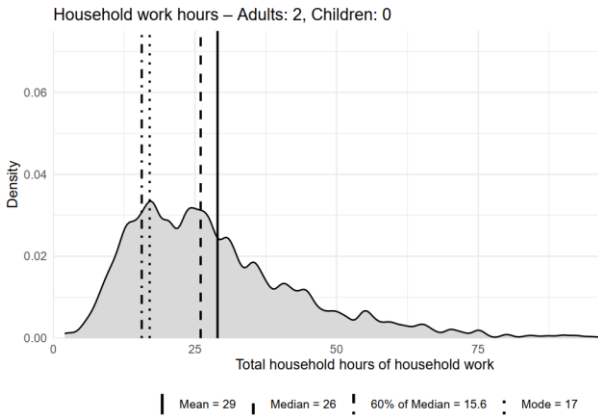

Figure 5: Total hours of housework including shopping of all adults age 18-65 in two-adult households without children

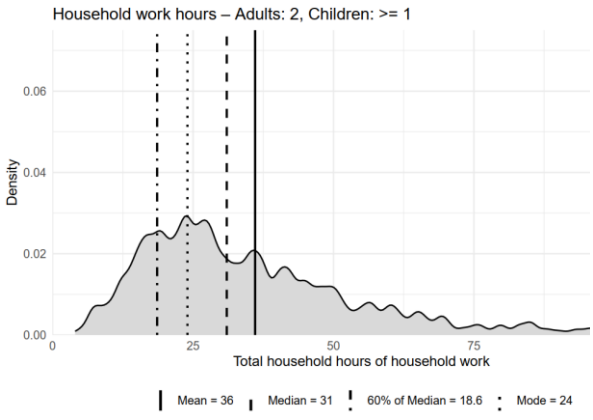

Figure 6: Total hours of housework including shopping of all adults age 18-65 in two-adult households with at least one child under 6

Based on our exploratory analysis, we suggest using 60% of the median of housework time per week as the minimum threshold. As for one-adult households with no children, this coincides with the mode. However, 60% of the median is the more practical measure, as it preserves the original time-use unit and avoids binning, which is particularly relevant when data are recorded in minutes rather than hours. This measure aligns with the commonly used relative income poverty line, which considers the overall income distribution and reflects the living standards within a society.

For couples and households with children, the relative measure is less accurate. Therefore, we recommend using the equivalence scales suggested by Folbre et al. (2017). Notably, two-adult households spend more than double the time on housework compared to one-adult households. This difference is likely driven more by economies of scale or the enjoyment of shared activities than by higher needs. Relative measures in this context provide insights into patterns of behavior but may not reflect a socially necessary minimum. While the use of equivalence scales for unpaid household work is relatively unexplored and necessarily involves normative assumptions, it provides a reasonable first-order approximation for adjusting thresholds across household types. We therefore modify the formula to scale the thresholds upward, which allows the specification of appropriate thresholds for multi-person households. This is defined by Equation (1). Thereby, T_{NMAC} is the estimated minimal threshold on time for non-market household production, *A* is the number of adults, and *K* is the number of children. T_{NM1} is the non-market household production for a one-adult household, which is set at 6 hours per

week, which is 60% of the median for one-adult households. Table 3 reports the results for the equivalence scales.

$$T_{NMAC} = T_{NM1} * (A + 2 * K)^{0.5} \quad (1)$$

Table 3: Socially necessary minimum unpaid household work (hours per week)

Adults / Children	0	1	2	3
1 adult	6 h	10.3 h	13.4 h	15.9h
2 adults	8.5 h	12 h	14.7 h	17 h

4.1.2. Childcare

Unlike housework, childcare time is highly variable, even when controlling for household structure, likely due to uneven patterns of assistance from family, friends, and neighbors, as well as the utilization of paid childcare. Unfortunately, data on these patterns of assistance is not available, making statistical analysis of the determinants of childcare time much less insightful.

Figures 7 (single-adult households) and 8 (two-adult households), all with at least one child under 6, illustrate this complexity by showing the statistical thresholds and distribution of household time. Visualizing the distribution by the age of the youngest child reveals a similar pattern across age groups, suggesting that the distribution is unlikely to be influenced by the child's age. Determining appropriate thresholds for childcare could potentially be informed by a child-centric data set, such as the Child Development Supplement of the PSID, which records the time children spend with non-parents.

The high values for childcare are influenced by the PSID's broad framing of childcare, which includes supervisory time. Nonetheless, it is noteworthy that all relative statistical estimates for childcare alone are substantially higher than Vickery's (1977) assumed minimum of 14 hours per week of unpaid household supervision and management — the residual time she assigns to households that could otherwise substitute paid services for all domestic and family care tasks. Vickery's (1977) approach clearly ignores supervisory care. All graphics display a notable peak at 168 hours for single households and 336 hours for two-adult households. The high frequency of these reported values significantly affects the relative measures. These high numbers likely reflect the influence of supervisory care as well as ambiguity regarding its definition.

Table 4: Relative statistical measures for unpaid childcare work for one and two adult households

Dataset	Child	Mean	Median	60% of Median	Mode
One adult	at least one under 6	82	60	36	168
Two adult	at least one under 6	102	80	48	80

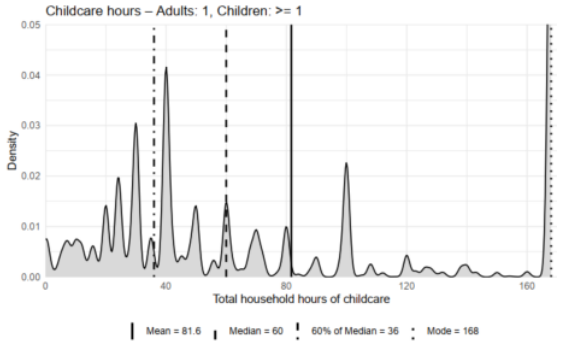

Figure 7: Unpaid childcare provided by adults age 18-65 in one-adult households with at least one child under 6

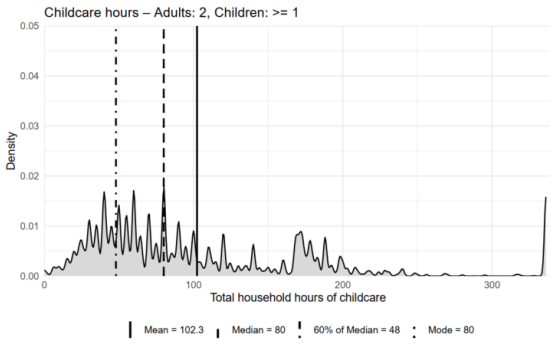

Figure 8: Total household hours spent on unpaid childcare for two-adult households age 18-65 with at least one child under 6

4.2. Unpaid Work and Expenditure Bundles

Based on Figure 1, the relationship between expenditure on services and time spent on self-produced services can be linear or convex. To define the bundles of unpaid work time and expenditure that determine the poverty threshold in the substitutability space, we employ the bivariate relative poverty line (BRPL) approach developed by Dorn et al. (2024). We create separate threshold lines based on household composition, analyzing two-adult and single-adult households with 0, 1, 2, or 3 or more children.

We examine the relationship between unpaid household work (including shopping) and household expenditure on food to develop joint bundles for these two aspects, defining the bivariate poverty threshold line. As shown in the univariate threshold analysis, establishing reliable thresholds for unpaid childcare remains challenging. The available data does not distinguish between supervisory care and direct care. This limits our ability to identify meaningful thresholds, as households are likely to substitute supervisory care first while maintaining the most essential childcare tasks. Since childcare cannot be postponed, a lack of access to formal childcare can leave a household with up to 168 hours per week of unpaid childcare responsibilities, especially when children are very young or have special needs. Under these conditions, defining a univariate socially necessary threshold for unpaid childcare—and, by extension, a combined threshold for childcare expenditure and unpaid childcare—is problematic. To avoid producing misleading results, we therefore limit our BRPL analysis

to the bundle of household expenditures and unpaid household work. Nonetheless, developing strong childcare thresholds using the BRPL approach remains an important area for future research, particularly with richer data that better capture different forms of childcare and their substitutability.

4.2.1. Method Bivariate Relative Poverty Line (BRPL)

To identify the bundles of unpaid household work (including shopping) and household food expenditure, we draw on the joint distribution of these two variables in the data. The bivariate relative poverty line (BRPL) represents the combination of time and money that separates households with adequate resources from those that are jointly constrained in both dimensions.[7] Rather than setting this threshold arbitrarily, we define it at a quantile level (τ) that corresponds to the socially necessary amount of unpaid work for each household type, ensuring that no household falls below this minimum (as specified in Table 3). The quantile level thus varies by household composition. The specific bundles that form the threshold line are then determined using a line search algorithm, following the method proposed by Dorn et al. (2024).

Figure 9 illustrates how to derive the BRPL. The black line shows the BRPL for the joint distribution of unpaid work and monetary expenditure. Each point along this line corresponds to a specific combination of expenditure and unpaid work that exactly matches the selected poverty threshold level τ. The bivariate relative poverty line is defined as the set of points (q_x^a, q_γ^a) such that the joint cumulative distribution function $F_{1,2}(q_x, q_\gamma)$ equals a chosen quantile level $\tau \in [0, 1]$: $F_{1,2}(q_x, q_\gamma) = \tau$. The BRPL contour connects all combinations of expenditures and unpaid work that share the same joint ranks in the population, that is, households occupying an equivalent relative position across both dimensions. To compute the BRPL, we choose a set of trade-off angles (α) from the origin. For each α-angle (shown as the differently styled lines), we perform a line search along the ray starting at (0,0) until reaching the point (q_x^a, q_γ^a) where $F_{1,2} (q_x^a, q_\gamma^a) = \tau$. This process identifies the unique intersection of the ray with the BRPL. The resulting points define angle-specific poverty rectangles, representing the minimum requirements in both dimensions for that trade-off, as exemplified by the points q_1, q_2, q_3, and q_4 on the BRPL.

The portion of the population below the BRPL can thus be larger than or equal to the set level τ, since τ represents the quantile of the joint cumulative distribution function (CDF), not the total probability mass of the region below it. All observations below the joint quantile level τ, thus the BRPL, represent values less than or equal to τ. The cumulative probability mass of this interior region exceeds τ if the two dimensions are

[7] The BRPL package provides an implementation in R for estimating bivariate relative poverty lines (Dorn et al., 2025).

interdependent. In other words, individuals below the BRPL are relatively poor in both dimensions, as they fall below the joint threshold defined by their reference group. For example, if τ is set at 15 in a sample of 100 households, then 15 households lie below each point on the BRPL within its corresponding rectangle. These households are therefore considered relatively poor in both unpaid work and expenditure, as they do not meet the combined thresholds indicated by their respective BRPL points. Figure 9 shows examples of the points and their respective rectangles in q_1, q_2, q_3, and q_4.

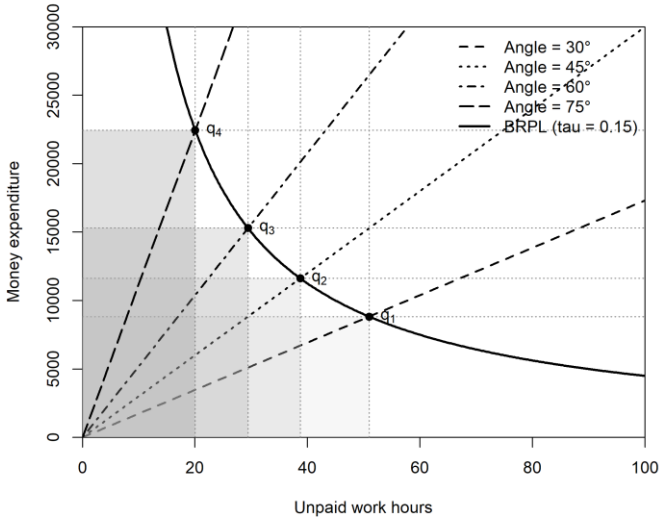

Figure 9: Schematic explanation of the line search approach to construct the BRPL[8]

Figure 10 sketches the bivariate relative poverty approach for unpaid work and expenditure. The line at U_0 indicates the univariate socially necessary threshold for unpaid household work, and the line at E_0 indicates the minimum expenditure threshold. U_1 and E_1 mark the upper thresholds for substituting unpaid work and expenditure, respectively. If these thresholds are exceeded, poverty should be defined as unidimensional rather than bidimensional. Therefore, joint bundles of unpaid work and expenditure are not defined.

[8] The graphic was designed by the author using *R* version 4.5.2.

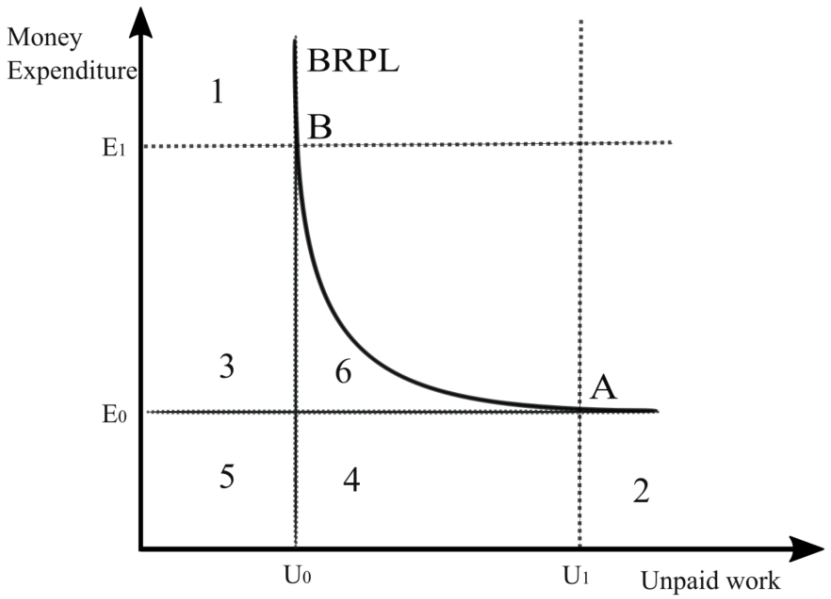

Figure 10: Graphical Explanation of Poverty Regimes[9]

Conventional poverty measurement for two dimensions often uses either the intersection or the union approach. The union approach identifies all households as poor if they are either below E_0 or U_0 (areas 1-5 in Figure 10). The intersection approach is more restrictive and identifies as poor those below E_0 and U_0 (area 5 in Figure 10). Our BRPL approach defines households as bidimensional poor in unpaid work time and money expenditure, located below E_1 and U_1, as well as the BRPL (areas 3-6 in Figure 10). Our definition includes area 6, which consists of observations that are relatively poor for the population but are unaccounted for in measures that do not look at the joint distribution of poverty dimensions, as do the union or intersection approaches.

4.2.2. Results

This section operationalizes the concept of socially necessary minimum bundles of unpaid household work and food expenditure within the BRPL framework introduced in Section 4. We use the BRPL approach to define the joint bundles of unpaid work time and monetary resources required to cover food expenditures and live above the poverty line. These necessary minimum bundles of unpaid household work and food expenditure lie above the respective dimension-specific minima and below the corresponding maxima, corresponding to the area between points A and B in the theoretical framework (Figure 1) and its empirical illustration (Figure 10). The equivalized number of unpaid work hours defined in Equation 1 is used to identify the percentile at which the socially necessary minimum of unpaid work is located in the unpaid work distribution, which then defines

[9] The author created all Figure 10 using Inkscape (version 1.4.3.).

the BRPL quantile τ. Table 5 presents the resulting percentiles for various household compositions. Expenditure is not equivalized, as bundles are estimated separately for each household size, and the joint distribution requires a single quantile level, such that the unpaid work percentile simultaneously determines the expenditure quantile. Table 5 reports the corresponding expenditure values and unpaid household work hours at the minimum and maximum percentile levels, with the upper bound set at the 90th percentile.[10]

Table 5: Minimum of expenditure and unpaid household work by household composition

			Point A		Point B	
	Children	Percentile (τ)	Minimum Value food in $ per year	90% unpaid household work (hours per week)	Socially necessary unpaid household work (hours per week)	90% food expenditure in $ per year
1 Adult	0	29.5	3,568	23.7	6	11,392
	1	41.2	5,312	29.8	10.4	12,515
	2	46.9	6,126	30.7	13.4	12,758
	3	49.6	6,966	45.1	15.9	13,309
2 Adults	0	3.5	3,187	49.8	8.5	16,307
	1	7.9	4,911	51.7	12	19,987
	2	10.3	6,235	59.2	14.7	21,220
	3	11.6	5,858	69.1	17	22,351

The minimum socially necessary bundle of food expenditure and unpaid household work varies substantially by household composition. For one-adult households, the minimum percentile (τ) ranges from 29.5% to 49.6%, corresponding to annual food expenditures between $3,568 and $6,966 and between 6 and 15.9 hours of unpaid household work per week. For example, a one-adult household without children requires annual food expenditure of $3,568 when supplying 23.7 hours of unpaid work weekly. By contrast, if the socially necessary threshold of unpaid work is 6 hours per week, this household requires $11,392 annually for food.

For two-adult households, the minimum percentiles are substantially lower, ranging from 3.5% to 11.6%. As shown in Section 4.1.1, two-adult households report more than twice the amount of unpaid work compared to one-adult households, which does not necessarily reflect the socially necessary minimum. Equation 1 is therefore applied to estimate the necessary minimum of unpaid work for couple households by number of children. Because the BRPL points for two-adult households are based on equivalized unpaid work, they

[10] Table A1 in the Appendix shows the results for the percentile level based on 60 percent of household food expenditure. The corresponding values for unpaid work time and food expenditure are higher. For single-adult households, the threshold corresponds is about 6 hours of unpaid work, which reflects the percentile level of food expenditure. This provides an additional index for the socially necessary unpaid work threshold. For couple households, however, the value is roughly twice as high, suggesting that two adults may engage in unpaid activities simultaneously and spend more time together, such as cooking.

correspond to lower percentile values that reflect the location of these households within the unpaid work distribution. The resulting threshold bundles represent observed combinations of unpaid household work and food expenditure at the identified percentile cutoffs and are therefore representative of households reporting such levels of unpaid work. For example, a two-adult household without children requires an annual food expenditure of $16,307 when the minimum of 8.5 hours of unpaid household work per week is met. At the same time, this underscores the importance of more detailed and careful data collection on unpaid work in two-adult households, where unpaid work may be shared between adults and partly reflect joint activities rather than necessity alone.

Figure 12 displays the BRPL and the joint distribution threshold for unpaid work and expenditure for a single-adult household, while Figure 13 presents the same for a two-adult household. Both figures suggest that the 90th percentiles are approximately at the point where the BRPL approaches its asymptote under the univariate thresholds, indicating that the parameter choices employed are internally consistent. Thus, the 90th percentile seems to be a valid proxy for the upper threshold of expenditure and unpaid work time to estimate the necessary bundles.

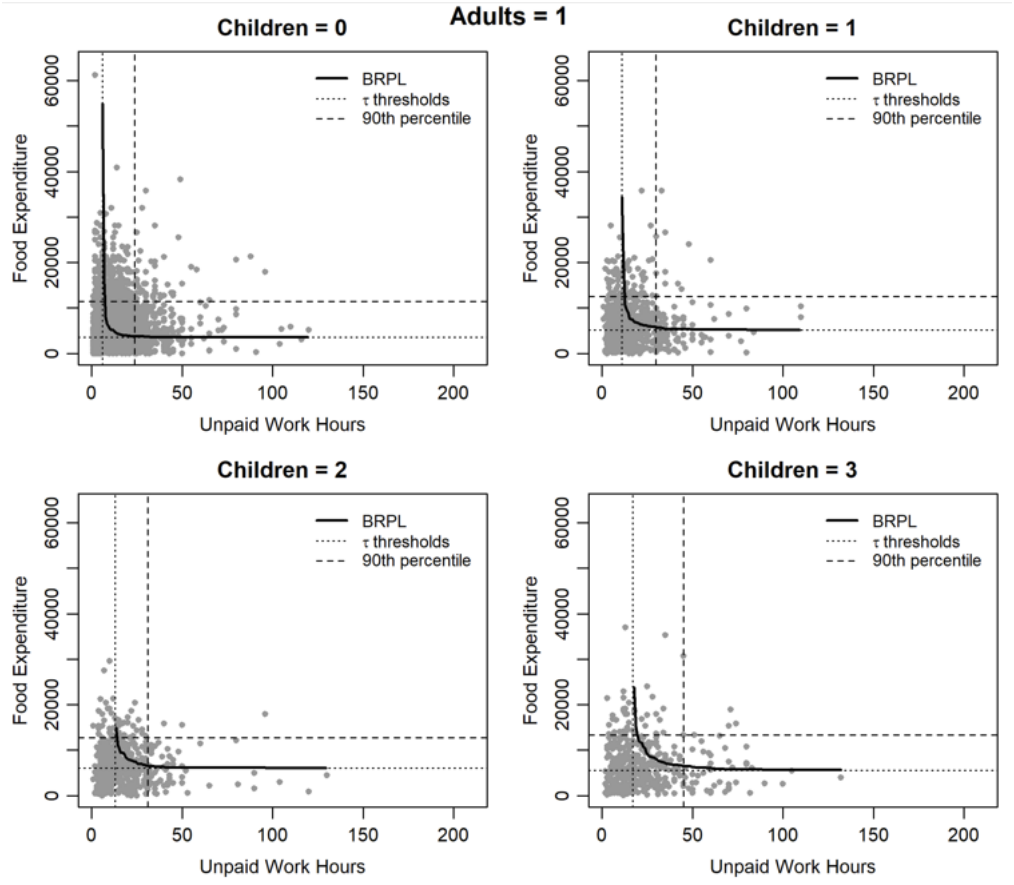

Figure 11: Plots for BRPL for one adult households with 1,2,3, or more children

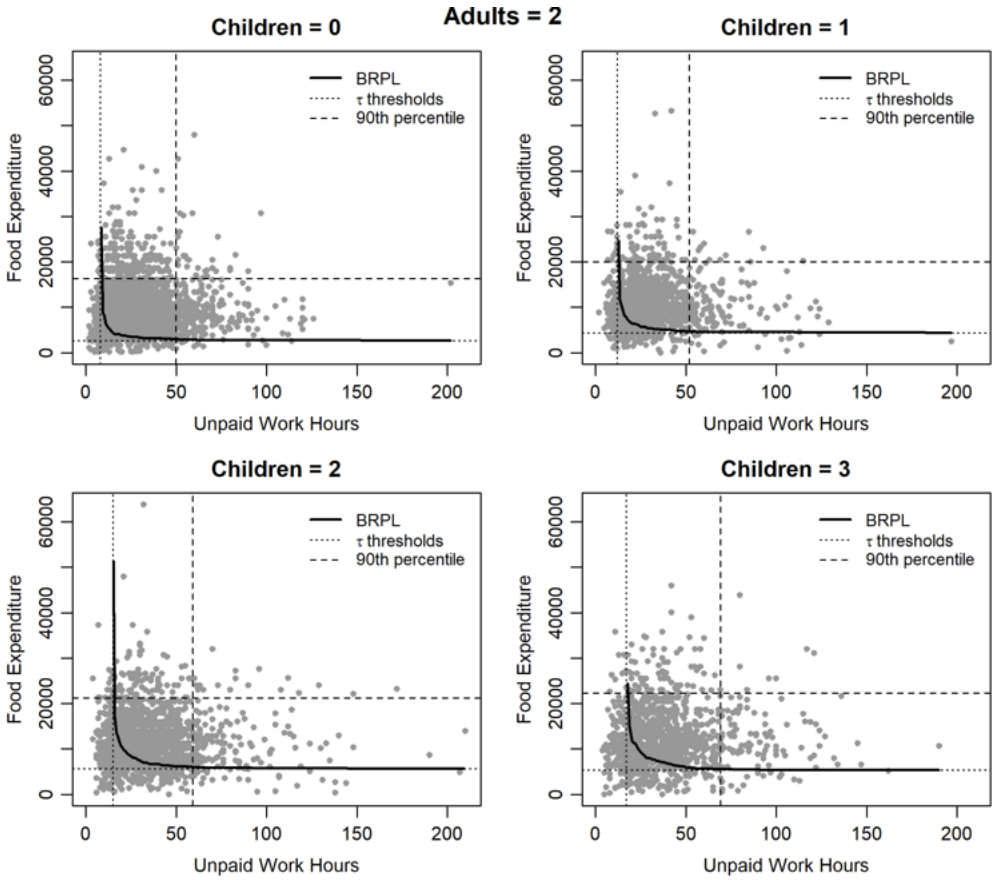

Figure 12: Plots for BRPL for two adult households with 1,2,3, or more children

Our results show that the BRPL is nonlinear across all household types, indicating nonlinear substitution between unpaid work and monetary expenditure. This means that additional hours of unpaid work cannot simply be offset by proportional increases in spending, and vice versa. Figures 12 and 13 illustrate the BRPL for one- and two-adult households, respectively, showing the varying slope of the curve along the distribution and reflecting different trade-offs between time and money at various levels of household resources. Table 6 provides concrete examples of this relationship by showing combinations of unpaid work time and expenditure for different household types along the BRPL threshold line. These combinations are reported for line search angles of 30°, 45°, 60°, and 75°, illustrating how the mix of unpaid work time and money for food is defined on the BRPL.

Table 6: Combinations of unpaid work and expenditure by angle of the line search algorithm.

		30°		45°		60°		75°	
	Children	Exp	UW	Exp	UW	Exp	UW	Exp	UW
1 Adult	0	4,590	13	5327	10	6729	8	9,321	7
	1	6,609	21	7458	16	8938	15	10,982	12
	2	7,458	24	8237	19	10089	16	11,396	14
	3	7,989	30	9310	25	11203	22	12,760	20
2 Adults	0	3,575	24	5087	13	8,506	10	12,108	9
	1	5,618	27	7275	18	10,215	14	15,098	13
	2	7,409	30	9090	22	12,389	18	15,973	16
	3	7,355	34	9587	24	12,727	20	17,844	18

Note: Exp = Expenditure in $ per year; UW = Unpaid work in hours per week

Table 7 reports the share of households falling below different poverty regimes by time and expenditure, highlighting how the interaction between unpaid work and expenditures affects the identification of households in time- or income-based poverty. The first column ("Below BRPL & in top 10%") shows the proportion of households below the BRPL that belong to the top decile of the univariate distribution of unpaid work and expenditures. These households are poor in one dimension but are not considered bidimensional poor because of the indication of relative affluence in the other dimension. The next two columns display the shares of households below univariate thresholds for food expenditures and unpaid work, respectively. The "Intersection approach" column identifies households that are simultaneously below both univariate thresholds, ranging from 7–23% among single-adult households and 0.3–1.4% among two-adult households. The final column ("Below BRPL & above univariate thresholds") captures households whose time–money bundles lie below the BRPL but above the univariate thresholds, as indicated in Area 6 in Figure 10. Depending on household size, between 3.5–14% of households fall into this group. These households experience simultaneous shortfalls in both time and money that univariate measures overlook.

Considering the full dataset and applying household-size-specific thresholds, 4.5% of households are deprived in one dimension while affluent in the other. Overall, 19.8% of households fall below the univariate food threshold, 15.7% below the univariate unpaid work threshold, and 5% are simultaneously deprived in both dimensions. In addition, 10.1% of households lie above the separate univariate thresholds for unpaid work and food expenditure but remain below the BRPL, indicating bidimensional deprivation that is not captured by conventional univariate or intersectional poverty measures. Overall, the results demonstrate that considering the joint distribution of time and money provides a more accurate and nuanced assessment of household living standards.

Table 7: Percentages below the different poverty regimes

	Children	Below BRPL & in top 10% (Area: 1 & 2)	Univariate food threshold (Area: 5,4,2)	Univariate unpaid work threshold (Area: 1,3,5)	Intersection approach (Area 5)	Below BRPL & above univariate thresholds (Area 6)
1 Adult	0	7	29.4	21.5	7	13.2
	1	10.6	40.2	39.8	16.4	14.0
	2	10.4	46.1	45.7	22.0	10.8
	3	9	48.2	47.6	23.2	8.8
2 Adults	0	0.7	3.4	3	0.3	3.5
	1	1.7	7.8	5.4	0.6	7.5
	2	1.6	10.2	8.6	1	11.0
	3	1.7	11.4	8.7	1.4	10.7
Full dataset	–	4.5	19.8	15.7	5	10.1

Areas refer to Figure 10.

5. Conclusion

This study highlights important differences in the relationship between unpaid childcare, housework, and related expenses across one and two-adult households within the U.S. Panel Study of Income Dynamics. It clarifies estimates for minimum univariate and bivariate thresholds, providing a stronger empirical basis for analyzing time and income poverty.

While both the mode and 60% of the median yield plausible thresholds for non-substitutable housework, 60% of the median is preferable because identifying a mode may require binning when unpaid work time is reported in minutes. In our analysis, one-adult households without children show a mode of 6 hours per week devoted to housework, which closely matches 60% of the median. Two-adult households have higher thresholds, with 15 hours for those without children and 17 hours for households with a child under 6. The more than double threshold for two-adult households may result from adults spending more time together on activities like cooking. These hours may be added up in household unpaid work. We therefore recommend applying an equivalence scale to estimate socially necessary unpaid work time across different household types, using the estimate for one-adult households as a baseline. These measures offer a more empirically grounded minimum

threshold for housework in the U.S. than the broader thresholds reported by Zacharias et al. (2012) at 7 hours per adult and by Vickery (1977) at 14 hours per household per week.

Estimating socially necessary childcare thresholds remains challenging given current data constraints. In particular, the lack of distinction between direct and supervisory care, and the lack of information on childcare support, limit the ability to set socially necessary minima for unpaid childcare. Reported childcare hours vary widely, reaching up to 168 hours per week. Such data are difficult to collect but should be a focus of future research to refine childcare thresholds. Given that all relative indicators exceed Vickery's (1977) minimum threshold of 14 hours, they point to substantially higher temporal demands.

This paper applies the bivariate relative poverty line (BRPL) approach to estimate the bundles of unpaid household work (including shopping) and food expenditures required to sustain living standards above the poverty line. To construct the joint poverty thresholds, we use equivalized unpaid household work time to identify the relevant quantile of the joint distribution of time and money. This method allows us to set poverty thresholds without assuming a linear substitution between unpaid work and expenditures. Our results show that the relationship between unpaid household work and expenditures is nonlinear. The analysis estimates bundles for different household sizes, illustrating combinations of unpaid work time and monetary resources along the poverty threshold line and how the necessary time–money trade-offs vary with household composition. The BRPL framework shows that 10.1 percent of households fall below the joint threshold defining the minimum bundles of unpaid work time and expenditures required to live above poverty, while remaining above the univariate thresholds for either income or unpaid work.

This method differs from linear adjustments to the income poverty line, which consider only households at the income threshold who lack sufficient time for unpaid work. Instead, the BRPL defines bundles of unpaid work time and money for expenditure that prevent households from falling into poverty, regardless of these conditions. These households are on the margin of society, and their deprivation becomes evident only when time and money are viewed together. Current poverty policies, which rely solely on univariate measures, may overlook them. By adopting the BRPL framework, poverty measurement can better reflect the complex constraints that influence household living standards.

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Appendix

Table A1

	Children	Percentile (tau)based on 60% expenditure	Minimum Value food in $	90% food expenditure ($)	Socially necessary unpaid household work (hours)	90% unpaid household work (hours)
1 adult	0	32.2	3,687	11,364	6.26	23.7
	1	28.8	4,030	12,258	7.49	29.8
	2	27.5	4,208	12,751	9.71	31.0
	3	34.2	4,255	12,894	11.6	44.9
2 adults	0	21.7	5,952	16,305	15.8	49.8
	1	21.3	7,010	19,983	17.6	51.7
	2	20.7	7,688	21,151	18.8	59.1
	3	22.1	7,985	22,325	21.5	69.0

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