Individual Consumption in Collective Households: Identification Using Repeated Observations with an Application to PROGRESA

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Abstract

Individual consumption is typically not observed for individuals living with others. Identification of individual resource shares from household expenditure data requires assumptions on preferences that are often difficult to justify. We show that individual resource shares can be identified from repeated observations under the intuitive assumption that individual preferences over a subset of goods are stable over time. Using this method to estimate the effect of PROGRESA on the intrahousehold distribution of household expenditure–and hence on individual consumption, we find unequal gains, with children's individual consumption increasing by 27.8%, fathers' consumption by 17.8%, and mothers' consumption by 5.8%.

Keywords: resource shares, collective household, PROGRESA
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1 Introduction

A key indicator of an individual's welfare is their level of consumption. For individuals who do not live alone, it is equal to the share of household expenditure that each individual consumes–their "resource share"–times household expenditure. While total household expenditure data is widely available, individual consumption is very costly to collect and hence typically not observed.[1] With growing evidence of intrahousehold inequality in health outcomes (Anderson and Ray, 2010; World Bank, 2011; Brown et al., 2017) and in consumption (Dunbar et al., 2013; Calvi, 2017) in poor countries, it is especially important to go beyond household-level indicators of wellbeing to improve the design of pro-poor policies.

Identification of individual resource shares from *household* expenditure data is possible within the collective household framework due to Chiappori (1988) and Apps and Rees (1988) but requires assumptions on preferences that are often difficult to justify.[2] The first approach to identify resource shares is to find suitable "distribution factors", i.e., variables assumed to influence the intrahousehold distribution of resources but not preferences (Chiappori and Ekeland, 2009; Dunbar et al., 2017). It is however difficult to find such valid distribution factors in practice–much like it is difficult to find suitable instrumental variables in treatment evaluation problems. The second approach consists of assuming that different individuals or individuals observed in different cohabiting states have similar preferences over at least some goods (Browning et al., 2013; Dunbar et al., 2013).[3] An influential approach due to Dunbar et al. (2013) limits the assumption of similar interpersonal preferences to one private assignable good by individual type (female adult, male adult, and children) and, contrary to previous identification strategies (e.g. Browning et al., 2013), does not require singles and individuals living in couples to have the same (or even similar) preferences. Instead, Dunbar et al. (2013) assume either that each individual type has similar preferences over some private assignable good irrespective of the number of children living in the household, or that preferences over some private assignable good are similar across adult males, adult

[1]See Menon et al. (2012), Cherchye et al. (2012), Lise and Yamada (2014), Mercier and Verwimp (2017), and Bargain et al. (2019) for exceptions.

[2]Cherchye et al. (2015) and Cherchye et al. (2017) only make minimal assumptions on preferences, but their revealed preferences method allows the identification of bounds rather than point identification.

[3]Variants of Dunbar et al. (2013) have recently been proposed to address the partial lack of private assignable goods (Penglase, 2018), or to obtain identification from assuming that interpersonal differences in preferences are the same across Engel curves for different private assignable goods (Brown et al., 2019). In other related work, Lise and Seitz (2011) assume that utility functions have a particular functional form and point-identify the resource shares of adults in households without children off the adults' labor supply function and the assumption that adults with equal earnings have equal resource shares.

females, and children.[4]

When expenditure is only observed at one point in time, it may not be possible to identify resource shares without relying on preference stability assumptions either between individuals or between different values of valid distribution factors. Repeated cross sectional and panel data are however increasingly available through nationally representative household surveys such as the Living Standards Measurement Surveys as well as through the large body of experimental work carried out in developing countries, which routinely collects data prior to- and after a randomized experiment.[5] A natural extension to Dunbar et al. (2013) is therefore to exploit the availability of additional data points over time and identify resource shares from the assumption that preferences are stable over short periods of time rather than between different individuals. In this paper, we provide identification results for this alternative approach and apply this method to study the effect of the Mexican conditional cash transfer program PROGRESA on the resource shares of women, men, and children, and the resulting increases in their individual consumption.

Conditional cash transfer (CCT) programs are a popular social policy tool implemented in over 60 countries (Parker and Todd, 2017) which pay social transfers to (typically, women in) poor households conditional on some behaviors such as regular child school attendance and adherence to the recommended child immunization schedule. Evidence of their beneficial effects on children's educational and health outcomes abounds (for PROGRESA, see the excellent recent review by Parker and Todd, 2017). The evidence regarding the effect of these CCTs on intrahousehold allocation of resources, however, is mixed. Changes in expenditure patterns caused by cash transfer programs targeted at women can often be indirectly rationalized by a change in intrahousehold bargaining in their favor (Schady and Rosero, 2008; Rubalcava et al., 2009; Attanasio and Lechene, 2010; Attanasio et al., 2012a; Angelucci and Attanasio, 2013). But contrary to observational studies which have found that an increase in the share of household income controlled by the mother or grandmother leads to higher investments in child health (e.g: Thomas, 1990; Duflo, 2003), recent field experiments in which the gender of the recipient of conditional or unconditional cash transfers was randomized find mixed evidence of the effect of the recipient's gender on

[4]Where "similar" means that the Engel curves for the private assignable good have the same shape, and "private assignable good" refers to a good that is only consumed by one type of individual (man, woman, children), and whose consumer is known to the researcher.

[5]Examples of countries where *panel* data were collected at short intervals (up to a year apart) through Living Standards and Measurement Survey, and comprising detailed household expenditure data including data on private assignable goods are: Albania, Ethiopia, Nigeria, Uganda, Serbia and Montenegro, and Cote dIvoire.

outcomes related to expenditures on food, health, or education (Akresh et al., 2012; Benhassine et al., 2015; Haushofer and Shapiro, 2016; Armand et al., 2016). Equally mixed results are found in studies estimating the effect of cash transfers targeted at women on self-reported measures of female bargaining power (Adato et al., 2000; De Brauw et al., 2014),[6] and in studies estimating the effect of cash transfers on domestic violence (Angelucci, 2008; Bobonis et al., 2013; Hidrobo and Fernald, 2013; Haushofer and Shapiro, 2016). Anthropological work in rural Mexico suggests that a CCT such as PROGRESA may have a different effect on individual consumption compared to other sources of increases in women's relative income. The majority of women interviewed in Haenn (2018) indeed reports that the modern version of PROGRESA (Prospera) provides an excuse for men to share less income with their wives–which may not be compensated by the program's transfer. In addition, local program implementers are reported to pressurize women to spend the transfers on their children, leading Schmook et al. (2018) to conclude that "rather than enable children's social mobility through their mother's empowerment, the program does so *at the expense* of their mother's autonomy" (p.110, emphasis in original). Independently and in parallel to our work, Tommasi and Wolf (2016) and, more recently, Tommasi (forthcoming) identify the effect of PROGRESA on individual resource shares using Dunbar et al. (2013)'s approach, i.e. by assuming that the preferences of men, women, and children for clothing are similar and that these preferences are similar across different household sizes. Tommasi and Wolf (2016) conclude that PROGRESA tended to reduce women's resource shares, while Tommasi (forthcoming) finds the reverse. All in all, there is no clear evidence that PROGRESA in particular, and CCTs directed at women in general, increase female empowerment, and whether this in turn affects the household's expenditure pattern in favor of women and/or children. We advance the literature by providing estimates of the overall effect of a cash transfer program on the individual consumption of women, men and children without relying on the assumption that different individuals have similar preferences.

We find that the CCT program, while increasing household expenditure by 16.4% on average in our sample, reduced significantly the share of household resources consumed by women, mostly to the benefit of their children. This suggests that the positive effects on child outcomes previously documented

[6]Departing from self-reported measures of female empowerment, Almås et al. (2015) find that, when women are the randomly assigned recipient of a CCT in Macedonia, they are less willing to sacrifice total household payoffs from a lab experiment to increase their own payoffs, which can be rationalized within a collective household framework as evidence of increased female bargaining power following the receipt of the CCT.

resulted not simply from the direct effect of meeting the conditionality requirements and the increase in total household expenditure but also from the redistribution of resources from mothers towards children within the household. Translating these findings in terms of individual consumption gains, we conclude that children benefited from a 27.8% increase in consumption, their fathers from a 17.8% increase, and their mothers from a 5.8% increase.

The model we use allows more than one interpretation for the Pareto weights given to each individual's utility function in the household utility function, and hence it does too for the effect of PROGRESA on resource shares. Under egoistic preferences–i.e., if we assume that individuals only care about their own utility, our results can be interpreted as evidence of a reduction in mothers' bargaining power. But in the more realistic case of caring preferences–such that individuals derive utility not only from their own utility but also from that of other household members, our results are consistent with unchanged or even increasing female bargaining power alongside reduced altruism of fathers towards mothers (as discussed in Section 6.2).

The rest of the paper is organized as follows. In Section 2, we present the model, before turning to our identification approach in Section 3. In Section 4 we describe the PROGRESA program and dataset, discuss the suitability of the model and identification assumptions to our empirical context and provide details of the estimation. Section 5 presents our estimates. Section 6 compares our results with results obtained under the assumption that preferences are stable across different individuals and discusses the interpretation of our findings when altruism (of the "caring" type) is taken into account. Section 7 concludes.

2 The Model

We use the same collective household model as in Dunbar et al. (2013), which extends Browning et al. (2013) to include children.[7] However, as we will see in Section 3, we depart from the identification

[7] Attanasio and Lechene (2014) test the restrictions implied by a collective model of household consumption in a dataset based on the same survey as that used in the application presented in this paper, and cannot reject efficiency of household decisions. Angelucci and Garlick (2016) and De Rock et al. (2017) carry out similar tests as Attanasio and Lechene (2014) in different subsets of the same data and reject efficiency for some subsamples of the data. One important limitation of these tests, however, is that two variables, including a binary variable for PROGRESA treatment status, need to be assumed to be valid distribution factors. In this paper, we do not assume that PROGRESA is a distribution factor and thus allow PROGRESA to affect demand through a number of channels.

strategy used in either paper. We consider households composed of an adult female, her male partner and s children. We refer to females f, males m and children c as three individual "types". There are K goods with market price vector $p = (p^1, .., p^K)'$. While $z_s = (z_s^1, .., z_s^K)'$ denotes the vector of quantities of goods purchased by a *household* of size s (i.e., comprising two adults and s children), the quantities of goods consumed by *individuals* of type $\ell = f, m, c$ are denoted by vector $x^\ell = (x_\ell^1, ..., x_\ell^K)'$.

One attractive feature of Browning et al. (2013)'s model is that goods do not have to be classified into purely privately consumed and purely public goods. No assumption is made with regard to the extent to which the consumption of each good is shared. Instead, a linear "consumption technology" à la Gorman (1976) is introduced, which transforms individual consumptions (x^f, x^m and x^c) into household expenditure (z_s), so that there exists a $K \times K$ matrix A_s such that $A_s(x^f + x^m + sx^c) = A_s x_s = z_s$. This approach therefore allows, in a very general way, the sum of private consumptions to be larger than the quantity purchased by the household. For instance, the fuel purchased by the household can be partly used by individuals privately when traveling alone, and partly shared when individuals are traveling together.

As in Dunbar et al. (2013) and Bargain and Donni (2012), we assume that children have their own utility function. One important benefit of modeling children's utility function as distinct from that of their parents is that it allows us to estimate the resource share consumed by children. This also allows for the possibility that children have their own preferences. The evidence reported in Dauphin et al. (2011) is consistent with the hypothesis that older children have their own utility function in the U.K. In addition, the bounds on resource shares estimated by Cherchye et al. (2015) are wider for households with children than childless households in their US data, leading the authors to suggest that this may be due to children having some bargaining power.

The model assumes that all children living in the household have the same utility function. This could be relaxed, but identification would require that the researcher observes the consumption of as many goods privately consumed only by one individual child as there are children. In the surveys we use (as in most datasets we are aware of), there are no such data.

Assuming that the household's allocation of goods reaches Pareto efficiency and that the household does not suffer from money illusion, the household solves the following problem:

$$\max_{x_f, x_m, x_c, z_s} \tilde{U}_s[U_f(x^f), U_m(x^m), U_c(x^c), p/y] \tag{1}$$

$$\text{such that} \quad z_s = A_s[x^f + x^m + sx^c] \quad \text{and} \quad y = z_s' p$$

where $U_\ell(x^\ell)$ for $\ell = f, m, c$, is the sub-utility of individual ℓ over non-durable goods in the current period and y is total household expenditure on non-durable goods. It captures the utility obtained by individual ℓ from consuming the bundle of goods x^ℓ when living in a household. Contrary to Browning et al. (2013), this utility function is not restricted to be the same function as that of ℓ-type individuals living on their own.

$U_c(x^c)$, the children's individual utility, can be interpreted either in the same way as $U_f(x^f)$ and $U_m(x^m)$, or it can be interpreted as the utility that the parents think the child has (Dunbar et al., 2013). And the "Pareto weight" associated with the child's utility function–defined as the derivative of $\tilde{U}_s$ with respect to $U_c(x^c)$–may be interpreted either as a measure of the child's bargaining power, or a measure of the weight which the parents put on the child's utility, or a combination of the two. We return to this point in Section 6.2.

One convenient way to implement the maximization of the collective decision problem given in (1) is to decentralize the decision such that each individual maximizes their individual utility function subject to their individual budget constraint, which equates their vector of individual consumptions x^ℓ, valued at shadow prices reflecting joint consumption in the household $A_s' p$, to the budget $\eta_\ell y$ that the household decides to optimally allocate to individual ℓ.[8] Browning et al. (2013) show that there is a one-to-one correspondence between Pareto weights and resource shares in this model. But contrary to Pareto weights, resource shares do not depend on the particular cardinalization of preferences.

Let $H_s^k(p, y)$ be the demand function for good k in a household with s children. As shown by Browning et al. (2013) in the case of a couple, and extended by Dunbar et al. (2013) by adding the children's utility

[8] The model does not assume that the sequence of events in the household actually is to first split total household expenditure between household members and then for each household member to decide how to spend their individual expenditure. It simply is a convenient way to solve Problem (1).

function, we can write the household's demand functions as:

$$z_s^k = H_s^k(p,y) = A_s^k[h_{fs}^k(\eta_f y, A_s'p) + h_{ms}^k(\eta_m y, A_s'p) + sh_{cs}^k(\eta_c y/s, A_s'p)] \quad (2)$$

where $h_{\ell s}^k(.)$ denotes the demand for good k of an individual of type ℓ and η_ℓ is the resource share of person ℓ. For example, $h_{fs}^k(\eta_f y, A_s'p)$ denotes the demand an adult female in a household with s children would have chosen if she were to maximize her utility given the prices $A_s'p$ and income $\eta_f y$.

Moreover, by definition, the resource shares sum up to 1:

$$\eta_f + \eta_m + \eta_c = 1 \quad (3)$$

Pareto weights, and hence resource shares, may, in general, depend on preference factors, prices, total expenditure, and distribution factors that affect demand *only* through their effect on the distribution of resources within the household (rather than through preferences or the budget constraint). For clarity, in this and the next sections we omit preference shifters and distribution factors, but the model can be extended to allow each utility function and resource shares to depend on covariates, which we allow to influence the parameters of the model in a very flexible way in our application.

We follow Lewbel and Pendakur (2008), Bargain and Donni (2012) and Dunbar et al. (2013) in assuming that the resource shares η_ℓ do not depend on total household expenditure.[9] In order to test convincingly this assumption, it must not be required for identification. This is the case in Menon et al. (2012), Cherchye et al. (2015) and Bargain et al. (2019), where this assumption is tested empirically and supported by the data.[10]

One useful aspect of the method we use in this paper to recover individual resource shares is that it does not require any distribution factor, and hence we do not rely on the assumption that a particular vari-

[9] Resource shares can, however, depend on prices, distribution factors, and any variable which affects preferences and the distribution of resources in the household, including variables that are correlated with total household expenditure (Dunbar et al., 2013). In Section 4.3, we discuss the suitability of this and our other assumptions specifically in the case of our application to PROGRESA.

[10] This is not to say that no form of intrahousehold inequality has ever been found to be correlated with total household expenditure. In a sample of Senegalese households where 25% of men and 39% of women live in polygamous households, De Vreyer and Lambert (2019) observe that intrahousehold inequality between "cells" is correlated with total household expenditure, where a cell is a sub-unit of individuals within the household (e.g., one of the head's wives and her children, or a relative of the head and and his dependents).

able only affects demand through its effect on the distribution of resources between household members. In particular, we do not need to assume that PROGRESA only affected demand through this channel. Instead, we estimate the total effect of the program on resource shares, which may include an effect on preferences and/or an effect on prices.[11]

In the next section, we present our approach to identifying the resource shares η_ℓ, $\ell = f,m,c$ in this model.

3 Identification

3.1 The Identification Problem

While the household's demand function (Equation 2) is rather unyielding, Dunbar et al. (2013) suggest two assumptions which greatly simplify the identification problem: the assumption that the resource shares do not depend on total expenditure, and the assumption that, for each individual whose resource share is to be identified, there exists a private good which is known to the researcher to be consumed only by this individual–i.e., a private assignable good. Formally (for ease of exposition, we do not include a subscript for household size, or condition on covariates, but it would be straightforward to do so without altering the proofs):

Assumption 1 *Equations (1), (2) and (3) hold at each time period* $t = 1,..T, T \geq 3$ *with resource shares* $\eta_{\ell t}$ *that depend on prices but not on total household expenditure.*

Assumption 2 *The demand functions include a private assignable child good, a private assignable female good and a private assignable male good denoted as* x_c*,* x_f *and* x_m *respectively.*

From Assumptions 1 and 2, it follows that the household's demand function for each $n = f,m$ private assignable good and time t, simplifies to:

$$z_t^n = h_{nt}(\eta_{nt}(p_t)y_t, A'p_t) \tag{4}$$

[11] As explained in Section 3, our method requires that, while varying freely between each type of individuals (adult women, adult men and children), preferences for the private assignable good (clothing and footwear in our application) be similar over the short period covered by the data (i.e., about 12 months between the first and last survey waves). In Section 4.3, we discuss the suitability of this assumption specifically in the case of PROGRESA.

denoting $h_{\ell t}, \ell = f, m, c$ the demand of individual ℓ for the private good assignable to him or her. Similarly, the demand function for the child good is:

$$z_t^c = s_t h_{ct}(\eta_{ct}(p_t) y_t / s_t, A' p_t) \tag{5}$$

where $z_t^\ell, \ell = f, m, c$, s_t and y_t are observed in the data. Under some restrictions on the indirect utility function, the resource shares $\eta_{\ell t}(p_t)$, $\ell = f, m, c$ can then be identified from the Engel curves for the private assignable goods. For the sake of clarity, below we explain our identification approach in the case of a specific (PIGLOG) functional form for the indirect utility function, which we use in our application. In Appendix A, we give the conditions under which the resource shares can be identified nonparametrically, provide the formal proofs and a fully-specified example, highlighting where our proofs depart from Dunbar et al. (2013).

We use clothing and shoes as private assignable goods in our application, as it is the only good for which we have separate expenditure data for male adults, female adults, and children.[12]

3.2 Identification in the PIGLOG Case

In our application, and similar to Dunbar et al. (2013), we assume that consumers have Price-Independent Generalised Logarithmic (PIGLOG) preferences (as in, e.g., Deaton and Muellbauer (1980)'s popular Almost Ideal Demand System). In this simple case, we have the following indirect utility function:[13]

$$V_{\ell t} = \psi_{\ell t}\left[\ln\left(\ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right)\right) + F_{\ell t}(p_t), \tilde{p}_t\right] \tag{6}$$

where G is non-zero, differentiable and homogeneous of degree 1 and F is differentiable and homogeneous of degre zero and $\tilde{p}_t$ is the vector of prices at time t excluding the prices of the three private

[12] It is not clear what the ideal private assignable good is in practice, but Bargain et al. (2019) compare resource shares estimated using Dunbar et al. (2013)'s restrictions on preferences to observed resource shares using exceptionally detailed individual consumption data collected in 2004 in Bangladesh. They find that some versions of these restrictions on preferences perform well as long as clothing and footwear or total food (but not rice) is used as private assignable good.

[13] To facilitate comparison with Dunbar et al. (2013), we use similar notations and also use their representation of PIGLOG preferences obtained by taking the logarithm of $\frac{\ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right)}{\check{F}_{\ell t}(p_t)}$–a monotonic transformation which does not affect the demand functions.

assignable goods.

Applying Roy's identity to this indirect utility function (which, omitting $\psi_{\ell t}$'s arguments for conciseness, states that $h_{\ell t}(y_t, p_t) = \frac{-\partial\psi_{\ell t}}{\partial p_{\ell t}} / \frac{\partial\psi_{\ell t}}{\partial y_t}$), we obtain individual demand functions of the form:

$$h_{\ell t}(y_t, p_t) = y_t \delta_{\ell t}(p_t) - \varphi_{\ell t}(p_t) y_t ln(y_t) \tag{7}$$

where $\varphi_{\ell t}(p_t) = \partial F_{\ell t}(p_t)/\partial p_{\ell t}$ and

$$\delta_{\ell t}(p_t) = \frac{\partial G_{\ell t}(p_t)}{\partial p_{\ell t}} \frac{1}{G_{\ell t}(p_t)} + \varphi_{\ell t}(p_t) ln(G_{\ell t}(p_t))$$

Plugging into Equation (4), dividing by y_t, and multiplying by p_{nt}, the share of total household expenditure spent on adult $n = f, m$'s private assignable good is:

$$\begin{aligned} \frac{z_{nt} p_{nt}}{y_t} &= p_{nt} \delta_{nt}(A' p_t) \eta_{nt}(p_t) - p_{nt} \varphi_{nt}(A' p_t) \eta_{nt}(p_t) ln(\eta_{nt}(p_t)) \\ &\quad - p_{nt} \varphi_{nt}(A' p_t) \eta_{nt}(p_t) ln(y_t) \end{aligned} \tag{8}$$

And the household budget share spent on the children's private assignable good is:

$$\begin{aligned} \frac{z_{ct} p_{ct}}{y_t} &= p_{ct} \delta_{ct}(A' p_t) \eta_{ct}(p_t) - p_{ct} \varphi_{ct}(A' p_t) \eta_{ct}(p_t) ln(\eta_{ct}(p_t)/s_t) \\ &\quad - p_{ct} \varphi_{ct}(A' p_t) \eta_{ct}(p_t) ln(y_t) \end{aligned} \tag{9}$$

With data for the private goods budget shares and total household expenditure, this system can be used to estimate the intercepts of the Engel curves for the private assignable goods and their slopes with respect to the logarithm of total household expenditure. But in order to pin down the resource shares $\eta_{\ell t}$, we need to make some assumptions. With three individuals $\ell = f, m, c$, three time periods, and no price information, we therefore have 12 equations (9 equations coming from the slopes of 9 Engel curves and 3 adding-up of individual resource shares constraints) in 18 unknowns (9 resource shares and 9 $p_{\ell t}\varphi_{\ell t}$). The restrictions proposed by Dunbar et al. (2013) to solve this identification problem correspond to imposing either that $p_{\ell t}\varphi_{\ell t} = p_t \varphi_t \neq 0$, bringing the number of unknowns down to 12, or that $p_{\ell st}\varphi_{\ell st} = p_{\ell t}\varphi_{\ell t} \neq 0$ where s is the number of children, which, if there are at least three family sizes, also allows identification (since, denoting S the number of family size groupings, we have $12S$ equations and $9+9S$ unknowns). These restrictions can be interpreted as assuming stability of preferences (for the private assignable good) across different individuals observed at a given point in time or across different household sizes, respectively. Instead, we assume that preferences for the private assignable good are similar over time for a given individual type (women, men, children) and that there is a degree of price stability over the period of observation (one year in our application), as discussed in detail in Section 3.3. More precisely, in our application, we assume that $p_{\ell t}\varphi_{\ell t} = p_{\ell}\varphi_{\ell} \neq 0$ to identify the model, which results in 12 equations in 12 unknowns. We only impose assumptions on the demand for one private assignable good per household member–therefore allowing preferences for any other good to vary over time.

Our identification approach has two alternative interpretations depending on the type of data used. With repeated cross-sectional data, our identification strategy assumes that preferences are similar between individuals of the same type (female adults, male adults, children) observed in different time periods–e.g., that a sample of men living in households with similar characteristics including the same number of children but observed in different time periods have similar preferences for the private assignable good. With panel data, our identification strategy assumes instead that preferences are similar between time periods for the **same** individuals of a given type. In the panel data case, however, our model formulation also assumes separability of decisions across periods. This static model is best suited to contexts, such as the one in the empirical part of this paper, where the household's ability to transfer wealth from period to period is very limited, as discussed in Section 4.3. In different contexts, it may be preferable to use repeated cross-sectional data from a representative survey.

If we imposed the same restrictions on the demands for all goods, one could think of our approach as one that uses time as a distribution factor (i.e., whereby time affects the distribution of resources within the household but not preferences).[14] Specifically, we assume that the 3×3 matrix composed of the ratios of each individual resource share relative to its value in the first period is non-singular (Assumption 5 in Appendix A.1). When using repeated cross-sectional data, resource shares may vary over time due to changes in the characteristics of the sampled individuals. In our panel-data static model application, resource shares may vary over time due to changes in variables affecting resource shares, even if these

[14]We thank Krishna Pendakur for this insightful perspective.

changes are predictable.[15] Resource shares could, for instance, vary with the age of household members, which is supported by Calvi (2017) and our own estimates (see Section 5.1). Changes in resource shares over time would seem likely when children are modeled as having their own resource share–it is probable that children have more say in consumption decisions as their cognitive abilities improve, which they substantially do within a 12-month period (Crawford et al., 2014). Among poor households with children, there is also good reason to believe that resource shares should vary over time even in the absence of price variation or changes in the bargaining power of household members. In these households, food expenditure accounts for a large share of total household consumption (79% in our case), while children's caloric needs from birth to age 13 increase nonlinearly between 3.4% (for girls age 8) and 8% (for boys age 4) per year (Gidding et al., 2005). As shown in Appendix A.3, this change in nutritional needs may result in a change in resource shares even in the absence of changes in prices or bargaining power.

3.3 Assumptions Regarding Price Variation

In order to identify the resource shares, we assume that $p_{\ell t}\varphi_{\ell t} = p_{\ell}\varphi_{\ell} \neq 0$. Here we make precise what this entails in terms of price stability.

If *all* prices are constant over the study period, a sufficient condition for $\varphi_{\ell t} = \partial F_{\ell t}(p_t)/\partial p_{\ell t}$ to be constant over time is that the function $F_{\ell}(.)$ does not vary over the study period. But the assumption that $\partial F_{\ell t}(p_t)/\partial p_{\ell t}$ does not vary over time is also compatible with some price variation–e.g., as long as the prices that vary are those of goods whose prices solely affect demands for the private assignable goods through an income effect.[16] In the widely used Almost Ideal Demand System due to Deaton and Muellbauer (1980), $exp(F_{\ell t}(p_t))$ is a Cobb-Douglas price aggregator (Banks et al., 1997) so that $p_{\ell t}\varphi_{\ell t}$ is independent of prices altogether. In this case, our assumption that $p_{\ell t}\varphi_{\ell t}$ is constant over time is consistent with any price variation.

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[15]Examples of dynamic collective household models in which resource shares vary over time are Adams et al. (2014) (where resource shares change over time due to intrahousehold differences in discount factors) and Mazzocco (2007) (where resource shares respond to unexpected changes in relative spousal income when spouses are not fully committed).

[16]For instance, using $\tilde{p}_t$ to denote the vector of prices at time t excluding the prices of the three private assignable goods and a subset r of goods, it could be that F_{ℓ} is the sum of two homogeneous of degree zero functions $F_{\ell}(p_{\ell t}, p_r, \tilde{p}_t) = f_{1\ell}(p_{\ell t}, p_r) + f_{2\ell}(\tilde{p}_t)$, where the derivative of the first function depends only on the price(s) of good(s) r (p_r), and the price of this/these good(s) is stable over time. In this case (used in our illustrative example in Appendix A.3), it is assumed that $\tilde{p}_t$ only affects demand for the private assignable goods through the individual's expenditure deflator $G_{\ell t}(p_t)$ and thus through an income effect. Or we could have price variation if the derivative of $F_{\ell}(.)$ depended on some price ratio which does not change over time. Either case is plausible in our application given that only about one year separates the first and last panel waves.

If we observed the prices of the private assignable goods $p_{\ell t}, \ell = f, m, c$, we could plug in their values in $p_{\ell t}\varphi_{\ell t}$ and assume that only $\varphi_{\ell t}$ is constant over time. We do not observe the prices of the private assignable goods in our data, since the ENCEL surveys record the total spent on clothing and shoes separately for adult men, adult women, and children, but not the number of items purchased. In our application, we therefore need to assume that the prices of these goods are constant during the period covered by our data, which is plausible given that the three rounds of the panel dataset we use were collected only (approximately) six months apart.

In Appendix A.3, we provide an example of a household maximization problem which meets all our assumptions, allows for some price variation (as per footnote 16), and results in the Engel curves we estimate.

4 PROGRESA, Dataset, and Estimation

4.1 The PROGRESA Program and Its Expected Effect on Individual Resource Shares

PROGRESA (a Spanish acronym for "Education, Health and Nutrition Program") was initiated in 1997 in selected areas of rural Mexico and progressively expanded to the rest of the country. The program had several components: cash transfers conditional on regular school- and, for younger children, health clinic attendance, as well as in-kind benefits such as nutritional supplements. Eligibility for the program was means-tested and determined at baseline, in both treated and control areas. Among beneficiaries, the transfers amounted to a large share of household income (16.4% in our sample).

PROGRESA may have had an effect on the intrahousehold distribution of resources through several mechanisms. First, it may have increased the bargaining position of women in the household through an increase in their relative income, an improvement in their "threat point" or income outside marriage, as well as, possibly, through compulsory attendance at monthly health and nutrition information sessions also aimed at empowering women. Divorce or separation is however extremely rare in the population of interest (at baseline in 1997, only 2.22% of adults age 21 to 59 in households eligible for PROGRESA were either divorced or separated),[17] and the consumption of women in our study sample is almost exclusively the result of transfers from their husbands or partners, since only 4.2% to 5.1% (depending on survey wave) of mothers work, while between 96.8% and 98.6% of fathers work. These figures suggest that the threat to cease cohabitation might not be very credible–as noted by Chiappori and Mazzocco (2017) to be the case in rural societies in many developing countries–and that, in most households, husbands have the option to reallocate the value of PROGRESA transfers to their own consumption by reducing transfers to their wives. The extent to which women may use PROGRESA transfers as a bargaining chip is therefore not obvious in this context. In recent anthropological work in rural Mexico interviewing spouses separately among 222 couples, 40% of men and 57% of women report that the modern version of PROGRESA (Prospera) provides an excuse for men to share less income with their wives (Schmook et al., 2018). In addition, men may resent the fact that their partners receive cash transfers, and may become less altruistic towards them. Previous work has indeed found evidence that, although conditional and unconditional cash transfers directed at women tend to reduce domestic violence towards them (Ramos, 2016), these transfers can increase some forms of violence on average, and physical violence towards some women. In the case of Mexico's Oportunidades (the expanded version of PROGRESA), Bobonis et al. (2013) find that the program decreased physical violence but increased emotional violence, while Angelucci (2008) reports no change in aggressive behavior on average but an increase for some women.

A number of studies have estimated the effect of cash transfers targeted at women on self-reported measures of female bargaining power, with mixed findings (De Brauw et al., 2014). In the case of PROGRESA, Adato et al. (2000) find that the CCT program had no durable effect on women's self-reported role in household expenditure decisions, despite some influence on *attitudes* towards women's autonomy in spending their own income.[18] Self-reported measures of control over household expenditure

[17] Bobonis (2011) estimates that the effect of PROGRESA on marital dissolutions was modest in the short run (an increase by 0.32 percentage points in two years).

[18] More specifically, Adato et al. (2000) find that, when asked: "When the woman has some extra income, do you think that...she should decide how to spend it?/she should give it to her husband?/they should decide together how to spend it?", PROGRESA beneficiaries are more likely to answer that the woman should decide and less likely to answer that she should give the money to her husband, in May 1999 (after just over one year of implementation). In October 1998, after six months of implementation, PROGRESA beneficiaries are instead *less* likely to answer that the wife alone should decide. Turning now to the woman's self-reported role in decisions regarding expenditure on durable goods, house repairs, child clothing, and food, estimates are mixed in the October 1998 wave, and there is no statistically significant effect of PROGRESA on any of these dimensions in May 1999.

decisions may however not be very informative. In the panel of households we use in our analysis, the correlation coefficient between a binary indicator for whether the wife (the husband) is "in charge of household expenditure" and its 6-month lag is 0.040 (0.066). If answers to these questions were reasonable proxies for female bargaining power, then one would expect a degree of persistence, which does not appear to be the case here.

If mother and father care differently about the utility of their children, then a change in the bargaining power of one of the parents may also result in changes in children's resource shares. Either or both parents may also increase the weight they put on the child's utility through a labeling effect of PROGRESA's transfers (Kooreman, 2000; Benhassine et al., 2015), or through pressure from local program implementers to spend the transfers on children (Schmook et al., 2018). Finally, another channel through which individual resource shares within the household may be affected by an educational CCT such as PROGRESA is by lending children more say in household expenditures through an increase in the share of household income that is attached to their actions. PROGRESA education transfers are conditional on 85% attendance. In addition, one of the PROGRESA rules was that the child becomes ineligible if they repeat a class twice, and therefore it is indirectly conditional on performance at school. Even without assuming that the children have any bargaining power, parents may want to put more weight on the children's wellbeing simply because a CCT introduces a financial return to their ability to attend–and, to a lesser extent, perform reasonably well at school.

4.2 Data

One particularly attractive feature of PROGRESA is that, in the early stages, localities were randomized into the program, and several waves of a rich household survey were administered to the experimental sample (in both treated and control areas). Five hundred and six localities out of the initial rollout were selected into the evaluation sample, of which 320 were randomly allocated to the treated group (early beneficiaries) and 186 to the control group (late beneficiaries). In each of these localities, all households were interviewed in each survey wave, i.e. every six months or so until November 2000, and then again in 2003 and 2007.

In order to obtain a causal estimate of the effect of PROGRESA on resource shares, we use the

Encuesta de Evaluación de los Hogares (ENCEL) for the three waves during which PROGRESA is being implemented in the treated areas while the control areas are not yet treated, namely: October 1998, May 1999, and November 1999. Transfers to eligible households in treatment villages started in March/April of 1998, and eligible households in treatment areas were included in the program in November/December of 1999. In order to limit anticipation effects, households in control villages were only informed of their incorporation into the program two months before (Gertler et al., 2012). Attanasio et al. (2012b) test for anticipation effects and find no evidence of such effects. In addition, there is no sign of household expenditure "catching up" in control areas relative to treatment areas as of the last survey wave used here– PROGRESA households have a total expenditure 10.5% (21.3%) higher in October 1998 (November 1999) compared to control households. Still, our model estimates the effect of being in a PROGRESA village separately for each wave, and therefore we allow the program's effect to vary over time.

Although there are more survey waves than the ones we use, we are limited by data availability as the detailed expenditure data we require are only available from October 1998. We restrict the sample to eligible households (based on the means-test applied in October 1997) in both treated and control areas, who have a male household head, for whom we have non-missing data for all the variables used in the analysis and whose expenditures data pass minimal validity tests.[19]

Table A-1 (Appendix E) reports summary statistics for all the variables used in the analysis, by treated and control villages. The level of parental education is quite low in this population, and fairly similar between men and women, with a mean of between 1.20 and 1.34 for the education variable which takes values 0 for no schooling, 1 for less than completed primary schooling, 2 for completed primary schooling, and 3 for anything above that. On average over the period covered by our data, control households had 3.32 children, with an average child age of 6.14 years. In our sample as in the overall PROGRESA sample, there are some differences in the geographical distribution of control and treatment areas across states. Consistent with the randomization of PROGRESA, differences in other predetermined variables such as parental education and age are small.

Households in treated villages have substantially higher total expenditure, and increasingly so (from

[19]More specifically, we drop households with invalid (i.e., zero) food expenditures, households who do not report any non-food expenditure, and 49 households with outlying values of any of: food expenditures, other 7-day recall, 1-month recall, or 6-month recall expenditures, or suspiciously high values for expenditures on women's, men's or children's clothing and shoes.

10.5% higher in October 1998 to 21.3% higher in November 1999).[20] Although not shown here, in treated villages, households have 0.16 more children enrolled in school than in control villages (an increase by 9.6%).

Expenditure shares on clothing are small, as would be expected given that the households considered are poor, but are increasing over time, and higher in treated villages than in control villages. In 1999, expenditure on clothing and footwear corresponds to between 5 (control villages) and 6 (treated villages) percent of total household expenditure.

4.3 Suitability of the Model and Identification Assumptions to the PROGRESA Context

The short time span covered by our three data waves (October 1998 to November 1999), and the limited ability of the households in our dataset to borrow and save fits our static model approach. Only 2.6% (5.4%) of the households in our dataset report that any of their members borrowed (saved) any money in the previous 6 months, when asked (which was the case in the November 2000 ENCEL survey, and thus shortly after the end of our study period). In addition, Attanasio et al. (2012b) find no evidence that households in control villages change their behavior before PROGRESA is rolled out to their villages, since their structural model does not fit the data better when they allow control households to anticipate the transfers. This could be due either to control households being liquidity constrained, or to them not being aware that they are about to become eligible for PROGRESA. In Appendix B, we present a reduced-form test where the possibility that households may not anticipate future transfers due to lack of information rather than due to liquidity constraints is unlikely. In order to do so, we exploit the fact that the educational component of PROGRESA only kicked in when children reached Grade 3, and that this should have been well-known by parents of school children. While imprecise, our estimates suggest that households in PROGRESA villages only consume expected grant income once they start receiving this income. This provides further support for the hypothesis that, in our setting, a static model is a reasonable approximation to the household's maximization problem.

[20] Transfers increased with child age, female gender, and over time. During the first half of 1998 (second half of 1999), education transfers ranged from 130 (160) pesos every two months for a male third-grader to 480 (610) pesos for a girl in the third year of secondary school (Attanasio et al., 2012b).

Another key assumption we make, as others have before us, is that resource shares do not vary with total household expenditure, although, as noted by Dunbar et al. (2013), they may vary with variables related to total expenditure such as income from PROGRESA or other sources. Given that our sample is restricted to households who met a means-tested eligibility test at baseline (and were therefore eligible for PROGRESA in treated villages), there is less variation in total household expenditure than across the general population, which makes this assumption more realistic. Households in PROGRESA villages experienced substantial increases in income as a result of the program, and we allow resource shares (and all the Engel curve intercepts and slopes) to vary with PROGRESA.

Our identification approach allows the possibility that PROGRESA changed preferences. What we require is that preferences for clothing and footwear, if affected by PROGRESA, be affected in the same way between the October 1998 and November 1999 waves–recalling that these are three 'post-treatment' waves in the sense that PROGRESA villages are treated in all three periods and that the remaining villages act as control villages throughout this period. We do not make assumptions on the way preferences for other goods may change during this period.[21]

Our identification strategy also accommodates the possibility of price variation as long as it is in line with the discussion in Section 3.3. For instance, PROGRESA may affect prices without restriction as long as any price change is constant between October 1998 and November 1999. Our assumption that φ_ℓ is constant across the three waves is more likely to hold when prices are constant, as otherwise this assumption restricts the functional form of F (see Section 3.3). Food accounts for 79% of total household expenditure in our sample, and the ENCEL surveys we use collected detailed food price information as part of the expenditure module. Attanasio et al. (2013) carefully construct food price indices and expenditure shares for 8 food groupings, for each ENCEL survey. Based on the figures reported in Tables 2 and 3 in Attanasio et al. (2013), the Stone price index for food is largely unchanged between the first (October 1998) and last (November 1999) panel wave used in our analysis (1.942 to 1.946), suggesting low price variation during the study period.[22]

[21]De Rock et al. (2017) reject the implications of the collective household model in some but not all PROGRESA panel waves, which they suggest may be due to PROGRESA having an effect on preferences. Their test of the implications of the collective household model however relies on the untestable assumption that two variables, including whether the village receives PROGRESA, are valid distribution factors and thus do not affect preferences.

[22]In Appendix Section A.3, we present a fully specified example of a household maximization problem which meets all our identification assumptions and allows a subset of prices, including food prices, to vary.

Finally, for identification we require variation in the resource shares between panel waves to ensure point identification (i.e., we require the non-singularity of matrix Λ, Assumption 5 in Appendix A.1). Such variation may come, for instance, from children having more say in consumption decisions over time as their cognitive ability increases and from changes in children's nutritional needs, as discussed in Section 3.2. The American Heart Association nutritional guidelines imply an average annual increase in caloric needs between 3 and 8% between the ages of 1 and 18, varying by gender and–non-linearly–by age (Gidding et al., 2005). It therefore seems reasonable to assume that resource shares increase (non-linearly) with a child's age and do so between panel waves six months apart. We estimate, in each panel wave, how resource shares vary cross-sectionally with the average age of children in the household, and find that children's resource shares increase by between 1 and 2 percentage points for an additional average year of age.[23]

4.4 Estimation

With three survey waves, we can identify the resource shares of the adult female, adult male, and children separately. As explained in Section 3.2, we adopt a PIGLOG specification for the indirect utility functions which results in the following system of estimating equations (obtained from Equations (3), (8), (9), and assuming $p_{\ell t}\varphi_{\ell t} = p_\ell \varphi_\ell \neq 0$):[24]

$$\begin{aligned} w_{ft} &= \eta_{ft}(a_{ft} + b_f ln(\eta_{ft})) + b_f \eta_{ft} ln(y_t) + \varepsilon_{ft} \\ w_{mt} &= \eta_{mt}(a_{mt} + b_m ln(\eta_{mt})) + b_m \eta_{mt} ln(y_t) + \varepsilon_{mt} \\ w_{ct} &= (1 - \eta_{ft} - \eta_{mt})(a_{ct} + b_c(ln(1 - \eta_{ft} - \eta_{mt}) - ln(s_t))) \\ &+ b_c(1 - \eta_{ft} - \eta_{mt}) ln(y_t) + \varepsilon_{ct} \end{aligned} \tag{10}$$

[23]See Appendix A.3 for a fully specified example meeting all our model assumptions and in which the changing nutritional needs of children alter resource shares over time.

[24]The system of equations found in (10) is very similar to that of DLP under their SAT restriction, i.e., the assumption that preferences are similar across household size for men, women, and children. However, the assumptions we impose on the indirect utility function to obtain this estimating system are different. More precisely, SAT imposes strong restrictions on cross-price effects in the demands for the private goods which is not the case here.

for $t = 1,2,3$ and where $w_{\ell t}$ denotes the budget share of the private assignable good of individual $\ell = f,m,c$ at time t and $\varepsilon_{\ell t}$ captures unobserved heterogeneity. Estimating the model given data on $w_{\ell t}$ and y_t, we obtain estimates of slopes with respect to $\ln(y_t)$. For three waves, we thus obtain a system of 9 equations (one for each estimated slope) in 9 unknowns (6 resource shares η_{nt}, $n = f,m$ and 3 b_ℓ, $\ell = f,m,c$) under the identification assumption that b_ℓ is allowed to vary across individuals but not over time.

In the empirical application, each parameter $a_{\ell t}$, b_ℓ and $\eta_{\ell t}$ is modeled as a linear combination of 17 covariates (a constant, the number of children in the household, a PROGRESA village dummy, 6 state indicator variables, education of head and spouse, age of head and spouse, share of daughters among children, average child age, an indicator variable for whether the household's head is indigenous, and an indicator variable for whether the village was affected by a drought in the six months preceding the survey). In this case, estimating the model given data on the covariates, $w_{\ell t}$ and y_t allows us to estimate one slope with respect to $\ln(y_t)$ per variable included in the model so that we have 9 equations in 9 unknowns for each of these variables.

The inclusion of this rich set of covariates (including household size) allows preferences and resource shares to vary flexibly across households. In addition, this flexible specification can also be thought of as controlling for variation in prices across space and over time to the extent that households with different characteristics (such as state of residence or whether recently hit by a drought) may be exposed to different relative prices. Allowing the intercept of the $a_{\ell t}$ and $\eta_{\ell t}$, $\ell = f,m,c$ to vary by panel wave also allows for a range of seasonal effects.

One issue in the estimation of Engel curves is the question of endogeneity of the total expenditures, y_t. This endogeneity may stem from either measurement error in total expenditure or unobserved heterogeneity. In order to account for the endogeneity of total expenditure, we instrument it with the log of average laborer's daily wage at the village level as in Attanasio and Lechene (2014) and estimate the system using Hansen (1982)'s Generalized Method of Moments.[25,26] As shown in Attanasio and

[25]To be more precise, we use the moment condition $E[\varepsilon|Z] = 0$, where ε, is the vector $\varepsilon = (\varepsilon_{ft}, \varepsilon_{mt}, \varepsilon_{ct})'$ for $t = 1,2,3$ and Z is the vector of instruments which contains the exogenous variables in our model and the instrument, average laborer's wages in the village, for $t = 1,2,3$. In order to improve efficiency, we use optimal instruments. Optimal instruments are given by the derivatives of the moment conditions with respect to the parameters up to a scale factor. Following Dunbar et al. (2013), we compute the derivatives using nonlinear seemingly unrelated regression (NLSUR) estimates and then use them in the GMM estimation.

[26]Our rich specification gives us a system of 9 equations with 306 parameters to estimate. Hence, the estimation is

Lechene (2014), average laborer's wages in the village is a valid instrument under the assumption that consumption and leisure are separable in the household's utility function. This assumption is implicit in the maximization problem presented in Section 2, since the household utility function does not depend on hours worked, as in Browning et al. (2013), Dunbar et al. (2013), and Attanasio and Lechene (2014).

We report standard errors allowing for arbitrary correlation of the error terms within household as well as, in the case of the coefficient associated with the PROGRESA indicator, standard errors allowing for arbitrary correlation within village, since PROGRESA was randomly allocated or not to the whole village.

5 Results

5.1 Effect of Covariates on Resource Shares

In Table 1, we present our main regression estimates. We first report estimates of the constant coefficient in the linear combinations which compose the resource shares in our estimating equations. The coefficients associated with the constant correspond to the average resource shares for adult females, adult males, and children for the reference household, defined as a household in a control village with all other covariates set at the sample mean (for continuous variables) or mode (for categorical variables). We then show estimates of how these shares vary with the number of children in the family, and estimates of the effect of PROGRESA. In control areas, the average resource share of mothers in the reference household varies between 32.4% to 41.3% of the household expenditure over the three waves of the survey, and is, on average, somewhat larger than that of the father, which varies over time between 27.4% and 41.3%. Average children's shares vary between 24% and 40.2% of total household expenditure, and increase by between 2.9 and 4.9%-point per additional child. Given the non-negligible amount of variation over time, it appears to be empirically important to measure resource shares at different points in time to obtain a fuller picture of intrahousehold resource allocation.

We find that, in the first and last periods, PROGRESA decreased women's shares by 3.8 to 6.9%-points, while children's shares increased by about 3.6 to 4.7%-points due to PROGRESA. These effects

performed by author-written code in MATLAB.

on mothers' shares are statistically significant even when allowing for arbitrary correlation in the error terms within village (which should be done when analyzing the effect of PROGRESA because the program was randomly allocated at the village level), while the effect on children's shares becomes statistically insignificant when using standard errors clustered at the village level. The point estimates on the effect of PROGRESA on men's shares are positive but small in all time periods (between 0.2 and 2.2%-points) and statistically insignificant. The estimated effect of PROGRESA on resource shares during the second time period are all statistically insignificant. F-tests of pairwise equality of (PROGRESA) treatment effects between survey waves lead to the rejection (at the 5% significance level) of the null of equal effects on women's shares in all three pairwise comparisons, and in two out of three pairwise comparisons for children's shares, again suggesting that conclusions may vary over time and hence that studying more than one time period helps avoid misleading interpretations. One possible explanation for these results is that the effect of PROGRESA on resource shares has a seasonal component, but note that we allow the intercept of the $\eta_{\ell t}$, $\ell = f,m,c$ to vary by panel wave and thus capture seasonal changes in resource shares that are independent of PROGRESA.

A joint F-test of significance of the effect of PROGRESA on each of the three individuals' resource shares across the three time periods rejects the null of no effect for women, but not for men or children.[27] There is therefore clear evidence that PROGRESA reduced mothers' resource shares to the benefit of the other members of the household. The relative magnitude of estimated effects for men and children suggests that the reduction benefited children more than adult men, but the F-test results indicate that we cannot be as conclusive regarding whether children specifically benefited from the reduction in their mothers' shares. Recall that the average increase in total household expenditure in PROGRESA villages is about 16.4% (see Table A-1). Therefore, PROGRESA may increase mothers' consumption despite a decrease in their expenditure *share*, and indeed we find that it did. We return to this point in Section 5.3 below.

Turning now to the effect of demographic characteristics on resource shares (Table A-3 in Appendix E), we find that older individuals have lower resource shares to the benefit of their spouses, while none of the adults' age influences much children's shares (except for one significant, positive coefficient associ-

[27]The test statistic for the null of no joint effect of PROGRESA on women's shares across the three time periods is 13.15 with standard errors clustered at the village level (79.06 with standard errors clustered at the household level), that for children is 2.03 (12.23) and that for men is 0.72 (4.35), for a $\chi^2(3)$ critical value of 7.82 for a 5% significance level.

ated with the effect of mother's age on children's shares in October 1998). These findings echo those of Calvi (2017), who finds that adult women's consumption shares decrease with age in India. And similar to both Dunbar et al. (2013) and Calvi (2017), as the proportion of daughters among children increases, mothers' shares tend to increase. Although none of the coefficients associated with the effect of daughters' share on *children*'s shares is individually statistically significant, children's shares tend to decrease when more of the children are daughters. This may stem from a degree of son preference, so that women (have to) give up some of their consumption to the benefit of their sons and/or from sons having more bargaining power than daughters. Children's mean age increases the children's share mostly to the detriment of fathers. We also find that men's shares increase with their level of education (significantly so in two out of three time periods), but the other effects of socioeconomic characteristics (parental education and indigenous household head) are inconclusive.[28]

5.2 Robustness Checks

As explained in Section 3, we identify the resource shares off the slopes of the Engel curves with respect to the logarithm of total expenditures. It is therefore important to ensure that all these slopes are non-zero. It is the case here. Recall that each b_ℓ, $\ell = f,m,c$ slope in the estimated system of equations (10) is a linear combination of 16 demeaned/demoded variables plus a constant. We find that all 3 coefficients associated with the constant term in each one of these three slopes (one for each type of individual) are statistically significant with p-values below 0.01.

It should be expected from a complex nonlinear model such as the one we estimate that the objective function may exhibit local minima, and results obtained at different local minima may differ. We therefore carried out extensive checks using 600 different starting values for the parameters of the model and report here the results for which the optimization led to the lowest function value, as in Cherchye et al. (2012) and Dunbar et al. (2017). Reassuringly, although estimates vary across local minima, the general pattern is qualitatively similar across the board (see Appendix C for full details).

[28]The variability of the effect of parental education across waves may be explained in part by the fact that we are restricting the sample to poor households (as non-poor households are not eligible for PROGRESA). While parental education is significantly positively correlated with total expenditure in the ENCEL sample including both poor and non-poor households, it is not so among the poor, especially when considering maternal education. This suggests that parents with high education levels who are nonetheless poor, and therefore included in our sample of households eligible for PROGRESA, may have other characteristics that appear to have negative consequences for the household's standard of living.

5.3 Average Resource Shares and Individual Consumption

In Section 5.1, we discussed estimates of the level of resource shares in the reference household, as well as the effect of PROGRESA and demographic and socioeconomic characteristics of the household on these shares. We now use these estimates to compute average resource shares across households in treated and control villages, as well as individual poverty rates which take into account the potential unequal distribution of expenditure between household members.

As shown in Table 2, women's shares tend to be larger than men's shares, except for the last wave, where women's shares are substantially lower than men's shares in PROGRESA villages. Over the three time periods, the average resource share of women is 3 percentage points lower in PROGRESA villages, while children's resources shares go up by 3 percentage points (from 29% to 32%). Men's resources shares are unchanged at 34%-points in both treated and control villages. The figures reported imply that, on average over the three time periods, each child consumes between 9.7% (in control areas) and 10.4% (in treatment areas) of the household's resources.

As a point of comparison, existing estimates of women's resource shares vary from substantially lower than men in Malawi and India (Dunbar et al., 2013; Calvi, 2017) to somewhat smaller than men in the US (Cherchye et al., 2015; Voena, 2015) and in the UK (Lise and Seitz, 2011), slightly larger for women in Cote d'Ivoire (Bargain et al., 2014), and substantially larger than men's in France and in Canada (Bargain and Donni, 2012; Browning et al., 2013). It is important to note that our consumption data excludes leisure, as in most related work. It is therefore possible that women, while consuming a slightly larger share of non-durable and semi-durable household expenditure more than compensate through work–predominantly domestic work given that less than 5% of women in our sample have a job.

Reassuringly, out of 24,471 resource share estimates (one for each of three time periods, for three types of individuals in each of 2,719 households), only 6 shares are negative, and none is larger than one, although we do not restrict individual shares to fit a particular range of values in the estimation. With a maximum of 0.75 for any single individual in any given period, the range of the estimated resource shares also appears reasonable.

Finally, estimates of individual consumption obtained by multiplying individual resource shares by total household expenditure show that, on average, children, men and women in PROGRESA villages have higher individual consumption than individuals in control villages, but that these consumption gains are distributed unequally between women, men, and children (see Table A-4 in Appendix C). Children benefit most from PROGRESA (by a 27.8% increase in expenditure from 3236.03 to 4134.97), followed by men (17.8% increase in expenditure from 3552.96 to 4186.72), and then women (5.8% increase in expenditure going from 3963.83 to 4193.97). Unsurprisingly, in this sample of households who qualified as poor enough to be eligible for PROGRESA, poverty rates are high, and the increases in total expenditure achieved by PROGRESA lower poverty rates, but most beneficiaries remain below the poverty line (see Appendix D for a detailed poverty analysis).

Recall that while, on average, PROGRESA households in our sample have an additional 0.16 child enrolled, we do not control for the number of children enrolled in school. While it would be important to do so if we were using PROGRESA as a distribution factor (and thus requiring it not to affect preferences after conditioning on the other regressors), we do not condition on this endogenous regressor in our estimation. Instead, we interpret our estimate of the effect of PROGRESA as including any effect that may arise through increased schooling. It is however interesting to note that our results are not simply driven by increases in school-related expenditure. Indeed, the increase in children's consumption in treated relative to control areas amounts to 899 pesos per year, on average over the three waves. Based on the information contained in the ENCEL household and locality surveys, we can calculate the approximate cost of schooling an extra child, including school fees, uniforms, school supplies and other school contributions. Even assuming that each enrolled child requires as many as 6 uniforms per year, the total annual cost of schooling an extra 0.16 child is only 72 pesos per year, or 8% of the estimated increase in child consumption.

6 Discussion

In this section, we first check whether our conclusions regarding the effect of PROGRESA are specific to our identification approach, or whether a similar qualitative pattern emerges from the data when each time period is considered individually and identification relies on interpersonal stability of preferences. We then discuss the interpretation of our results under the realistic assumption that parents are altruistic towards their children and towards each other.

6.1 Comparison with Results Obtained When Assuming Stable Preferences Between Individuals and Tests of SAT/SAP

When repeated observations are not available, it is not possible to use the identification approach proposed here, while identification of resource shares can still be achieved by assuming that preferences are stable between individuals, as in Dunbar et al. (2013). Table A-6 in Appendix E presents the results obtained when estimating, panel wave by panel wave, a system of three Engel curves (one for each household member) similar to System (10), but where the slopes are assumed to be the same for men, women and children ($b_f = b_m = b_c$)–i.e., similar across people–and do not depend on family size–i.e., are similar across household type. While none of the coefficients obtained with this alternative approach are statistically significant, the qualitative pattern is similar independently of the identification approach used: out of 9 coefficients associated with PROGRESA, only two have different signs compared to our results in Table 1–men's shares in October 1998 (-0.003 instead of 0.002) and in November 1999 (-0.011 instead of 0.022)), and these two coefficients are statistically insignificant in both models.

In addition, under our assumption that preferences are similar over time, we can test the assumption that preferences are similar between individuals (Dunbar et al. (2013)'s "SAP" assumption) or similar between household types (Dunbar et al. (2013)'s "SAT" assumption). In a Wald test of the null that the three coefficients associated with the number of children in the three b_ℓ slopes are all equal to zero, the test statistic is equal to 1.86 for a 5% critical value of 7.82. Thus we cannot reject SAT. But we reject the null that all the coefficients associated with each of the covariates entering b_ℓ are the same for men, women, and children, and thus reject SAP as our test statistic is equal to 2409 compared to a 5% critical value of of 48.60. These findings echo those of Bargain et al. (2019), who find support for some versions of SAT but not SAP when comparing estimated resource shares with observed resource shares in Bangladesh.

6.2 Interpretation in the Context of Caring Preferences

If we believe that women, men and children only care about their own utility (egoistic preferences), then our findings on the effect of PROGRESA on individual resource shares should be interpreted as a decrease in the bargaining power of mothers relative to the other household members–especially relative to children. But in the arguably more realistic context of "caring" preferences, whereby the total utility of individual ℓ depends on the utility of some or all of the other household members, these findings do not necessarily imply that women's bargaining power has decreased, or that the bargaining power of children has increased.

The formulation in maximization problem (1) is compatible with caring preferences such that individuals derive utility from the utility of other household members.[29] While Pareto weights are often interpreted as indicators of the bargaining power enjoyed by the individual to which individual utility they are attached to, they may depend instead or as well on how much other household members value the individual's utility. For instance, one may prefer to think of the Pareto weight attached to the children's utility function as resulting only from the caring preferences of their parents towards them. To fix ideas, consider the simple case of caring preferences such that the total utility of adult $n = f,m$ can be expressed as

$$W_n = U_n(x^n) + \tau_n^{-n} U_{-n}(x^{-n}) + \tau_n^c U_c(x^c)$$

where $\tau_n^{-n} \in (0,1)$ captures the response of adult n's utility to an increase in the utility of the other adult (denoted $-n$), $\tau_n^c \in (0,1)$ captures the response of adult n's utility to an increase in the utility of children– i.e., how "caring" parents are towards their children.[30] In this case, the household's total utility function $\tilde{U}_s$ (omitting $\tilde{U}_s$'s arguments to simplify notations) is:

$$\begin{aligned} \tilde{U}_s &= \mu W_f(x^f) + (1-\mu) W_m(x^m) \\ &= (\mu + (1-\mu)\tau_m^f) U_f(x^f) + ((1-\mu) + \mu\tau_f^m) U_m(x^m) + (\mu\tau_f^c + (1-\mu)\tau_m^c) U_c(x^c) \end{aligned} \tag{11}$$

where μ denotes the woman's bargaining power. With this type of caring preferences, the Pareto weight associated with the woman's individual utility function $U_f(x^f)$ depends not only on her bargaining power μ but also on the extent to which her husband values her utility (τ_m^f), and the Pareto weight associated with the man's individual utility function $U_m(x^m)$ depends not only on his bargaining power $1-\mu$ but also on the extent to which his wife values his utility (τ_f^m). The Pareto weight associated with the children's utility function depends on their parents' degree of caring for children's utility, weighted by each parent's

[29]What the problem formulation does not allow is for individual ℓ's total utility to depend directly on the *consumptions* of other household members ($x^{\ell'}$, $\ell \neq \ell'$).

[30]This example is based on the two-person household example found in Browning et al. (2006).

relative bargaining power.

In the example represented by Equation (11), the woman's bargaining power μ may increase due to PROGRESA while her resource share decreases, as long as fathers care sufficiently less about mothers' utility due to PROGRESA.[31] It seems plausible to expect men to feel more that women should fend for themselves now that PROGRESA pays out large transfers to them, as suggested by Schmook et al. (2018) and by evidence that, for some women or some types of aggressive behavior, being the recipient of cash transfers increases intimate partner violence (Angelucci, 2008; Bobonis et al., 2013; Hidrobo and Fernald, 2013). Similarly, the increase in children's resource shares may stem from an increase in women's (men's) bargaining power combined with mothers (fathers) being more caring towards their children than men (women), or from an increase in the weight put by either or both parents on the wellbeing of children, or a combination of both. Given the pressure said to be exerted by local implementers for recipients to spend PROGRESA transfers on their children (Schmook et al., 2018), it seems especially likely that the weight mothers put on children's utility should increase with PROGRESA. Given the very low incidence of marital dissolution and the quasi-universal reliance of women on their husbands for income in our sample, it is not surprising that we do not find that women's resource shares increased due to PROGRESA. Both features of the data (low incidence of marital dissolution and reliance on male earnings) are common to many developing country settings. This and recent evidence from a range of poor countries suggests that social transfers targeting women may only have limited success in redistributing resources towards them. While studies using data from developed countries have found that an increase in the relative income of one spouse tends to increase their bargaining power (e.g., Lise and Yamada, 2014), recent evidence suggests that it may not necessarily be the case when considering income from social transfers in poor countries. Out of four recent field experiments in which the gender of the recipient of conditional or unconditional cash transfers was randomized, three studies set in Africa do not find any effect of the recipient's gender on outcomes related to expenditures on food, health, or education (Akresh et al., 2012; Benhassine et al., 2015; Haushofer and Shapiro, 2016), while Armand et al. (2016) find that, in Macedonia, food expenditure shares increase by 6.8% when the recipient is female.[32]

[31] Recalling from Section 2 Browning et al. (2013)'s result that there is a one-to-one correspondence between Pareto weights and resource shares.

[32] Out of these four studies, only two estimate the effect of the gender of the recipient on food expenditure (Haushofer and Shapiro, 2016; Armand et al., 2016). Haushofer and Shapiro (2016) report a minimum detectable effect size for this outcome

7 Conclusion

Household-level consumption is a poor measure of individual consumption if resources are unequally distributed within the household. Individual consumption data are however not normally available. Estimating individual consumption based on the typically available household-level expenditure data requires assumptions on preferences that are often difficult to justify. Previous literature has achieved point-identification of individual resource shares of adult men, women, and children by assuming that different individuals have similar preferences, or by assuming that some variables (distribution factors) affect the distribution of resources within the household but do not influence preferences. We allow preferences to vary between different types of individuals and do not rely on the existence of valid distribution factors. Instead, we propose a new assumption on preferences which is intuitively appealing–restricting the way preferences vary over time within individual types, and which exploits increasingly available repeated cross-sectional and panel data.

Applying our method to estimate the effect of PROGRESA, we find that, on average, the CCT benefited all individuals in eligible households, but that children benefited from the largest increase in consumption (27.8%), followed by their fathers (17.8%) and, to a much lesser extent, their mothers (5.8%), thus suggesting that part of the beneficial effects of PROGRESA on child outcomes is a result of the redistribution of household resources towards children. These findings also echo those of recent studies highlighting the limits of social transfers programs targeted at women as a tool to improve women's bargaining power in poor countries.

of 20% of the control group mean, and therefore lack power to detect an effect of the magnitude found by Armand et al. (2016).

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Table 1: Resource Shares in Reference Household, Effect of Household Size and Effect of PROGRESA

	Mothers		Fathers		Children	
	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient	Std Err.	Coefficient	Std Err.	Coefficient	Std Err.
October 1998						
Constant	0.413	0.004	0.347	0.005	0.240	0.009
Additional child	-0.012	0.008	-0.017	0.007	0.029	0.015
PROGRESA	-0.038	0.009	0.002	0.009	0.036	0.017
		(0.021)		(0.022)		(0.043)
May 1999						
Constant	0.324	0.008	0.274	0.0123	0.402	0.018
Additional child	-0.013	0.010	-0.020	0.010	0.033	0.019
PROGRESA	0.027	0.013	0.003	0.013	-0.030	0.026
		(0.032)		(0.032)		(0.064)
November 1999						
Constant	0.342	0.004	0.413	0.006	0.246	0.009
Additional child	-0.022	0.016	-0.027	0.015	0.049	0.031
PROGRESA	-0.069	0.010	0.022	0.011	0.047	0.020
		(0.024)		(0.027)		(0.050)

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999. Sample size: 2719 households. System 10 estimated by the Generalized Method of Moments using the log of average laborer's daily wage at the village level as an instrument for total expenditure, and controlling nonlinearly for a constant, the number of children, a PROGRESA village dummy, 6 state indicator variables, education of head and spouse, age of head and spouse, an indicator for whether the head of the household is indigenous, share of daughters among children, average child age, and an indicator variable for whether the village was affected by a drought in the six months preceding the survey. Standard errors allowing for arbitrary correlation of the error terms within village are reported in parenthesis. The other standard errors in Columns (2), (4) and (6) allow for arbitrary correlation of the error terms within household. The constant can be interpreted as the resource share for a household in control villages in the largest state (Veracruz) with all other characteristics set to their average (for continuous variables) or modal value (for binary variables).

Table 2: Estimated Resource Shares

	(1) Control Areas				(2) PROGRESA Areas			
	mean	sd	min	max	mean	sd	min	max
October 1998								
Women	0.45	0.050	0.22	0.61	0.40	0.050	0.21	0.59
Men	0.36	0.072	0.15	0.55	0.36	0.074	0.13	0.58
Children	0.20	0.087	-0.01	0.45	0.24	0.088	0.00	0.50
May 1999								
Women	0.33	0.089	0.09	0.65	0.35	0.086	-0.00	0.75
Men	0.30	0.072	-0.00	0.55	0.31	0.066	0.04	0.50
Children	0.37	0.116	0.05	0.65	0.34	0.111	0.02	0.71
November 1999								
Women	0.35	0.053	0.18	0.51	0.27	0.052	0.04	0.46
Men	0.35	0.102	0.08	0.62	0.36	0.102	0.05	0.63
Children	0.30	0.116	0.01	0.67	0.36	0.118	0.05	0.91
Average over Time								
Women	0.37	0.048	0.16	0.55	0.34	0.046	0.14	0.51
Men	0.34	0.072	0.10	0.54	0.34	0.070	0.11	0.56
Children	0.29	0.099	0.03	0.56	0.32	0.097	0.05	0.75
One Child	0.097	0.044	0.02	0.40	0.104	0.052	0.04	0.50
N	1022				1697			

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999. Predicted resource shares based on estimates from system 10 estimated by the Generalized Method of Moments using the log of average laborer's daily wage at the village level as an instrument for total expenditure, and controlling nonlinearly for a constant, the number of children, a PROGRESA village dummy, 6 state indicator variables, education of head and spouse, age of head and spouse, an indicator for whether the head of the household is indigenous, share of daughters among children, average child age, and an indicator variable for whether the village was affected by a drought in the six months preceding the survey.

Appendices

For Online Publication

A Identification in the General Case

In Section 3.2, we discussed identification under Assumptions 1 and 2 for a commonly used functional form for the indirect utility function. In this appendix section, we present our nonparametric identification results (Sections A.1 and A.2) an provide an example model which satisfies our identification assumptions (Section A.3).

A.1 Assumptions and Identification Theorem (Theorem 1)

In addition to Assumptions 1 and 2, we need to introduce some further assumptions.

Assumption 3 *For $\ell \in \{f, m, c\}$ and $t = 1, ..., T, T \geq 3$, the indirect utility function of person ℓ is given by:*

$$V_{\ell t} = \psi_{\ell t} \left[\nu_{\ell} \left(\frac{y_t}{G_{\ell t}(p_t)} \right) + F_{\ell t}(p_t), \tilde{p}_t \right] \tag{12}$$

where

- *$\tilde{p}_t$ denotes the vector of prices at time t excluding the prices of the three private assignable goods, x_c, x_f and x_m.*
- *$G_{\ell t}$ is nonzero, differentiable and homogenous of degree 1.*
- *ν_{ℓ} is differentiable and strictly increasing.*
- *$F_{\ell t}(p_t)$ is differentiable, homogenous of degree zero and satisfies $\partial F_{\ell t}(p_t)/\partial p_{\ell t} = \varphi_l(p_t) = \varphi_l(p_{t'}) \neq 0$ for $t \neq t'$. In words, its derivative with respect to the price of good x_{ℓ} may differ from one individual $\ell = f, m, c$ to the other, but it may not vary over time.*

Except for the absence of restrictions on the stability of $\nu_{\ell}(.)$ and $\varphi_{\ell}(.)$ across individuals, this indirect utility function is similar to that used by Dunbar et al. (2013) for expenditure levels below a certain threshold. Since, in both their case and ours, identification comes from households with expenditure levels below this threshold, for simplicity we do not add an unrestricted portion of the indirect utility function for higher expenditure levels. Given that all the households in our sample are eligible for PROGRESA and thus poor, our indirect utility function is consistent with any utility function for higher levels of expenditure than those observed in our data. We do not impose any restrictions on preferences for goods other than the three private assignable goods required (clothing and footwear in our application).

Instead of restricting demand functions for private assignable goods to be similar across types of individuals (male, female, and children) and/or households with a different number of children, we rely on the stability of individual preferences over short periods of time and thus assume that demand functions for assignable goods are similar over time for the same individual type (Assumption 3). We are able to do so by using repeated information on demands and preferences of individuals in the household given by repeated observations. In our case, the key assumptions are that the function $\nu_\ell(.)$ and the value of the derivative of the function $F_{\ell t}(p_t)$ with respect to the price of ℓ's private assignable good can vary across individuals but do not vary over time.

Using Roy's identity, we can write the demand function for good ℓ at time t as:

$$h_{\ell t}(y_t, p_t) = y_t \frac{\partial G_{\ell t}(p_t)}{\partial p_{\ell t}} \frac{1}{G_{\ell t}(p_t)} - \frac{\varphi_l(p_t)}{\nu'_\ell(y_t/G_{\ell t}(p_t))} \frac{G_{\ell t}(p_t)}{y_t} y_t$$

$$h_{\ell t}(y_t, p_t) = y_t \delta_{\ell t} + g_\ell\left(\frac{y_t}{G_{\ell t}(p_t)}, p_t\right) y_t \tag{13}$$

where

$$\delta_{\ell t} = \frac{\partial G_{\ell t}(p_t)}{\partial p_{\ell t}} \frac{1}{G_{\ell t}(p_t)}$$

and

$$g_\ell\left(\frac{y_t}{G_{\ell t}(p_t)}, p_t\right) = \frac{\varphi_\ell(p_t)}{\nu'_\ell(y_t/G_{\ell t}(p_t))} \frac{G_{\ell t}(p_t)}{y_t}$$

Substituting into Equation (2), it follows that the household demand for good $n = f, m$ at time t is given by:

$$H_{nt}(y_t, p_t) = \delta_{nt}(A'p_t)\eta_{nt}(p_t)y_t + g_n\left(\frac{\eta_{nt}(p_t)y_t}{G_{nt}(p_t)}, A'p_t\right)\eta_{nt}(p_t)y_t \tag{14}$$

And the household demand for good c is given by:

$$H_{ct}(y_t,p_t) = \delta_{ct}(A'p_t)\eta_{ct}(p_t)y_t + g_c\left(\frac{\eta_{ct}(p_t)y_t}{s_t G_{ct}(p_t)}, A'p_t\right)\eta_{ct}(p_t)y_t \tag{15}$$

Assumption 4 *$g_\ell(.,.)$ is $r \geq 2$ times differentiable with respect to its first argument. Denote $g_{\ell 1}^{(r)}(.,.)$ the rth derivative of $g_{\ell 1}(.,.)$ with respect to its first argument and let $\tilde{G}_{\ell t}(p_t) = 1\{\ell = f,m\}G_{\ell t}(p_t) + 1\{\ell = c\}s_t G_{\ell t}(p_t)$.*

- *Case 1: $g_\ell(.,.)$ is polynomial in $ln(y)$ such that:*

$$g_\ell\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}, A'p_t\right) = \sum_{i=0}^{I}\left(\frac{ln(\eta_{\ell t}(p_t))}{\tilde{G}_{\ell t}(p_t)} + ln(y_t)\right)^i k_{\ell i}$$

- *Case 2: $\lim_{X\to 0} X^\zeta g_{\ell 1}^{(r)}(X,.)/g_{\ell 1}^{(r-1)}(X,.) < \infty$ and the rth derivative of $g_{\ell 1}(X,.)$ is a constant.*

As in Dunbar et al. (2013)'s "Similar across People" (SAP) identification proof, assumption 4 imposes a degree of nonlinearity on $g_\ell(.,.)$ which allows us to identify the resource shares ($\eta_{\ell t}$'s). Popular demand systems such as the Almost Ideal Demand System and Quadratic Almost Ideal Demand System fall within *Case 1*, while *Case 2* is more general and encompasses *Case 1*. In *Case 2*, we depart from Dunbar et al. (2013)'s proof in that we rely on the rth derivative of $g_\ell(.,.)$ being constant, and hence we allow $g_\ell(.,.)$ to be $r \geq 2$ differentiable.

Assumption 5 *Consider the two cases given in Assumption 4. Assume that $t = 1,2,3$ and define $\rho_{\ell t}$ as follows:*

- *Under Case 1: $\rho_{\ell t} = \frac{\partial^I \tilde{H}_{\ell t}(y_t,p_t)}{\partial(ln(y_t))^I} = I!k_{\ell I}\eta_{\ell t}$ where $\tilde{H}_{\ell t} = H_{\ell t}/y_t$.*
- *Under Case 2: $\rho_{\ell t} = g_{\ell 1}^{(r)}\left(\frac{y_t}{\lambda_\ell}, A'p_t\right)\frac{\eta_{\ell t}(p_t)}{\lambda_\ell^r}$ for $\lambda_\ell \neq 0$.*

Then matrix Λ defined below is nonsingular.

$$\Lambda = \begin{pmatrix} 1 & 1 & 1 \\ \rho_{f2}/\rho_{f1} & \rho_{m2}/\rho_{m1} & \rho_{c2}/\rho_{c1} \\ \rho_{f3}/\rho_{f1} & \rho_{m3}/\rho_{m1} & \rho_{c3}/\rho_{c1} \end{pmatrix}$$

Assumption 5–which departs from Dunbar et al. (2013)'s SAP proof–is needed to guarantee that there is a unique solution to the system of equations used for identification. Given data on total household expenditure and the quantities demanded and prices of each of the three private assignable goods, under Assumptions 1 to 5 we can identify the resource shares for adult males, females, and children, provided we have at least three time periods. If we observe the value of expenditures on each of the private assignable goods, but do not observe separately the prices of these goods and the quantities demanded, then we need to further assume that the prices of the private assignable goods $p_{\ell t}$ are constant over the time period considered. Theorem 1 below states our result formally. The proof is presented in Appendix A.2.

Theorem 1 *Under Assumptions 1 to 5, the resource shares for adult male (η_{mt}), adult female (η_{ft}) and children (η_{ct}) are identified.*

A.2 Proof of Theorem 1

Recall that, under Assumptions 1, 2 and 3, the household demand for good $n = f, m$ at time t is given by:

$$H_{nt}(y_t, p_t) = \delta_{nt}(A'p_t)\eta_{nt}(p_t)y_t + g_n\left(\frac{\eta_{nt}(p_t)y_t}{G_{nt}(p_t)}, A'p_t\right)\eta_{nt}(p_t)y_t \tag{16}$$

And the household demand for good c is given by:

$$H_{ct}(y_t, p_t) = \delta_{ct}(A'p_t)\eta_{ct}(p_t)y_t + g_c\left(\frac{\eta_{ct}(p_t)y_t}{s_tG_{ct}(p_t)}, A'p_t\right)\eta_{ct}(p_t)y_t \tag{17}$$

Let us define $\tilde{H}_{\ell t} = H_{\ell t}/y_t$:

$$\tilde{H}_{nt}(y_t, p_t) = \delta_{nt}\eta_{nt}(p_t) + g_n\left(\frac{\eta_{\ell t}(p_t)y_t}{G_{nt}(p_t)}, A'p_t\right)\eta_{nt}(p_t)$$

and

$$\tilde{H}_{ct}(y_t, p_t) = \delta_{ct}(A'p_t)\eta_{ct}(p_t) + g_c\left(\frac{\eta_{ct}(p_t)y_t}{s_tG_{ct}(p_t)}, A'p_t\right)\eta_{ct}(p_t)$$

Given data on total household expenditures and quantities of private assignable goods demanded by the household, below we show that the resource shares $\eta_{\ell t}$, $\ell = f, m, c$ are identified under either of the two cases set out in Assumption 4.

Case 1:

Assume that $g_\ell(.,.)$ is a polynomial in $ln(y)$ such that:

$$g_\ell\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}, A'p_t\right) = \sum_{i=0}^{I}\left(\frac{ln(\eta_{\ell t}(p_t))}{\tilde{G}_{\ell t}(p_t)} + ln(y_t)\right)^i k_{\ell i}$$

Define $\rho_{\ell t}$ as:

$$\rho_{\ell t} = \frac{\partial^I \tilde{H}_{\ell t}(y_t, p_t)}{\partial(ln(y_t))^I} = I!k_{\ell I}\eta_{\ell t}$$

Then for $t \neq t'$, we can write:

$$\frac{\rho_{\ell 1}}{\rho_{\ell 2}} = \frac{\eta_{\ell 1}}{\eta_{\ell 2}} \Rightarrow \eta_{\ell 2} = \frac{\rho_{\ell 2}\eta_{\ell 1}}{\rho_{\ell 1}}$$

$$\frac{\rho_{\ell 1}}{\rho_{\ell 3}} = \frac{\eta_{\ell 1}}{\eta_{\ell 3}} \Rightarrow \eta_{\ell 3} = \frac{\rho_{\ell 3}\eta_{\ell 1}}{\rho_{\ell 1}}$$

for $\ell = m, k, c$.

Given that the resource shares add up to one in each period, we can write:

$$\begin{pmatrix} 1 & 1 & 1 \\ \rho_{f2}/\rho_{f1} & \rho_{m2}/\rho_{m1} & \rho_{c2}/\rho_{c1} \\ \rho_{f3}/\rho_{f1} & \rho_{m3}/\rho_{m1} & \rho_{c3}/\rho_{c1} \end{pmatrix} \begin{pmatrix} \eta_{f1} \\ \eta_{m1} \\ \eta_{c1} \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$

Under Assumption 5, we can invert the matrix Λ and recover the resource shares.

Case 2:

Let us denote $\tilde{h}_{\ell t}^{(r)} = \partial^r \tilde{H}_{\ell t}/\partial y_t^r$, then:

$$\tilde{h}_{\ell t}^{(r)}(y_t, p_t) = g_{\ell 1}^{(r)}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}, A'p_t\right)\frac{\eta_{\ell t}^{r+1}(p_t)}{\tilde{G}_{\ell t}^{r}(p_t)}$$

Define $\lambda_\ell = \lim_{\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)} \to 0}\left(\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)^{\zeta} g_{\ell 1}^{(r)}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)},.\right)/g_{\ell 1}^{(r-1)}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)},.\right)\right)^{1/1-\zeta}$, $\zeta \neq 1$

and

$$\kappa_{\ell t}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)=\left(X_t^{\zeta}\frac{\tilde{h}_{\ell t}^{(r)}(X_t,.)}{\tilde{h}_{\ell t}^{(r-1)}(X_t)}\Bigg|_{X_t=\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}}\right)^{1/1-\zeta}$$

$$\kappa_{\ell t}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)=\frac{\eta_{\ell t}(p_t)}{\tilde{G}_{\ell t}(p_t)}\left(\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)^{\zeta}\frac{g_{\ell 1}^{(r)}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)},A'p_t\right)}{g_{\ell 1}^{(r-1)}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)},A'p_t\right)}\right)^{1/1-\zeta}$$

Then the following holds:

$$\lim_{\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)\to 0}\kappa_{\ell t}\left(\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)}\right)=\frac{\eta_{\ell t}(p_t)}{\tilde{G}_{\ell t}(p_t)}\lambda_{\ell}\quad\Rightarrow\quad\kappa_{\ell t}(0)=\frac{\eta_{\ell t}(p_t)}{\tilde{G}_{\ell t}(p_t)}\lambda_{\ell}$$

Now let us define $\rho_{\ell t}=\partial\tilde{h}_{\ell t}^{(r)}(X_t,p_t)/(\kappa_{\ell t}(0))^r\Big|_{X_t=\frac{\eta_{\ell t}(p_t)y_t}{\tilde{G}_{\ell t}(p_t)\kappa_{\ell t}(0)}}$, then:

$$\rho_{\ell t}=g_{\ell 1}^{(r)}\left(\frac{y_t}{\lambda_{\ell}},A'p_t\right)\frac{\eta_{\ell t}(p_t)}{\lambda_{\ell}^{r}}$$

Assuming that $g_{\ell 1}^{(r)}$ is constant over time (Assumption 4), we have $g_{\ell 1}^{(r)}\left(\frac{y_t}{\lambda_\ell},A'p_t\right)=g_{\ell 1}^{(r)}\left(\frac{y_{t'}}{\lambda_\ell},A'p_t\right)$, for $t\neq t'$. Given data on the quantities of the private assignable goods demanded by households and total household expenditures, ρ_{ft}, ρ_{mt} and ρ_{ct} are identified for $t=1,...,T,T\geq 3$, thus we can solve for $\eta_{\ell t}$, $\ell=f,m,c$.

Using the definition of ρ and the fact that $g_{\ell 1}^{(r)}\left(\frac{y_t}{\lambda_\ell},A'p_t\right)=g_{\ell 1}^{(r)}\left(\frac{y_{t'}}{\lambda_\ell},A'p_t\right)$, for $t\neq t'$, we can write:

$$\frac{\rho_{\ell 1}}{\rho_{\ell 2}}=\frac{\eta_{\ell 1}}{\eta_{\ell 2}}\Rightarrow\eta_{\ell 2}=\frac{\rho_{\ell 2}\eta_{\ell 1}}{\rho_{\ell 1}}$$

$$\frac{\rho_{\ell 1}}{\rho_{\ell 3}}=\frac{\eta_{\ell 1}}{\eta_{\ell 3}}\Rightarrow\eta_{\ell 3}=\frac{\rho_{\ell 3}\eta_{\ell 1}}{\rho_{\ell 1}}$$

for $\ell=m,k,c$. Identification follows again from the use of Assumption 5.

A.3 Example

In this subsection, we provide an example of a maximization problem meeting our assumptions in order to fix ideas. We build upon the fully specified model presented in Dunbar et al. (2013)'s Appendix

A.4, adopting the same functional forms except for function $F_{\ell t}(p_t)$. More precisely, let the indirect utility function be:

$$V_{\ell t}(p_t, y_t) = \exp\left[\ln\left(\ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right)\right) + \frac{p_{\ell t}}{\prod_{k_1=1}^{K_1}(\tilde{p}_{1k_1})^{(a_{1k_1\ell})}} + \frac{\tilde{p}_{21t}}{\prod_{k_2=2}^{K_2}(\tilde{p}_{2k_2t})^{(a_{2k_2\ell t})}}\right] \tag{18}$$

where the prices of goods other than the three private assignable goods ℓ are split into two sets: $\mathcal{P}_1$ and $\mathcal{P}_2$. $\mathcal{P}_1$ refers to goods indexed by $k_1 = 1$ to K_1 whose price is stable during the period under study (and which needs to be non-empty but can include only one good). $\mathcal{P}_2$ refers to goods indexed by $k_2 = 1$ to K_2 whose price varies freely. This functional form satisfies the assumption that, for $\ell = f, m, c$, $\partial F_{\ell t}(p_t)/\partial p_{\ell t} = \varphi_\ell(p_t) = \varphi_\ell(p_{t'})$ for $t \neq t'$. In addition, to satisfy Assumption 3, we assume that $\varphi_\ell(p_t) \neq 0$ and that $\sum_{k_1=1}^{K_1} a_{1k_1\ell} = 1 = \sum_{k_2=2}^{K_2} a_{2k_2\ell t}$ (to ensure homogeneity of degree 0). Here we have chosen a functional form in which the prices of some goods ($\mathcal{P}_2$) only affect the demand for the private assignable goods through the individual's expenditure deflator $G_{\ell t}(p_t)$ and thus through an income effect. Our identification strategy does not require this to be the case, but this choice allows us to illustrate how our assumptions can accommodate variation in prices and in some private assignable good preference parameters during the period under study.

Taking the log of Equation (18), we obtain:

$$lnV_{\ell t}(p_t, y_t) = \ln\left(\ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right)\right) + exp\left[\ln p_{\ell t} - \sum_{k_1=1}^{K_1} a_{1k_1\ell} \ln \tilde{p}_{1k_1}\right] + exp\left[\ln \tilde{p}_{21t} - \sum_{k_2=2}^{K_2} a_{2k_2\ell t} \ln \tilde{p}_{2k_2t}\right]$$
$$= \ln\left(\ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right)\right) + \frac{exp(\ln p_{\ell t})}{exp\left[\sum_{k_1=1}^{K_1} a_{1k_1\ell} \ln \tilde{p}_{1k_1}\right]} + \frac{exp(\ln \tilde{p}_{21t})}{exp\left[\sum_{k_2=2}^{K_2} a_{2k_2\ell t} \ln \tilde{p}_{2k_2t}\right]} \tag{19}$$

And taking the exponential of Equation (19), we can write:

$$V_{\ell t}(p_t, y_t) = \ln\left(\frac{y_t}{G_{\ell t}(p_t)}\right) \times \exp(p_{\ell t} e^{(-a'_{1\ell} \ln \tilde{P}_1)}) \times \exp(\tilde{p}_{21t} e^{(-a'_{2\ell t} \ln \tilde{P}_{2t})}) \tag{20}$$

where $\tilde{P}_{2t}$ is the vector of prices $\{\tilde{p}_{2k_2t}\}_{k_2=2}^{K_2}$, $\tilde{P}_1$ is the vector of prices $\{\tilde{p}_{1k_1}\}_{k_1=1}^{K_1}$, $a_{1\ell}$ is the vector $\{a_{1k_1\ell}\}_{k_1=1}^{K_1}$ and $a_{2\ell t}$ is the vector $\{a_{2k_2\ell t}\}_{k_2=2}^{K_2}$. Turning now to the maximization problem, we follow Dunbar et al. (2013) in adopting the following general Bergson-Samuelson social welfare function, where

Pareto weight functions are denoted $\omega_\ell(p)$, $\ell = f,m,c$ and $\rho_\ell(p)$, $\ell = f,m,c$ are utility transfer or externality functions.[33]

$$\begin{aligned}\tilde{U}[U_f(x^f),U_m(x^m),U_c(x^c),p/y] &= \omega_f(p)[U_f(x^f)+\rho_f(p)]+\omega_m(p)[U_m(x^m)+\rho_m(p)] \\ &\quad +\omega_c(p)[U_c(x^c)+\rho_c(p)] \qquad (21)\end{aligned}$$

Assuming that the extent to which a good is shared does not depend on the consumption of other goods, all the off-diagonal elements of matrix A are equal to zero. Denoting A_k the kth element along the diagonal of A, and plugging in Equation (21) into the household's maximization problem of Section 2, for a given time period, the household's problem is:

$$\max_{x_f,x_m,x_c,z} \omega(p)+\omega_f(p)U_f(x^f)+\omega_m(p)U_m(x^m)+\omega_c(p)U_c(x^c) \qquad (22)$$

$$\text{such that} \quad z_k = A_k[x^{fk}+x^{mk}+sx^{ck}] \quad \text{and} \quad y = z'p$$

where $\omega(p) = \omega_f(p)\rho_f(p)+\omega_m(p)\rho_m(p)+\omega_c(p)\rho_c(p)$.

Problem (22) can be solved by first maximizing the household's indirect utility function with respect to resource shares evaluated at the optimal level of expenditures, and then obtain the optimal level of expenditures by maximizing, for each member ℓ, their individual utility $U(x_\ell)$ subject to their individual budget constraint $\sum_k A_k p_k x^{\ell k} = \eta_\ell y$.

The first step is thus:

$$\max_{\eta_f,\eta_m,\eta_c,z} \omega(p)+\omega_f(p)V_f(A'p,\eta_f y_t)+\omega_m(p)V_m(A'p,\eta_m y_t)+\omega_c(p)V_c(A'p,\eta_c y_t) \qquad (23)$$

$$\text{such that} \quad \eta_f+\eta_m+\eta_c = 1$$

Which, given our chosen functional forms, can be rewritten:

$$\max_{\eta_f,\eta_m,\eta_c,z} \omega(p)+\tilde{\omega}_f(p)\ln\frac{\eta_f y}{G_f(A'p)}+\tilde{\omega}_m(p)\ln\frac{\eta_m y}{G_m(A'p)}+\tilde{\omega}_c(p)\ln\frac{\eta_c y}{G_c(A'p)} \qquad (24)$$

[33]To simplify notation, we omit the household size index s throughout this example.

$$\text{such that} \quad \eta_f + \eta_m + \eta_c = 1$$

where $\tilde{\omega}_\ell(p) = \omega_\ell(p)\exp(A_\ell p_{\ell t} e^{(-a'_{1\ell}\ln \tilde{A}'_1 \tilde{P}_1)}) \times \exp(A_1 \tilde{p}_{21t} e^{(-a'_{2\ell t}\ln \tilde{A}'_{2t}\tilde{P}_{2t})})$

The first order conditions for this maximization problem are:

$$\frac{\tilde{\omega}_f(p)}{\eta_f} = \frac{\tilde{\omega}_m(p)}{\eta_m} = \frac{\tilde{\omega}_c(p)}{\eta_c} \tag{25}$$

And thus the solution to the problem is:

$$\eta_\ell(p) = \frac{\tilde{\omega}_\ell(p)}{\tilde{\omega}_f(p) + \tilde{\omega}_m(p) + \tilde{\omega}_c(p)} \quad \text{for} \quad \ell = f, m, c \tag{26}$$

Note that the optimal resource shares do not depend on y, as per Assumption 1. In addition, Equation (26) can be used to illustrate the different ways in which $\eta_\ell(p)$ can vary from one time period to the next, as required by the assumption that matrix Λ defined in Assumption 5 be nonsingular. The $\tilde{\omega}_\ell(p)$, and thus the resource shares could indeed change over time due to any of the following: a change in the Pareto weight functions, a change in the transfer or externality functions, a change in any price associated with the subset of goods $k_2 = 1$ to K_2, and/or a change in preference parameters $a_{2\ell t}$ associated with these goods. All of these changes may occur over time without violating our assumptions. Assuming that food prices enter function $F_\ell(p_t)$ through $\frac{\tilde{p}_{21t}}{\prod_{k_2=2}^{K_2}(\tilde{p}_{2k_2})^{(a_{2k_2\ell t})}}$, then a likely source of time variation in the $\eta_\ell(p)$ would be one driven by increases in the children's caloric needs and thus a change in a_{2k_2ct}.

The second step of the maximization problem is for individuals to maximize their individual utility subject to their shadow budget constraint. Plugging into Equation (20) the shadow income and shadow prices faced by individual ℓ, and applying Roy's identity to obtain the individual's demand functions:

$$\begin{aligned} h^k_{\ell t}(\eta_{\ell t} y_t, A' p_t) &= (\eta_{\ell t} y_t) \times \frac{1}{G_{\ell t}} \frac{\partial G_{\ell t}(p_t)}{\partial A_k p_{kt}} \\ &\quad - (\eta_{\ell t} y_t) \frac{\ln(\eta_{\ell t} y_t)}{G_{\ell t}} \left[\frac{\frac{\partial \exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}'_1 \tilde{P}_1)) \exp(F_{\ell 2t}(\tilde{A}'_{2t}\tilde{P}_{2t}))}{\partial A_k p_{kt}}}{\exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}'_1 \tilde{P}_1)) \exp(F_{\ell 2t}(\tilde{A}'_{2t}\tilde{P}_{2t}))} \right] \end{aligned} \tag{27}$$

Where $F_{\ell 1}(A_\ell p_\ell, \tilde{A}'_1 \tilde{P}_1) = A_\ell p_{\ell t} e^{(-a'_{1\ell}\ln(\tilde{A}'_1 \tilde{P}_1))}$, $F_{\ell 2t}(\tilde{A}'_{2t}\tilde{P}_{2t}) = \tilde{A}_{1t}\tilde{p}_{21t} e^{(-a'_{2\ell t}\ln(\tilde{A}'_{2t}\tilde{P}_{2t}))}$, and $\tilde{A}_1$ and $\tilde{A}_{2t}$ denote the vectors of the diagonal elements of A corresponding to the goods whose prices enter vectors $\tilde{P}_1$ and $\tilde{P}_{2t}$, respectively.

The household level demand for good k is then obtain from Equation (2), which, assuming that all the off-diagonal elements of matrix A are equal to zero as we do in this particular example, can be written:

$$z_t^k = H_t^k(p_t, y_t) = A_k[h_{ft}^k(\eta_{ft} y_t, A' p_t) + h_{mt}^k(\eta_{mt} y_t, A' p_t) + s h_{ct}^k(\eta_{ct} y_t / s, A' p_t)] \tag{28}$$

In the case of private assignable goods, z_t^k simplifies to $h_{nt}^k(\eta_{nt} y_t, A' p_t)$ for $n = f, m$ and to $s h_{ct}^k(\eta_{ct} y_t, A' p_t)$ for the children's private assignable good. In addition, for private assignable goods,

$$\begin{aligned} \frac{\partial \exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}_1' \tilde{P}_1)) \exp(F_{\ell 2t}(\tilde{A}_{2t}' \tilde{P}_{2t}))}{\partial A_k p_{kt}} &= \frac{\partial \exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}_1' \tilde{P}_1))}{\partial p_\ell} \exp(F_{\ell 2t}(\tilde{A}_{2t}' \tilde{P}_{2t})) \\ &= \exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}_1' \tilde{P}_1)) \exp(F_{\ell 2t}(\tilde{A}_{2t}' \tilde{P}_{2t})) e^{-a_{\ell 1}' \ln(\tilde{A}_1' \tilde{P}_1)} \end{aligned} \tag{29}$$

And substituting the above expression into Equation (27), multiplying by p_ℓ, and dividing by y_t, we obtain Engel curves of the form presented in Equations (8) and (9). Recalling that our choice of functional form in this example is such that, for the three private assignable goods ($\ell = f, m, c$), $\partial F_{\ell t}(p_t)/\partial p_{\ell t} = \varphi_\ell(p_t) = \varphi_\ell(p_{t'})$ for $t \neq t'$, we obtain the following Engel curves for $n = f, m$ and for the children's private assignable good c:

$$\begin{aligned} \frac{z_{nt} p_{nt}}{y_t} &= p_{nt} \delta_{nt}(A' p_t) \eta_{nt}(p_t) - p_{nt} \varphi_n(A' p_t) \eta_{nt}(p_t) \ln(\eta_{nt}(p_t)) \\ &\quad - p_{nt} \varphi_n(A' p_t) \eta_{nt}(p_t) \ln(y_t) \end{aligned} \tag{30}$$

and

$$\begin{aligned} \frac{z_{ct} p_{ct}}{y_t} &= p_{ct} \delta_{ct}(A' p_t) \eta_{ct}(p_t) - p_{ct} \varphi_c(A' p_t) \eta_{ct}(p_t) \ln(\eta_{ct}(p_t)/s_t) \\ &\quad - p_{ct} \varphi_c(A' p_t) \eta_{ct}(p_t) \ln(y_t) \end{aligned} \tag{31}$$

where $\varphi_\ell(A' p_t)$ is time-invariant and the slope of the Engel curve with respect to $\eta_{\ell t} \ln(y_t)$, $p_{\ell t} \varphi_\ell(A' p_t)$, is equal to minus the price elasticity of $\exp(F_{\ell 1}(A_\ell p_\ell, \tilde{A}_1' \tilde{P}_1)) \exp(F_{\ell 2t}(\tilde{A}_{2t}' \tilde{P}_{2t}))$ with respect to the price of private assignable good ℓ.

For all the other goods, the expressions are more involved but are also linear in $\ln(y_t)$ and can be written:

$$\begin{aligned}
\frac{z_t p_{kt}}{y_t} \quad = \quad & A_k p_{kt} \left[\delta_{ft}^k (A' p_t) \eta_{ft}(p_t) + \delta_{mt}^k (A' p_t) \eta_{mt}(p_t) + s_t \delta_{ct}^k (A' p_t) \eta_{ct}(p_t)\right] \\
& - A_k p_{kt} \left[\varphi_{ft}(A' p_t) \eta_{ft}(p_t) \ln(\eta_{ft}(p_t)) + \varphi_{mt}(A' p_t) \eta_{mt}(p_t) \ln(\eta_{mt}(p_t)) \right. \\
& \left. + s_t \varphi_{ct}(A' p_t) \eta_{ct}(p_t) \ln(\eta_{ct}(p_t))\right] \\
& - A_k p_{kt} \left[\varphi_{ft}(A' p_t) \eta_{ft}(p_t) + \varphi_{mt}(A' p_t) \eta_{mt}(p_t) + s_t \varphi_{ct}(A' p_t) \eta_{ct}(p_t)\right] \ln(y_t)
\end{aligned}$$

B Reduced-Form Test of Anticipation Effects

Here we provide a reduced-form test where the possibility that households may not anticipate future transfers due to lack of information rather than due to liquidity constraints is unlikely.

At the time of the first wave of the dataset used in our analysis, PROGRESA had been rolled out for about six months in treated villages. Households who meet the means test (i.e., those "eligible") and living in treated villages are thus likely to know by then that, from Grade 3 of primary school onwards, the program pays out transfers conditional on regular school attendance. Until Grade 2 of primary school, however, eligible households are only entitled to a cash transfer of 100 pesos per month per household conditional on attending scheduled visits to health centers (Skoufias et al., 2001, p.49).

Households whose eldest child is in Grade 2 or below should therefore only consume up to 1200 pesos more per year unless they are able to increase their current consumption in response to the expected increase in income from the educational grants starting in Grade 3. In order to test if this is the case, we created a "net household consumption" variable equal to total annual household consumption in control villages and to total annual household consumption minus the basic annual 1200 peso transfer in treated villages. We then restricted the sample of households used in the main analysis to those whose eldest child is age 6 and above but is in Grade 2 or below, and thus whose parents should expect to receive educational transfers within a couple of years' time, resulting in a sample of 505 households. Regressing our "net household consumption" variable on household characteristics and a treatment indicator, the coefficient associated with PROGRESA villages is (a statistically insignificant) -157 pesos (Table A-2 Column (1)), suggesting that households consumed nearly all the 1200 pesos cash transfer they were already eligible for, but no more.

Finally, we carried out a difference-in-differences analysis to obtain the difference between treated and control households in the difference in net household consumption between households whose eldest child is in Grade 3 and above and households whose eldest child is in Grade 2 or below and found a (statistically insignificant) difference-in-differences of 391 pesos (Table A-2 Column (2)). While imprecise, these estimates suggest that households in PROGRESA villages only consume expected grant income once they start receiving this income. This provides further support for the hypothesis that, in our setting, a static model is a reasonable approximation to the household's maximization problem.

C Robustness

It should be expected from a complex nonlinear model such as the one we estimate that the objective function may exhibit local minima, and results obtained at different local minima may differ. We therefore carried out extensive checks using 600 different starting values for the parameters of the model and report here the results for which the optimization led to the lowest function value, as in Cherchye et al. (2012) and Dunbar et al. (2017).

More specifically, we first defined sets of possible starting values for each parameter entering the resource shares of each individual and all other parameters to be estimated (i.e., each parameter entering the $\eta_{\ell t}$, $\alpha_{\ell t}$ and b_ℓ, $\ell = f, m, c$ and $t = 1, 2, 3$ in estimation system (10)). We then drew 600 random combinations of starting values from these pre-defined sets, estimated the model for each of these random combinations, and selected the set of results with the lowest local minimum. Table A-5 in Appendix E reports the sets of possible values from which we drew the starting values for each parameter. Except for the number of children, for which we chose ranges of starting values consistent with decreasing parental resources shares as the number of children increases, and for adult education, for which we chose ranges of starting values consistent with bargaining power increasing with the level of education, we were agnostic as to the direction in which each variable would influence the intercepts, slopes, and resource shares appearing in the system. In particular, we did not restrict the starting values for the effect of PROGRESA on resource shares to be of any particular sign.[34] Reassuringly, although estimates vary across local minima, the general pattern is qualitatively similar across the board, as can be seen in Figure 1 in Appendix E.

D Poverty Analysis

Unsurprisingly, in this sample of households who qualified as poor enough to be eligible for PROGRESA, poverty rates are high, and the increases in total expenditure achieved by PROGRESA lower poverty rates, but most beneficiaries remain below the poverty line. We use as poverty line the poverty line defined by the Mexican Secretariat of Social Development as the individual expenditure that is necessary to maintain a healthy caloric intake, and which is equivalent to about US$1.6.[35] Assuming that (i) children's needs correspond to 50% of those of an adult, and (ii) resources are distributed proportionally to needs in the household yields a poverty rate estimate of 93% in control villages and 89% in PROGRESA villages (Table A-4 in Appendix E). But when we instead use our estimates of the distribution of resources within the household, the poverty rate of women falls to 77% (in control villages) and 73% (in treated villages), the poverty rate of men falls from 85% in control villages to 74% in treatment villages, while the child poverty rate is higher but also decreasing in treatment villages– from 97% in control villages to 93% in treatment villages. Although children experience the largest percentage increase in expenditure thanks to PROGRESA, there are more children in poorer households and their consumption is still very low, so that the effect on poverty rates is much less impressive.

[34]Tommasi (forthcoming) instead restricts starting values so as to correspond to a positive effect of PROGRESA on mothers' resource shares, based on reduced-form estimates of the positive effect of PROGRESA on answers to a question about who should decide how to spend any extra income of the wife in the May 1999 wave. We prefer to be agnostic given that this question asks about "who should decide" rather than "who decides" and due to variation over time in the sign of the effect of PROGRESA. As we explain in footnote 18, in the May 1999 (October 1998) wave, Adato et al. (2000) show that PROGRESA transfers are associated with a significantly higher (lower) probability of answering that the wife alone should decide when asked "When the woman has some extra income, do you think that...she should decide how to spend it?/she should give it to her husband?/they should decide together how to spend it?" ("Cuándo la mujer tiene algún ingreso extra, considera usted que.... ella debe decidir en que usarlo? . . . 1 se lo debe dar a su marido?. . . 2 ambos deben decidir como usarlo? . . . 3" (Question 186 (144) in the October 1998 (May 1999) wave).).

[35]Comité técnico para la medición de la pobreza (2002) suggests a poverty line of 15.4 pesos per person per day in rural areas in 2000. This corresponds to about US$1.6 at the December 1999 exchange rate.

Caution should prevail when interpreting these poverty rates, as they depend on the ratio used to compare children's to adult needs. As illustrated in the bottom panel of Table A-4 in Appendix E, children's poverty rates decline when it is assumed that they only need 40% of an adult's consumption. In addition, although the model allows for the consumption of goods to be shared within the household, we do not estimate the extent of economies of scale, which is likely to vary according to household size. In particular, we use the same adult-equivalent poverty threshold irrespective of household size. Given that there are more children in larger households, if taken into account in our poverty rate calculations, economies of scale would tend to benefit children disproportionately.

E Appendix Tables and Figures

Table A-1: Summary Statistics

	Control Areas		PROGRESA Areas	
	mean	sd	mean	sd
Time Invariant Variables				
State:				
Guerrero	0.07		0.09	
Hidalgo	0.11		0.18	
Michoacán	0.12		0.13	
Puebla	0.17		0.18	
Querétaro	0.04		0.03	
San Luis Potosi	0.14		0.14	
Veracruz	0.36		0.25	
Father's Education	1.23	0.867	1.34	0.848
Mother's Education	1.20	0.884	1.23	0.868
PROGRESA village	0.00		1.00	
Indigenous Household Head	0.41		0.40	
Time Varying Variables				
Number of Children	3.32	1.481	3.45	1.530
Father's age	33.76	8.302	33.58	7.567
Mother's age	29.47	6.459	29.81	6.687
Daughters' ratio	0.50	0.321	0.48	0.308
Mean Child Age	6.14	2.817	6.12	2.729
Village Suffered Drought	0.65		0.64	
Mean Labourer Wage	30.37	8.301	30.19	8.183
Total HH Expenditure	10752.82	5753.337	12515.67	6773.843
Share Female Cloth. & Shoes	0.01		0.01	
Share Male Cloth. & Shoes	0.01		0.01	
Share Children Cloth. & Shoes	0.02		0.03	
No. of Households	1022		1697	

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999.

Table A-2: Test of Anticipation Effects

	(1) Annual HH Expenditure Net of Food Subsidy	(2) Annual HH Expenditure Net of Food Subsidy
PROGRESA village	-156.85	-322.20
	(537.100)	(512.603)
PROGRESA× Child eligible for Grade≥3		390.55
		(582.723)
Child eligible for Grade≥3		-1372.35
		(823.922)
Observations	505	2000
R-Squared	0.123	0.112

Standard errors clustered at the village level reported in parentheses. The dependent variable is equal to total household expenditure minus 1200 Pesos per year if in a PROGRESA village (reflecting PROGRESA's food subsidy of 1200 Pesos per year). "Child eligible for Grade≥3" is a binary variable equal to one if the child has *completed* Grade 2 of primary schooling or more, and zero otherwise. For children currently enrolled in school, this implies that they are enrolled in Grade 3. For the few children who are not currently enrolled in school, this implies that, were they to enroll, they would do so in Grade 3. Both regressions include a constant, controls for the number of kids enrolled in school, the number of household assets owned in October 2017, age fixed effects, state fixed effects, age and education level of household head, age and education level of head's spouse, number of children in the household, share of girls among children, average age of the children in the household, whether the head is indigenous, and whether the household reports experiencing a drought in the previous 6 months. Column (1) includes only children aged 6-15 who are not yet in Grade 3 or above, Column (2) includes all children aged 6-15 and above irrespective of grade. Source: Authors' calculations using ENCEL October 1998.

Table A-3: Effect of Demographic Characteristics on Resource Shares

	Mothers		Fathers		Children	
	Est.	Std Err.	Est.	Std Err.	Est.	Std Err.
October 1998						
Father's Age	0.0002	0.0029	-0.0003	0.0026	0.0002	0.0016
Mother's Age	-0.0052	0.0041	0.0015	0.0036	0.0038	0.0020
Share Daughters	0.0030	0.0100	0.0245	0.0099	-0.0275	0.0199
Children's Age	0.0009	0.0091	-0.0123	0.0079	0.0114	0.0062
Father's Ed.	-0.0117	0.0055	0.0102	0.0055	0.0016	0.0109
Mother's Ed.	-0.0262	0.0057	0.0406	0.0056	-0.0144	0.0108
Indigenous	0.0004	0.0085	0.0168	0.0086	-0.0172	0.0170
May 1999						
Father's Age	0.0080	0.0023	-0.0069	0.0022	-0.0011	0.0022
Mother's Age	-0.0083	0.0036	0.0039	0.0026	0.0044	0.0034
Share Daughters	0.0291	0.0142	-0.0411	0.0142	0.0119	0.0283
Children's Age	-0.0154	0.0106	-0.0043	0.0086	0.0197	0.0096
Father's Ed.	-0.0224	0.0087	0.0078	0.0090	0.0146	0.0171
Mother's Ed.	0.0196	0.0086	0.0006	0.0087	-0.0202	0.0170
Indigenous	0.0130	0.0123	0.0318	0.0123	-0.0448	0.0245
November 1999						
Father's Age	0.0037	0.0023	-0.0045	0.0025	0.0008	0.0021
Mother's Age	-0.0035	0.0033	0.0012	0.0034	0.0023	0.0027
Share Daughters	0.0335	0.0137	-0.0009	0.0138	-0.0326	0.0275
Children's Age	0.0060	0.0067	-0.0156	0.0079	0.0096	0.0066
Father's Ed.	0.0198	0.0070	0.0323	0.0064	-0.0521	0.0129
Mother's Ed.	-0.0199	0.0066	-0.0172	0.0065	0.0371	0.0128
Indigenous	0.0279	0.0104	-0.0226	0.0106	-0.0053	0.0207

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999. Sample size: 2719 households. System 10 estimated by the Generalized Method of Moments using the log of average laborer's daily wage at the village level as an instrument for total expenditure, and controlling nonlinearly for a constant, the number of children, a PROGRESA village dummy, 6 state indicator variables, education of head and spouse, age of head and spouse, an indicator for whether the head of the household is indigenous, share of daughters among children, average child age, and an indicator variable for whether the village was affected by a drought in the six months preceding the survey. Standard errors allowing for arbitrary correlation of the error terms within household.

Table A-4: Individual Expenditures and Poverty Rates

	(1) Control Villages	(2) PROGRESA Villages
Woman's Expenditure	3963.83	4193.97
Man's Expenditure	3552.96	4186.72
Children's Expenditure	3236.03	4134.97
Child's Expenditure	1034.73	1296.03
Poverty Rates Assuming Children Needs Equivalent to 0.5 Adult		
Equal Shares	0.93	0.89
Women	0.77	0.73
Men	0.85	0.74
Children	0.97	0.93
Poverty Rates Assuming Children Needs Equivalent to 0.4 Adult		
Equal Shares	0.90	0.84
Women	0.77	0.73
Men	0.85	0.74
Children	0.93	0.88
N	1022	1697

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999. Predicted individual expenditure obtained from multiplying total household expenditure by the individual's predicted resource share based on estimates from system 10. System 10 was estimated by the Generalized Method of Moments using the log of average laborer's daily wage at the village level as an instrument for total expenditure, and controlling nonlinearly for a constant, the number of children, a PROGRESA village dummy, 6 state indicator variables, education of head and spouse, age of head and spouse, an indicator for whether the head of the household is indigenous, share of daughters among children, average child age, and an indicator variable for whether the village was affected by a drought in the six months preceding the survey.

Table A-5: Intervals for Starting Values

	η_f	η_m	α ($\alpha_f, \alpha_m, \alpha_c$)	β ($\beta_f, \beta_m, \beta_c$)
Constant	$[0.3, 0.4]$	$[0.3, 0.4]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Additional Child	$[-0.05, 0]$	$[-0.05, 0]$	$[-0.005, 0]^*$	$[-0.05, 0.05]$
PROGRESA	$[-0.05, 0.05]$	$[-0.05, 0.05]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Father's education	$[-0.05, 0]$	$[0, 0.05]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Mother's education	$[0, 0.05]$	$[-0.05, 0]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Father's age	$[-0.005, 0.005]$	$[-0.005, 0.005]$	$[-0.0005, 0.0005]$	$[-0.005, 0.005]$
Mother's age	$[-0.005, 0.005]$	$[-0.005, 0.005]$	$[-0.0005, 0.0005]$	$[-0.005, 0.005]$
Proportion Daughters	$[-0.05, 0.05]$	$[-0.05, 0.05]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Children's Mean Age	$[-0.005, 0.005]$	$[-0.005, 0.005]$	$[-0.0005, 0.0005]$	$[-0.005, 0.005]$
Indigenous head	$[-0.05, 0.05]$	$[-0.05, 0.05]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$
Drought	$[-0.05, 0.05]$	$[-0.05, 0.05]$	$[-0.005, 0]$	$[-0.05, 0.05]$
State Indicators**	$[-0.05, 0.05]$	$[-0.05, 0.05]$	$[-0.005, 0.005]$	$[-0.05, 0.05]$

*For α_c we set the interval to $[0, 0.005]$.

**We used the same interval for all state indicator variables.

Table A-6: Effect of PROGRESA on Resource Shares Assuming Stability of Preferences Across Individuals

	Mothers		Fathers		Children	
	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient	Std Err.	Coefficient	Std Err.	Coefficient	Std Err.
October 1998						
PROGRESA	-0.0248	0.0153	-0.0033	0.0165	0.0282	0.0318
		(0.0376)		(0.0406)		(0.0781)
May 1999						
PROGRESA	0.0113	0.0146	0.0190	0.0170	-0.0304	0.0257
		(0.0358)		(0.0417)		(0.0630)
November 1999						
PROGRESA	-0.0093	0.0126	-0.0107	0.0157	0.0200	0.0254
		(0.0322)		(0.0520)		(0.0745)

Source: Encuestas de Evaluación de los Hogares (ENCEL) October 1998, May 1999 and November 1999. Sample size: 2719 households. Standard errors allowing for arbitrary correlation of the error terms within village are reported in parenthesis. The other standard errors in Columns (2), (4) and (6) allow for arbitrary correlation of the error terms within household. Contrary to the other results tables, here we do not assume that preferences are stable over time. Instead, we assume that preferences for the private assignable goods are similar across individual types (woman, man, children) and similar across household sizes, as in Dunbar et al. (2013), and estimate the model separately for each panel wave.

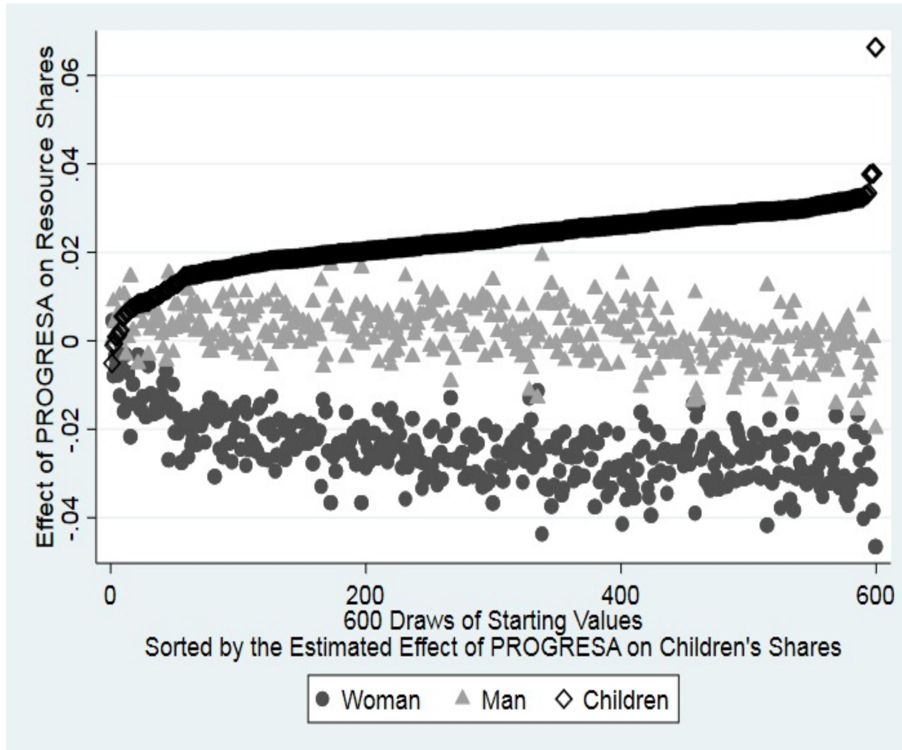

Figure 1:

Note: For each of the 600 randomly drawn set of starting values from the ranges presented in Table A-5, we take the average, across the three survey waves, of: the coefficient associated with PROGRESA villages in the resource shares of the woman ($\eta_f^{treated}$), the coefficient associated with PROGRESA villages in the resource shares of the man ($\eta_m^{treated}$), and the coefficient associated with PROGRESA villages in the resource shares of their children ($\eta_k^{treated}$). We then sort the 600 sets of results according to the value of $\eta_k^{treated}$ and plot $\eta_f^{treated}$, $\eta_m^{treated}$, and $\eta_k^{treated}$ for each draw thus ordered.