Predicting Intra-household allocation and individual poverty:

An assessment using direct evidence on sharing

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Background / motivation

- Early collective model literature:
    - tests & identification of the **marginal** sharing rule > not something easily observed
- Past 10 years:
    - high refinement of theory testing
    - also advances to estimate the **complete** sharing rule: Browning, Chiappori, Lewbel (2003, BCL)
    - many applications: to elderly (Cherchye et al., 2012a), children (Bargain and Donni, 2012, Dunbar, Lewbel, Pendakur, 2014 DLP), etc.
- Two advantages
    - directly usable for individual welfare/poverty evaluation
    - close to something that can be directly validated, i.e. if we observed sharing

- This is the simple idea of this paper
- We leverage an exceptional dataset for Bangladesh, 2004:
  - **fully individualized expenditure (both food and nonfood)**
  - rare in general, even more so for poor countries
- Individualized data allows us to
  - test identifying assumptions (individual Engel curves)
  - compare observed resource shares with those predicted from a simple collective model
  - draw implication for poverty analysis
- Throughout, sensitivity analysis:
  - various identification strategies as used in the recent literature
  - alternative assignable goods (clothing, rice or total food) - in the vein of Deaton (1997)

Model & identifying assumption

- Purely private model
- Sharing within nuclear families
  - couples with $n = 0, ..., 3$ children ($n = 0$: reference group for identification)
  - individuals $i = f, m, c$ (father, mother, children)
- Some notations
  - x the log household expenditure
  - $\eta_{i,n}(x, \mathbf{z})$ the resource share function to estimate
  - $\eta_{i,n}^{obs}(x, \mathbf{z})$: the observed resource share
  - W_n^k: household budget share on good k
  - $w_{i,n}^k$: basic budget share on good k for individual i

- Easily shown that *household budget shares* on good k is written

$$W_n^k(x, \mathbf{z}) = \sum_{i=f,m,c} \eta_{i,n}(x, \mathbf{z}) \cdot w_{i,n}^k\left(x + \log \eta_{i,n}(\mathbf{z}), \mathbf{z}\right)$$

- Rothbarth, BCL, DLP,...:
  - use of assignable goods (commonly available: clothing)
  - various preference-stability assumptions (SAP, SAT, SAT with singles, etc)
  - here: **we can test these assumptions**
- Let's focus on **'Similar Across Type' (SAT)**

- Exclusive good k_i, for $i = f, m$ (ex: female adult clothing), then:

$$W_n^{k_i}(x, \mathbf{z}) = \eta_{i,n}(x, \mathbf{z}) \cdot w_{i,n}^{k_i}\left(x + \log \eta_{i,n}(\mathbf{z}), \mathbf{z}\right)$$

- **Non-parametric** identification of $\eta_{i,n>0}$:
  - SAT: for good k_i, individual Engel curves independent from n
  - that is: $w_{i,n}^{k_i} = w_i^k()$ for $n = 0, ...3$, so that:

$$\begin{aligned} W_0^{k_i}(x, \mathbf{z}) &= \eta_{i,0}^{obs}(\mathbf{z}) \cdot w_i^{k_i}\left(x + \log \eta_{i,0}^{obs}(\mathbf{z}), \mathbf{z}\right) \\ W_{n>0}^{k_i}(x, \mathbf{z}) &= \eta_{i,n>0}(\mathbf{z}) \cdot w_i^{k_i}\left(x + \log \eta_{i,n>0}(\mathbf{z}), \mathbf{z}\right) \\ \text{leads to } \eta_{i,n>0}(i &= f, m) \end{aligned}$$

  - this requires prior or info on $\eta_{i,0}$ (but we're interested in prediction fit for those with kids)
  - we could also use singles (BCL)

- **Semi-parametric** identification (DLP):
  - parametric form:

$$w_{i,n}^{k_i}(x_{i,n}) = \alpha_{i,n} + \beta_{i,n} x_{i,n}$$

  - SAT: $\beta_{i,n} = \beta_i$ $(i = f, m)$ for $n = 0, ...3$, so

$$\begin{aligned} W_0^{k_i}(x, \mathbf{z}) &= ...\eta_{i,0}^{obs}(\mathbf{z})\beta_i x \\ W_{n>0}^{k_i}(x, \mathbf{z}) &= ...\eta_{i,n>0}(\mathbf{z})\beta_i x \\ \text{leads to } \eta_{i,n>0}(i &= f, m) \end{aligned}$$

- alternatively, without prior on $\eta_{i,0}$:
  - C-SAT (i.e. SAT extended to children, cf DLP): $n > 0$ only and $\beta_{i,n} = \beta_i$ for $i = f, m, c$ (9 unknowns and 9 equation)
  - or SAP: $\beta_{f,n} = \beta_{m,n} = \beta_{c,n}$ for each $n > 0$

- If we focus on sharing between parents and children
  - adult good k_a
  - pooled adult Engel curves $w_a^{k_a}()$
- Then similar reasoning
  - R-SAT: Rothbarth version of SAT
  - for instance in the non-param case:

$$\begin{aligned} W_0^{k_a}(x, \mathbf{z}) &= w_a^{k_a}(x, \mathbf{z}) \\ W_{n>0}^{k_a}(x, \mathbf{z}) &= \eta_{a,n>0}(\mathbf{z}) \cdot w_a^{k_a}\left(x + \log \eta_{a,n>0}(\mathbf{z}), \mathbf{z}\right) \\ & \text{leads to } \eta_{a,n>0} \end{aligned}$$

  - not need extra info here

Data

- Dataset:
  - "Capturing Intra-household Distribution and Poverty Incidence: A Study on Bangladesh" (HIES 2004)
  - 1,039 households
  - selection on couples: 803 households
  - standard hh characteristics
- Fully individualized expenditures

- Team:
  - specially trained enumerators (socio, eco, anthropo)
  - at least one of them from the interviewed region (local norms/culture)
  - the team spends 3 full days with families
- Collection:
  - food: measure the amount consumed by each individual (special weighting, etc)
  - food outside the home: interview (one week recall)
  - non-food: interview head (if husband, validated by wife) + inventory of goods consumed individually or jointly over the past year

Results

1. test identifying assumptions
2. compare observed and predicted resource shares for $n = 1, 2, 3$
    1. estimates of $\eta(\mathbf{z})$ versus $\eta^{obs}(\mathbf{z})$ (logistic forms)
    2. mean values of η versus η^{obs}
    3. distributions of η versus η^{obs} (with Andrews tests)
3. draw implication for poverty analysis

Identifying Assumptions	Individual Engel Curves	
	Linear in (log) expenditure	Quadratic in (log) expenditure
Non-param. SAT*, for $i = f, m$	$\alpha_{i,n}=\alpha_{i,0}, \beta_{i,n}=\beta_{i,0}$	$\alpha_{i,n}=\alpha_{i,0}, \beta_{i,n}=\beta_{i,0}, \gamma_{i,n}=\gamma_{i,0}$
Semi-param. SAT*, for $i = f, m$	$\beta_{i,n}=\beta_{i,0}$	$\gamma_{i,n}=\gamma_{i,0}$
Semi-param. C-SAT**, $i = f, m, c$	$\beta_{i,1}=\beta_{i,2}=\beta_{i,3}$	$\gamma_{i,1}=\gamma_{i,2}=\gamma_{i,3}$
Non-param. R-SAT*	$\alpha_{a,n}=\alpha_{a,0}, \beta_{a,n}=\beta_{a,0}$	$\alpha_{a,n}=\alpha_{a,0}, \beta_{a,n}=\beta_{a,0}, \gamma_{a,n}=\gamma_{a}$
Semi-param. R-SAT*	$\beta_{a,n}=\beta_{a,0}$	$\gamma_{a,n}=\gamma_{a,0}$

* Tests conducted on the full sample (n=0,...,3) but for n=1,2,3 separately

** Tests conducted on subsample with children (n=1,2,3)

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Result 1: testing identifying assumptions (p-values)

Rice: also rejected in most cases. Total food: better. SAP : rejected in most cases.

	Test of preference similarity between individuals in family types:	SAT, Clothing	
		Linear	Quad.
Non-param. SAT*	n=0 and n=1	0.443	0.346
	n=0 and n=2	0.530	0.507
	n=0 and n=3	0.771	0.018
Semi-param. SAT*	n=0 and n=1	0.641	0.189
	n=0 and n=2	0.595	0.316
	n=0 and n=3	0.592	0.005
Semi-param. C-SAT**	n=1 and n=2	0.000	0.003
	n=1 and n=3	0.010	0.179
Non-param. R-SAT*	n=0 and n=1	0.724	0.631
	n=0 and n=2	0.136	0.202
	n=0 and n=3	0.013	0.004
Semi-param. R-SAT*	n=0 and n=1	0.694	0.271
	n=0 and n=2	0.819	0.305
	n=0 and n=3	0.592	0.060

* Tests conducted on full sample (n=0,...,3), for n=1,2,3 separately

** Tests conducted on subsample with children (n=1,2,3)

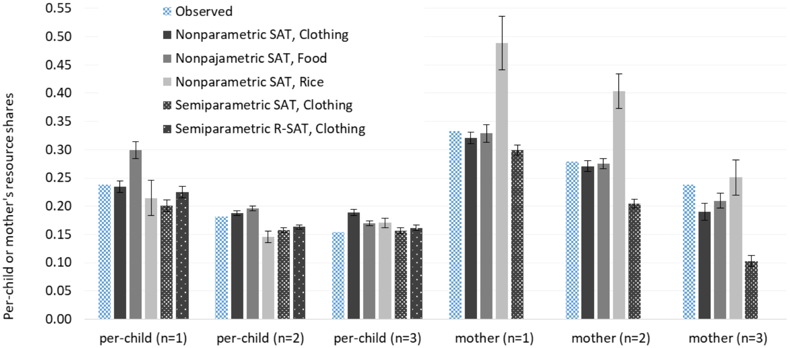
- Semi-parametric identification à la DLP rests on one coefficient
- Important to check if significant (no flat Engel curve, in log exp)
- With complete model, this coefficient is:

	women	men
clothing	.0226 (0.0093)**	.0300 (0.0077)***
rice	−0.1834 (0.0233)***	−0.2320 (0.0299)***
food	−0.3350 (0.0502)***	−0.1936 (0.0233)***

Estimates of $\eta^{obs}(\mathbf{z})$ versus $\eta(\mathbf{z})$:

Resource shares	Logistic estimation of observed resource shares (i.e. total individualized expenditure)	Structural model estimations of a demand system using the following identifying assumptions and exclusive goods:				
		Non-parametric SAT			Semi-parametric SAT	Semi-parametric R-SAT
		Clothing	Food	Rice	Clothing	Clothing
	(1)	(2)	(3)	(4)	(5)	(6)
Estimates of children's resource shares						
# children	0.448 ***	0.726 ***	0.320 ***	0.596 ***	0.536 ***	0.624 ***
	(0.027)	(0.076)	(0.062)	(0.138)	(0.151)	(0.087)
mean child age	0.064 ***	0.074 ***	0.082 ***	0.259 ***	0.103 ***	0.073 ***
	(0.004)	(0.011)	(0.011)	(0.026)	(0.017)	(0.015)
proportion of boys	0.112 ***	0.077	0.132 **	0.483 ***	0.077	0.086 *
	(0.043)	(0.054)	(0.062)	(0.169)	(0.059)	(0.051)
urban	0.025	0.176 *	0.068	-0.255	1.120 **	0.090
	(0.035)	(0.105)	(0.111)	(0.206)	(0.446)	(0.133)
woman's income share	0.373 ***	0.264 *	0.397 **	1.004 *	0.290 *	0.199
	(0.116)	(0.161)	(0.169)	(0.574)	(0.165)	(0.127)
nuclear	0.123 ***	0.027	0.305 ***	0.327 **	-0.055	-0.179
	(0.039)	(0.114)	(0.108)	(0.164)	(0.145)	(0.133)
constant	-1.643 ***	-2.146 ***	-1.454 ***	-3.880 ***	-2.760 ***	-2.561 ***
	(0.068)	(0.213)	(0.244)	(0.544)	(0.516)	(0.354)

Results 2b: average resource shares



Average child and mothers' resource shares according to direct observation of individual consumption and to model estimations, using alternative collective model identification strategies: alternative adult goods (clothing or rice); alternative identification: nonparametric (SAT applied to the whole Engel curve, implemented using quadratic form) or semiparametric (SAT only on the coefficient of log expenditure, using a linear form); alternative focus: predicting the full allocation of resources (using SAT) or only sharing between adults and children (using R-SAT, i.e. the Rothbarth approach). 95% confidence intervals indicated by vertical segments.

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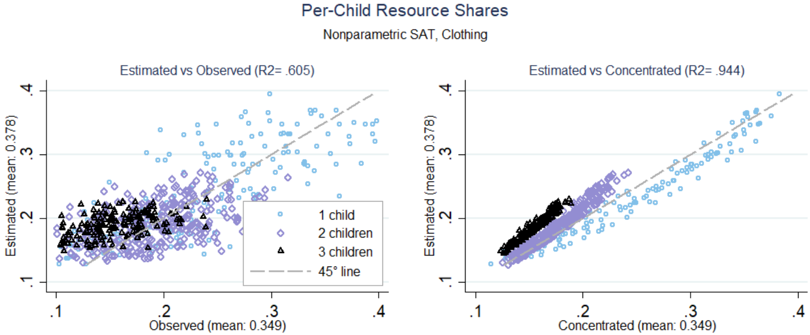
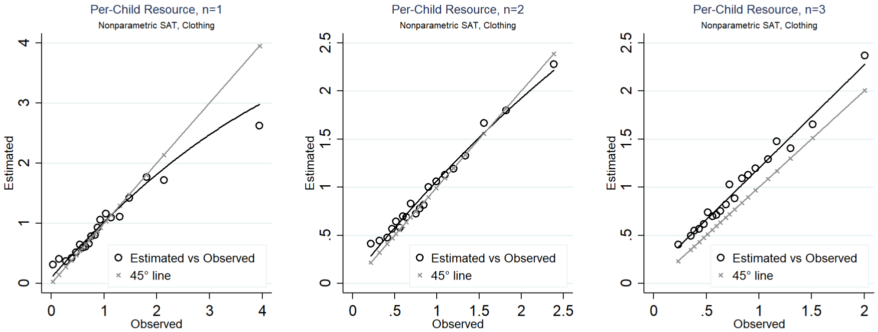
Results 2c: Andrews test (p-value)

Household type	Non-param. SAT, Clothing			Non-param. SAT, Food			Nonparametric SAT, Rice		
	partitions:			partitions:			partitions:		
	4	6	8	4	6	8	4	6	8
1 child	0.84	0.90	0.98	0.07	0.57	0.94	0.00	0.00	0.00
2 children	0.28	0.65	0.55	0.62	0.96	1.00	0.00	0.00	0.00
3 children	0.00	0.00	0.00	0.31	0.87	0.99	0.00	0.03	0.27

Concentrate shares: $\widetilde{\eta^{obs}}(\mathbf{z})$



Individual expenditure: $x_{i,n} = x + \log \eta_{i,n}(\mathbf{z})$ versus $x_{i,n}^{obs} = x + \log \eta_{i,n}^{obs}(\mathbf{z})$



Dots compare mean observed and estimated individual resources, averaged by same-sized bins, corresponding to vintiles of the observed distribution.

	'Per-adult equivalent' poverty (ignoring unequal sharing in the family)	Individual poverty Based on individual resource shares, using:			Misidentification: % poor children in nonpoor households, using:	
		Observed shares	Estimated shares (collective model, SAT)	Estimated shares (collective model, R-SAT)	Observed shares	Estimated shares (collective model, SAT)
	(1)	(2)	(3)	(4)	(5)	(6)
Child poverty rate:						
(a): per capita approach	0.36	0.57	0.51	0.51	0.24	0.17
(b) age-specific child needs	0.26	0.41	0.35	0.34	0.18	0.12
Mothers' poverty rate:	(a): 0.36 / (b): 0.26	0.33	0.33	-	-	-
Fathers' poverty rate:	(a): 0.36 / (b): 0.26	0.08	0.13	-	-	-
Adults' poverty rate	(a): 0.36 / (b): 0.26	0.17	0.21	0.21	-	-

Column (1): per-adult equivalent poverty rates based on a poverty line of \$1.25/day (2005 PPP) and equivalized expenditure, i.e. household expenditure divided by an equivalence scale with two alternative definitions of child weights:

(a) Child needs: equal to adults' (per-capita approach)

(b) Child needs: function of calorie requirements per age (FAO/WHO/UNU, 1985)

Next columns: individual poverty rates based on individual resources, either observed (2) or estimated using clothing and nonparametric SAT (3) or R-SAT (4). Individual poverty lines defined as the same adult poverty line (\$1.25/day) or a child poverty line as a fraction of the adult's using alternative child weights as indicated. Last columns report misidentification of poor children with the traditional approach (poor children in nonpoor households) according to observed shares, and how much of this misidentification is captured by estimated shares.

Conclusion

- Welfare analysis:
  - typically based on equivalized household expenditure/income
  - usually ignore intra-household allocation
  - in parallel, collective approach not much operationalized in policy analyses
- Using individualized expenditure
  - tests identifying assumptions (preference-stability assumption)
  - reasonable resource sharing predictiong
  - reasonable individual poverty assessment
  - traditional approach understate the poverty status of the poorest
  - good performances based on commonly available good (clothing)

- Practical aspects:
  - limited applicability
  - but readily available for parents vs children (Rothbarth)
- Extensions:
  - private expenditure allocation: central element to validate here / more complete model can be written without identification of scale econ (DLP)
  - further validation? other data, other structural elements (subjective declaration on degree of joint consumption?)
  - account for good quality? (malnutrition rather than under-nutrition, cf Brown et al, 2019, Pitt et al., 1990) / for life boat ethics?

Thank you!

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	Childless couple	Couple with 1 child	Couple with 2 children	Couple with 3 children
Family Characteristics				
Proportion of boys (%)	-	0.531	0.497	0.503
Average age of children	-	8.4	8.2	9.3
Average age of the head	51.7	39.7	39.6	41.8
Working women (%)	0.139	0.188	0.144	0.225
Urban (%)	0.406	0.329	0.381	0.278
Annual private expenditure (PPP $)	1,217	1,400	1,802	1,847
Private goods as % of total expenditure	0.63	0.67	0.69	0.73

		Childless couple		Couple with 1 child		Couple with 2 children		Couple with 3 children	
Budget shares of private goods [% of zeros]									
Cereals & pulses		0.060	[0.129]	0.067	[0.085]	0.070	[0.087]	0.070	[0.065]
Fruit & vegetables		0.100	[0.000]	0.113	[0.000]	0.108	[0.000]	0.126	[0.000]
Oils & fats		0.048	[0.010]	0.042	[0.014]	0.042	[0.016]	0.039	[0.018]
Beverages, sweets, tobacco		0.124	[0.089]	0.096	[0.136]	0.095	[0.103]	0.086	[0.030]
Fish, meat, eggs, dairy		0.210	[0.010]	0.205	[0.028]	0.207	[0.019]	0.196	[0.036]
Rice		0.217	[0.010]	0.249	[0.005]	0.261	[0.000]	0.293	[0.000]
	Father	0.117	[0.010]	0.106	[0.019]	0.092	[0.009]	0.083	[0.041]
	Mother	0.100	[0.010]	0.092	[0.005]	0.079	[0.006]	0.072	[0.006]
	Children	-	-	0.051	[0.108]	0.090	[0.000]	0.137	[0.041]
Other private non food		0.116	[0.079]	0.101	[0.085]	0.109	[0.038]	0.099	[0.030]
Clothes & shoes	Total	0.125	[0.030]	0.127	[0.005]	0.108	[0.000]	0.092	[0.000]
	Father	0.065	[0.040]	0.053	[0.005]	0.038	[0.009]	0.027	[0.006]
	Mother	0.061	[0.030]	0.047	[0.014]	0.035	[0.006]	0.026	[0.018]
	Children	-	-	0.026	[0.085]	0.035	[0.009]	0.039	[0.012]
# households		101		213		320		169	
# individuals (all children count for 1)		202		639		960		507	