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Online Appendix for

LATE with Missing or Mismeasured Treatment

Rossella Calvi, Arthur Lewbel, and Denni Tommasi

Contents

B.4 Exclusion Restriction

A A Graphical Illustration of MR-LATE for Generally Mismeasured Treatment

Assume that $supp\,(\varepsilon) \quad \kappa^b \quad e, \kappa^a \quad e$. Then it follows that for $T = T^a$ we have $p_1^a = 1$ with $p_0^a = 0$, and for $T = T^b$ we have $p_1^b = 0$ and $p_0^b = 1$, and so $\lambda^a \quad \lambda^b = E[Y_1 \quad Y_0\, j\, C]$. Given corollary 2, LATE can be point identified. Figure A1 provides a graphical representation of this. If there was no measurement error, the true treatment and control groups would coincide with the respective observed groups. All individuals on the black line on the right hand side of e, would have a R larger than the threshold value; otherwise, they would be on the black line on the left hand side of e. One could construct a treatment proxy $T = \mathbb{I}(R \quad c)$, where R is an estimate of R and c is one's best guess of the midpoint between $\varepsilon + e$. This approach, however, will not identify the treatment effect of interest. To achieve point identification of LATE in presence of measurement error or misclassification error, we need to have two treatment indicators, T^a and T^b, such that $q^a = p_1^a{=}(p_1^a \quad p_0^a) = 1$ and $q^b = p_1^b{=}\; p_1^b \quad p_0^b \;= 0$. By knowing the bounds κ^a and κ^b, we are able to define a T^a such that for all individuals on the red line on the left hand side of κ^a, $p_0^a = 0$. That is, with probability 0, these individuals, who are observed in the control group, belong to the true treatment group. Analogously, we are able to define also a T^b such that for all individuals on the blue line on the right hand side of κ^b, $p_1^b = 0$. That is, with probability 0, these individuals, who are observed in the treatment group, belong to the true control group.

B Women's Empowerment and Family Health: Details

B.1 Derivation of Household Demand Equations of Private Assignable Goods

Here we summarize the derivation of our structural model, based on Browning et al. (2013) (BCL) and Dunbar et al. (2013) (DLP), for estimating resource shares from the demand equations of private assignable goods. Consider a household comprised of T types of individuals indexed $t = 1, \ldots, T$. Recall M is the total expenditures of the household, i.e., the household's total budget, X denotes a vector of observable attributes of households and their members, Z denotes a vector of possible distribution factors (if any), and $Q_1,\ldots,Q_T$ are quantities of each private assignable good consumed by household member t. Let S be a vector of quantities of all other goods the household consumes. Unlike $Q_1,\ldots,Q_T$, the goods S may be shared and hence jointly consumed to some extent. In particular, $S = \sum_{t=1}^{T} S_t$ where S_t is the vector of quantities of these goods consumed by member t. The purchased quantities of these goods are given by $A(X)S$, where the matrix $A(X)$ summarizes the extent to which these goods are shared.

Let $P_1,\ldots,P_T$ be the market prices of the private assignable goods, let P_S be the vector of market prices of goods S, and let P denote the vector of all of these prices.

The household chooses what to consume using the program

$$\max_{Q_1,\ldots,Q_T,S_1,\ldots S_T} \tilde{U} \left[V_1 \right.$$

Applying duality theory and decentralization welfare theorems, it follows from BCL that the household's program above is equivalent to a program where each household member t chooses what to consume using the program

$$\max_{Q_t, S_t} V_t\left(Q_t, S_t, X\right) \quad \text{such that} \quad \eta_t(P, M, X, Z)M = P_S' A\left(X\right) S_t + P_t Q_t \tag{A2}$$

where $\eta_t = \eta_t(P, M, X, Z)$ is the resource share of member t, that is, η_t is the fraction of total household resources M that are allocated to member t. This member then chooses quantities Q_t

oretical evidence that η_t does not depend on M.[1] This allows them to rewrite equation (A3) as $w^t = \eta_t(X, \tilde{Z})\tilde{h}_t\left(\eta_t(X, \tilde{Z})M, X\right)$ for $t = 1, ..., T$, where $w^t = P_t Q_t / M$ is the household's budget share of good t, that is, the fraction of the household's total budget M that is spend on buying Q_t. DLP provide a class of functional forms for the utility functions $\tilde{V}$ that make $\tilde{h}_t$ linear in the log of its first argument, so $w^t = \eta_t(X, \tilde{Z})[\delta^t(X) + (\ln M + \ln \eta_t(X, \tilde{Z}))\beta(X)]$ for some functions $\delta^t(X)$

(Hindu, Buddhist, Sikh or Jain), for living in rural areas, for female and male higher education, and for belonging to a Scheduled Caste, Scheduled Tribe, or other backward classes.

NFHS data. The 2005-2006 National Family Health Survey provides a range of health indicators for women aged 15 to 49, for men aged 15 to 54, and for children born in the 5 years prior to the date of interview. The survey also contains many demographic and socio-economic attributes, comparable to those we observe in the NSS data. As above, we select households consisting of a mother, a father, and their children. We consider women, men and children datasets separately, observing a few different health measures for each individual. The health measures for adults include body mass index or BMI (weight in kilograms divided by height in meters squared) and measures of anemia. A BMI cut-off point of 18.5 is used to define undernutrition. Anemia is a condition in which the number of red blood cells, or their oxygen-carrying capacity, is insufficient. Although its primary cause is iron deficiency, it often coexists with (and hence serves as an indicator of) a number of other health issues such as malaria, parasitic infection, and nutritional deficiencies.

For children, the health related measures we observe include weight-for-age and height-for-age z-scores (standard deviations from the reference median based on the 2006 WHO Child Growth Standards). A z-score greater than 2 indicates over-nourishment with respect to the corresponding anthropometric measurements. Deficits on these indicators (measured by their values less than -2 standard deviations below the median) are known as underweight and stunting, respectively. Another child health measure we observe is mothers' reports of whether a child was sick with fever, cough or diarrhea in the past two weeks. Finally, we observe child vaccination records, which we

Table A1: NSS Consumer Expenditure Data and NFHS Household Data

	2005-2006 NSS Sample				2005-2006 NFHS Sample			
	Obs.	Mean	Median	St. Dev.	Obs.	Mean	Median	St. Dev.
Woman's Assignable Clothing Budget Share	7,744	0.88	0.75	0.69				
Man's Assignable Clothing Budget Share	7,744	0.93	0.71	0.87				

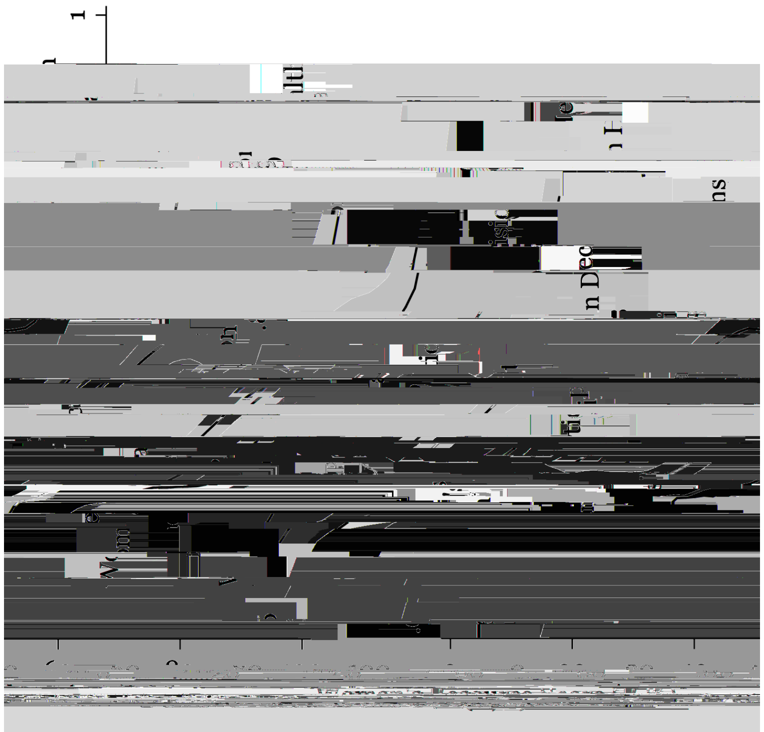
Table A2: 2005-2006 NFHS Individual Data

	Women ($N = 21,057$)			Men ($N = 11,516$)			Children ($N = 18,411$)		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Body Mass Index (BMI)I I	20.93	20.18	3.93	21.20	20.66	3.52			

B.3 Resource Shares and Self-reported Decision-making Power

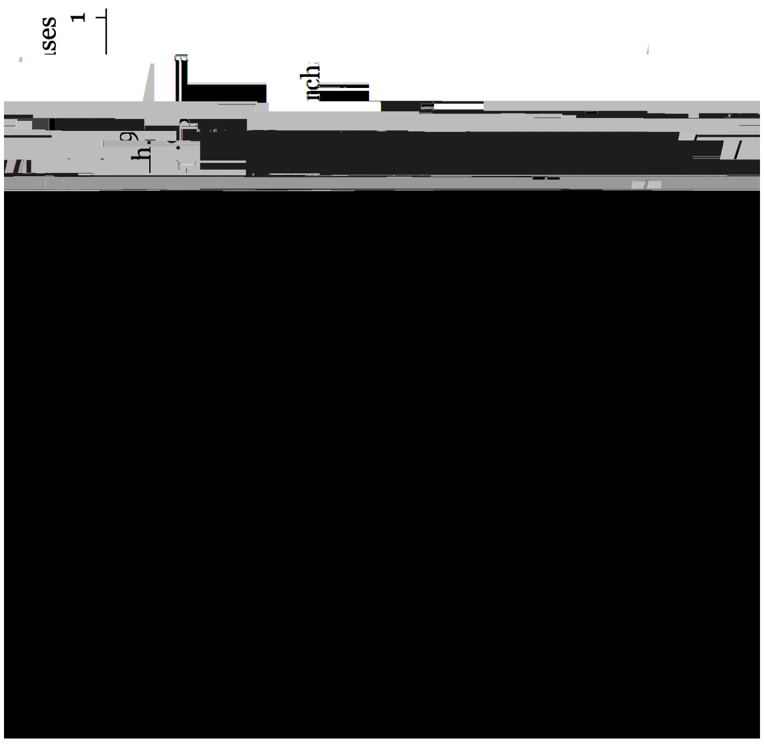
In this section, we compare our structurally-motivated measure of bargaining power R, estimated from household expenditure data, with some more typical proxies of power, namely, women's self-reports of control over various household decisions and mobility.

The NFHS data contains questions of the form, "Who usually makes decisions about [X] in your household?". Specifically, women are asked to report who has the final say over their own health care, household purchases, and visits to family or relatives. We construct indicator variables equal to 1 if the answer to these questions is "respondent alone" or "respondent and husband / partner jointly" and 0 if the answer is "husband / partner." We exclude women who answer "other / someone else" (less than 1 percent in any question). Several women in our sample report having no say in household decisions: 29 percent of women say they do not participate in decisions over their own health, 25 percent report having no say in determining visits to family and friends, and 33 percent claim to have no say in large household purchases. In addition, women are asked whether they are allowed to go alone to places outside the village, to the health facility or to the market. Many women report an inability to go places alone, especially to places outside the village or community (51 percent). One out of three women report not being allowed to go to the market or to a health



(A) Woman's Health

(B) Visits to Family and Relatives



(C) Household Purchases

(D) Autonomy Index

Figure A3: Structurally Recovered Bargaining Power and Household Decision Making

Table A3: Self-reported Decision Making and Woman's Control of Resource

	I(Woman Participates in Final Decisions on)			Autonomy
	Household Purchases	Visits to Family and Relatives	Own Health	Index
$T = \mathrm{I}(R \quad 50)$	0.0496 (0.0121)	0.0570 (0.0109)	0.0456 (0.0122)	0.624 (0.0857)
Observations	21,690	21,706	21,773	21,910

Note: NFHS data. The sample includes married women of age 15 to 49 in nuclear households. Bootstrap standard errors in parentheses. All specifications include individuals and household controls, state-religion fixed effects, mother's cohort-religion fixed effects and state specific time trends (up to degree four).

likelihood to marry up (i.e., to marry someone of a higher socio-economic status),[2] and on the extent of their migration upon marriage. As shown in Table A5, we do not find significant changes in marital sorting or marriage characteristics after the introduction of the amendments (with the exception of an increase in women's age at marriage). Importantly, all our results presented in Section 7.3 are robust to including women's age at marriage as an additional covariate.

C Additional Tables

Table A6: $j\mathrm{Bias}_{\mathrm{B\text{-}LATE}}j$

Panel A: $p_1^a = 0.9$, $p_0^b = 0.9$					
p_1^b # | p_0^a !	0	0.01	0.05	0.1	0.2
0	0.111	0.117	0.143	0.176	0.250
0.01	0.117	0.124	0.149	0.183	0.258
0.05	0.143	0.149	0.176	0.212	0.290
0.1	0.176	0.183	0.212	0.250	0.333
0.2	0.250	0.258	0.290	0.333	0.429

Panel B: $p_1^a = 0.8$, $p_0^b = 0.8$					
p_1^b # | p_0^a !	0	0.01	0.05	0.1	0.2

Table A7: $|\text{Bias}_{\text{MR-LATE}}|$

Panel A: $p_1^a = 0.9$, $p_0^b = 0.9$					
$p_1^b \downarrow$ | $p_0^a \rightarrow$	0	0.01	0.05	0.1	0.2
0	**0.000**	0.011	0.059	0.125	0.286
0.01	0.011	0.022	0.070	0.136	0.297
0.05	0.059	0.070	0.118	0.184	0.345
0.1	0.125	0.136	0.184	0.250	0.411
0.2	0.286	0.297	0.345	0.411	0.571

Panel B: $p_1^a = 0.8$, $p_0^b = 0.8$					
$p_1^b \downarrow$ | $p_0^a \rightarrow$	0	0.01	0.05	0.1	0.2
0	**0.000**	0.013	0.067	0.143	0.333
0.01	0.013	0.025	0.079	0.156	0.346
0.05	0.067	0.079	0.133	0.210	0.400
0.1	0.143	0.156	0.210	0.286	0.476
0.2	0.333	0.346	0.400	0.476	0.667

Panel C: $p_1^a = 0.7$, $p_0^b = 0.7$					
$p_1^b \downarrow$ | $p_0^a \rightarrow$	0	0.01	0.05	0.1	0.2
0	**0.000**	0.014	0.077	0.167	0.400
0.01	0.014	0.029	0.091	0.181	0.414
0.05	0.077	0.091	0.154	0.244	0.477
0.1	0.167	0.181	0.244	0.333	0.567
0.2	0.400	0.414	0.477	0.567	0.800

Notes: Results obtained setting $r = 0.5$. Each cell reports $|\text{Bias}_{\text{MR-LATE}}|$ under different values of $p_1^a, p_0^a, p_1^b, p_0^b$. Cells are empty if the bias is not finite. The true LATE is normalized to 1.

Table A8: Bounds κ^a and κ^b

	Women		Men		Children	
	κ^a	κ^b	κ^a	κ^b	κ^a	κ^b
$K = 0$	50.00	50.00	50.00	50.00	50.00	50.00
$K = 1$	50.21	49.79	50.21	49.77	50.21	49.79
$K = 5$	51.00	49.05	50.99	49.01	50.89	49.13
$K = 10$	52.00	48.13	51.98	48.13	51.75	48.36

Note: NFHS data.

Table A9: First Stage Estimates

	Women		Men		Children	
	T^a	T^b	T^a	T^b	T^a	T^b
	Panel A: K = 0					
I(HSA)	0.0867	-0.0867	0.0779	-0.0779	0.0930	-0.0930
	(0.0114)	(0.0114)	(0.0126)	(0.0126)	(0.0181)	(0.0181)
First Stage F-stat.	76.7245	76.7245	48.0541	48.0541	33.3953	33.3953
	Panel B: K = 1					
I(HSA)	0.0756	-0.0876	0.0681	-0.0775	0.0755	-0.0975
	(0.0111)	(0.0114)	(0.0124)	(0.0126)	(0.0177)	(0.0182)
First Stage F-stat.	58.6617	78.5649	37.2418	47.7399	22.5004	34.2528
	Panel C: K = 5					
I(HSA)	0.0581	-0.1078	0.0560	-0.0998	0.0588	-0.1320
	(0.0106)	(0.0120)	(0.0119)	(0.0133)	(0.0167)	(0.0189)
First Stage F-stat.	34.3853	117.3670	25.5154	77.5716	15.2348	62.0974
	Panel D: K = 10					
I(HSA)	0.0341	-0.1203	0.0349	-0.1059	0.0356	-0.1520
	(0.0100)	(0.0128)	(0.0110)	(0.0143)	(0.0162)	(0.0204)
First Stage F-stat.	11.5444	144.9936	9.8665	84.2524	7.6620	80.8510

Note: NFHS data. Robust standard errors in parenthesis. All specifications include individuals and household controls, state-religion fixed effects, mother's cohort-religion fixed effects and state specific time trends (up to degree four).

Table A10: Engel Curves Estimation Results (NSS Sample)

	$R(X)$	$\widehat{\delta}_w(X)$	$\widehat{\delta}_m(X)$	$\widehat{\beta}(X)$
$\mathbb{1}$(1 child)	0.0692	0.000550	-0.244	0.0299
	(0.0228)	(0.476)	(0.479)	(0.0393)
$\mathbb{1}$(2 children)	0.0250	-0.0777	-0.242	-0.0223
	(0.0210)	(0.477)	(0.479)	(0.0585)
$\mathbb{1}$(3 children)	0.0404	-0.451	-0.452	0.00759
	(0.0242)	(0.513)	(0.511)	(0.0596)
Fraction of Female Children	0.00217	-0.319	-0.351	0.0379
	(0.0177)	(0.343)	(0.341)	(0.0416)
Gender Age Gap (Man - Woman)	0.0298	2.552	1.998	-0.221
	(0.143)	(2.560)	(2.707)	(0.327)
Woman’s Age	-0.452	1.865	1.519	-0.125
	(0.123)	(2.899)	(2.901)	(0.355)
Children’s Avg. Age	-0.277	0.511	0.881	-0.206
	(0.237)	(4.846)	(4.822)	(0.587)
$\mathbb{1}$(Hindu, Buddhist, Jain, Sikh)	0.104	1.260	0.803	-0.113
	(0.0193)	(0.341)	(0.345)	(0.0413)
$\mathbb{1}$(Sch. Caste, Sch. Tribe, Oth. Back. Caste)	-0.0209	0.0666	0.103	-0.0310
	(0.0158)	(0.278)	(0.282)	(0.0338)
$\mathbb{1}$(Own Land)	-0.000975	0.00307	0.0821	0.0135
	(0.0165)	(0.310)	(0.308)	(0.0372)
$\mathbb{1}$(Woman Completed High School)	0.0550	-0.390	-0.388	0.0536
	(0.0263)	(0.488)	(0.489)	(0.0566)
$\mathbb{1}$(Man Completed High School)	0.0437	0.113	-0.0934	0.0139
	(0.0210)	(0.401)	(0.404)	(0.0474)
$\mathbb{1}$(Rural)	-0.00804	1.202	1.409	-0.152
	(0.0155)	(0.307)	(0.306)	(0.0373)
$\mathbb{1}$(North)	-0.0772	0.00410	0.814	-0.0253
	(0.0257)	(0.511)	(0.510)	(0.0615)
$\mathbb{1}$(East)	0.0896	-0.129	-0.445	0.0431
	(0.0267)	(0.529)	(0.518)	(0.0638)
$\mathbb{1}$(North-East)	0.197	-1.668	-2.212	0.168
	(0.0311)	(0.575)	(0.558)	(0.0686)
$\mathbb{1}$(South)	-0.0586	1.026	0.746	-0.0817
	(0.0253)	(0.531)	(0.537)	(0.0648)
Constant	0.494	6.723	7.065	-0.699
	(0.0503)	(1.031)	(1.031)	(0.113)

Note: NSS data. Robust standard errors in parenthesis. Age variables are are divided by 100 to ease computation. Number of children excluded category is 4 children and above.

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