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Revisiting habits and heterogeneity in demands

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Für den Inhalt der Passauer Diskussionspapiere ist der jeweilige Autor verantwortlich.
Es wird gebeten, sich mit Anregungen und Kritik direkt an den Autor zu wenden.

Revisiting habits and heterogeneity in demands*

Markus Fritsch[†], Andrew Adrian Yu Pua[‡], Joachim Schnurbus[§]

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Abstract

We conduct a narrow replication of Browning and Collado (*Journal of Applied Econometrics* 2007; **22**(3): 625–640). They estimate a linear panel AR(1) version of an Engel curve for six consumption composites using iterated GMM. We find that the coefficient estimates and standard errors differ from the reported results when we use their instrument set; in particular, we find habit formation in non-durable services and no state dependence in small durables. Despite finding evidence for weak instruments, our results support most of the claims made in the original paper and are also unable to detect intertemporal dependence strong enough to resolve existing macro puzzles.

Keywords. Habit formation, linear dynamic panel data methods, weak instruments.

JEL codes. C23, C26, D12.

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1 Introduction

Browning and Collado (2007), henceforth BC, construct budget shares from six consumption composites, namely, food inside the home (`foodin`), non-durable services (`nds`), food outside the home (`foodout`), alcohol and tobacco (`alct`), clothing (`clo`), and small durables (`sdur`) based on data from the Spanish Family Expenditure Survey (ECPF). BC use the data to estimate a quadratic almost ideal demand system (QAIDS; see Banks, Blundell, and Lewbel, 1997) version of an Engel curve. They deduce that the squared term in a QAIDS specification may introduce ‘spurious explanatory power that ignores temporal dependencies’ (see p.632) based on the empirical evidence of their Tables I to IV (which we are able to replicate). Consequently, they estimate a linear AR(1) panel data version of an Engel curve (results reported in their Tables V and VI). They use Holtz-Eakin, Newey, and Rosen (1988)-type and Arellano and Bover (1995)-type linear moment conditions, where the latter arise from a constant correlated effects assumption to identify habit persistence. Identifying habit persistence allows them (1) to classify these composites into habit-forming, durable, or neither, (2) to estimate short-run and long-run income elasticities, and (3) to provide a micro-founded estimate of the habit formation parameter used in calibrating real business cycle models.

In this paper, we revisit their application of linear dynamic panel data methods reported in their Tables V and VI. Pesaran (2015, p.686-688) uses this application as an example in his recent econometrics textbook discussing panel data econometrics. Precisely following the description in BC, we encounter missing details and obtain some differences regarding the results and the respective interpretations. All computations in this replication are carried out using **Stata 12** (StataCorp, 2011).¹ Since Tables I to IV of BC motivate the dynamic panel data methods employed in their paper, we discuss the narrow replication of these results in our introduction:

- Table I in BC, which contains the descriptive statistics of budget shares, is perfectly reproducible. We do not report the replicated results here.
- Table II of BC, which contains the estimates of the QAIDS specification of the Engel curves, is not perfectly reproducible. All entries for `foodout` and `alct` as well as all test results and elasticities are almost perfectly reproducible. For all other composites, the standard errors are very close to the reported ones, and most of the coefficients are close to the reported ones. The qualitative results remain unchanged. The results based on two-stage least-squares estimation carried out with the **Stata** command `ivregress` are presented in Table 3 of the Appendix.
- Table III of BC, which contains estimated autocorrelations of residuals based on the Engel curve estimates in Table II of BC, is not perfectly reproducible, but our replication results are very close to the reported ones. The remaining statistics are the Arellano and Bond (1991) test statistics for first and second order autocorrelation in the error terms. Although the results are not perfectly reproducible, the substantive conclusions are unchanged. The detailed results are reported in Table 4 of the Appendix.
- Table IV of BC contains two-step GMM estimates of an Engel curve. Apart from the intercepts, the non-dummy coefficient estimates and standard errors can be reproduced exactly with the **Stata** command `ivreg2`; using the command `ivregress` produces slightly different standard errors. Concerning the elasticities, the qualitative results remain unchanged when

¹More specifically, we use the built-in functions `ivregress`, `ivreg2`, and `gmm`, along with the function `xtdpdgmm` contributed by Kripfganz (2018).

using either command – although minor differences compared to BC occur. We present our estimation results obtained with the function `ivregress` and the corresponding elasticities in Table 5 of the Appendix. Note that the instrument set actually employed in BC differs from their description (see p.632) and is given below Table IV.

2 GMM estimation of Engel curves

BC estimate augmented Engel curves allowing for household-specific unobserved heterogeneity and first-order dynamics, while excluding the quadratic term from the QAIDS specification. In particular, they model budget shares $\omega_{i,h,t}$ as follows:

$$\omega_{i,h,t} = \alpha_i + \beta_i \text{lrxtot}_{h,t} + \gamma_i \omega_{i,h,t-1} + \sum_k \delta_{i,k} z_{k,h,t} + u_{i,h,t}, \quad (1)$$

$$u_{i,h,t} = \rho_{i,h} + \varepsilon_{i,h,t}, \quad (2)$$

where i indexes the six composite commodities, h indexes households, t indexes time, $\text{lrxtot}_{h,t}$ is the logarithm of real total expenditures, α_i denotes a good-specific intercept, $z_{k,h,t}$ are a set of controls, $\rho_{i,h}$ is an unobserved household-specific effect, and $\varepsilon_{i,h,t}$ is an unobservable idiosyncratic error term. The controls include the number of children (`nch`) and adults (`nah`) in the household, the age and squared age of the husband (`hage` and `hage2`), year-quarter dummies (up to a maximum of 48 for the four quarters of the 12 years investigated), and weekly seasonal dummies.

The presence of unobserved household-specific effects along with lagged budget shares $\omega_{i,h,t-1}$ requires considering the usual assumptions of linear dynamic panel data methods in order to consistently estimate the coefficients of Equation (1). Instead of using past values of the lagged budget share as instruments (which is usually done in estimation of linear dynamic panel data models; see, e.g., Holtz-Eakin, Newey, and Rosen, 1988 and Arellano and Bover, 1995), BC use lags and lagged first differences of $\text{lrxtot}_{h,t}$ and of the logarithm of real husband income $\text{lrhearn}_{h,t}$ as instruments to identify the parameters of the model, in particular, the habit persistence parameter γ_i . These instruments arise from the following orthogonality conditions for the equation in first differences and the equation in levels:

$$\mathbb{E}(\Delta \varepsilon_{i,h,t} \text{lrxtot}_{h,t-k}) = 0, \quad \forall k = 2, \dots, K_x \quad (3)$$

$$\mathbb{E}(\Delta \varepsilon_{i,h,t} \text{lrhearn}_{h,t-k}) = 0, \quad \forall k = 0, \dots, K_y \quad (4)$$

$$\mathbb{E}(u_{i,h,t} \Delta \text{lrxtot}_{h,t-k}) = 0, \quad \forall k = 1, \dots, K_{\Delta x} \quad (5)$$

$$\mathbb{E}(u_{i,h,t} \Delta \text{lrhearn}_{h,t-k}) = 0, \quad \forall k = 0, \dots, K_{\Delta y}. \quad (6)$$

On p.634 and the notes to Table V, BC report that they use $K_x = K_y = 5$ and $K_{\Delta x} = K_{\Delta y} = 4$. Employing this instrument set, we are unable to reproduce the reported 81 degrees of freedom for the J -statistic. We therefore set $K_{\Delta x} = K_{\Delta y} = 5$ to obtain the reported number of overidentifying restrictions. As a robustness check, BC impose the orthogonality conditions stated in Equations (4) and (6), with $K_y = 5$ and $K_{\Delta y} = 4$, while we set $K_{\Delta y} = 5$ to be consistent with our preceding choice. We are unable to obtain the 73 degrees of freedom reported by BC for the J -statistic for either choice of $K_{\Delta y}$. BC use iterated GMM to obtain their results. We report our replication of their Tables V and VI in the corresponding Tables 1 and 2.

We use the built-in `Stata` command `gmm` to estimate the Engel curves under the orthogonality conditions discussed above. This built-in function has the advantage of allowing for iterated GMM whereas other built-in `Stata` commands and user-contributed functions only allow for two-step

GMM. Unfortunately, both the interactive and moment-evaluator versions of the command are susceptible to programming errors and breakdowns due to perfect collinearity of instruments, especially when there are a large number of time and seasonal dummies. We suggest that practitioners use the extension of the Frisch-Waugh-Lovell Theorem provided by Giles (1984) and first orthogonalize the dependent variable and the regressors with respect to the dummies (also denoted as partialling out) before GMM estimation. Note that there is no need to orthogonalize the instruments with respect to the dummies. This first step facilitates estimation with the `gmm` command, does not affect the number of overidentifying restrictions, and results in estimation output that focuses on the key variables of interest. Finally, partialling out the dummies speeds up the `gmm` command considerably.

3 Replication in a narrow sense

Contrasting our estimation results with BC reveals that, while most of the standard errors are roughly similar, some of the coefficient estimates for the natural logarithm of real total expenditures (`lrxtot`) and the lagged budget shares differ considerably. An example for a pronounced change is the result for `foodout` in Table 2, where our habit persistence parameter estimate is near one. However, most of the coefficient estimates and standard errors for the non-dummy control variables do not change very much. Commodities are classified based on the statistical significance and the sign of the coefficient estimate of the lagged budget share (`lbs`) at a significance level of $\alpha = 5\%$. Habit formation is attributed to a statistically significant coefficient which is positive, and durability to a statistically significant coefficient which is negative; otherwise, commodities are considered to exhibit no state dependence. In particular, BC report that `nds` are not state dependent and that `sdur` exhibit durability. Our results suggest that `nds` are habit-forming, while `sdur` have no state dependence.

Similar to BC, we also report overidentifying restriction tests and tests for underidentification. For testing overidentifying restrictions, we proceed as BC and calculate the J -statistics of Sargan (1958) and Hansen (1982). We find that the null is not rejected even at the 10% level for the six consumption composites, while BC report rejections of the null for the J -test at the 5% significance level for `foodin` ($p = 0.0495$) and `c1o` ($p = 0.0418$) in their Table V.

In contrast to BC, we use the underidentification test proposed by Windmeijer (2017) instead of the Arellano, Hansen, and Sentana (2012) test because all the moment conditions employed are linear. Windmeijer (2017) shows that an easily implementable version of the test by Arellano, Hansen, and Sentana (2012) involves computing the J -statistic from the same `Stata` command used to calculate GMM estimates but with the lagged dependent variable not used as a covariate, but as the dependent variable.² A rejection of the test of overidentifying restrictions indicates that the chosen instruments may not be weak. BC do not report any weak instrument problem in their Table V and do not elaborate on the indication of weak instruments for `foodout` ($p = 0.1662$) in their Table VI. The diagnostics employed in our replication suggest that the instruments employed are considerably weak, especially for `nds` and `foodout` in Table 1 and `nds`, `foodout`, `alct`, and `c1o` in Table 2.

We report the 25th, 50th, and 75th percentiles of the calculated point estimates of short-run and long-run expenditure elasticities. Most of the descriptive statistics and relative magnitudes for the calculated income elasticities are similar to the results reported by BC, with the exception of `foodout` in Table 2 where the long-run income elasticities exhibit the most pronounced changes. BC report values from 1.09 to 1.30, while we obtain values from 8.68 to 27.15. In total, despite some of

²At this point, we use `xtpdgmm` for the calculation since two-step GMM estimation should be adequate.

the changes in the results being substantial, they were not large enough to change the classification of the composites from luxuries to necessities and vice versa.

Finally, BC calculate point estimates of the relative loss from habits $\chi_{h,t}$ defined as

$$\chi_{h,t} = \sum_i \gamma_i \omega_{i,h,t}.$$

Their definition for the relative loss from habits assumes a constant total expenditure path. BC obtain 0.01, 0.076, and 0.14 for the 1st, 5th, and 9th deciles of the relative loss from habits. We obtain 0.047, 0.122, and 0.198, if we use the estimates from Table 1. Equivalently, we obtain 0.018, 0.147, and 0.296, if we use estimates from Table 2. Our results are larger than what BC report but not large enough to reach a value of 0.73. This value is required for habits (arising from the preferences of consumers) to reconcile asset return data with a standard real business cycle equilibrium model (Boldrin, Christiano, and Fisher, 2001). This large discrepancy in the required amount of habit formation, which contributes to existing macro puzzles, has been extensively documented and explained in a recent meta-analysis of habit formation studies by Havranek, Rusnak, and Sokolova (2017). Even if we compute the time series average of $\chi_{h,t}$, the estimated values are in between 0.004 to 0.249 and -0.069 to 0.465, for Tables 1 and 2, respectively. The only way to reach a value of 0.73 for $\chi_{h,t}$ is to consider the estimates in Table 2 and focus on estimates of the relative loss from habits above the 99th percentile.

4 Concluding remarks

We are able to replicate Tables I to IV of BC, while we are not able to fully replicate their results for Tables V and VI. Reporting results of GMM estimation of dynamic panel data models can be daunting, given that we have to explicitly state the orthogonality conditions in order to enable straightforward replication. The presence of time and seasonal dummies along with unbalanced panel data may complicate the counting and inclusion of instruments for the level and differenced equations in `Stata` and other statistical software. We suggest using the extension of the Frisch-Waugh-Lovell Theorem to facilitate the inclusion of such dummies in practice. BC identify the habit persistence parameters by imposing a constant correlated effects assumption. As in BC, our results suggest that there is no evidence to reject this assumption. However, the weak instrument problem has yet to be addressed.

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Table 1: Replication of Table V of BC – Iterated GMM

	foodin	nds	foodout	alct	clo	sdur
lrxtot	-9.8360*** (1.9275)	-3.3543* (1.6736)	3.3088** (1.1231)	-0.5093 (0.4244)	5.3193** (1.5575)	4.4096*** (0.9329)
lbs	0.0038 (0.0307)	0.2964*** (0.0821)	0.4211*** (0.0938)	0.1280* (0.0571)	-0.1772*** (0.0427)	-0.0379 (0.0512)
nch	1.9428*** (0.2109)	-0.3271 (0.1765)	-0.4704*** (0.1189)	0.0413 (0.0561)	-0.2927 (0.1518)	-0.3974*** (0.1014)
nad	0.3413 (0.3195)	0.3820 (0.2879)	0.2678 (0.1832)	0.2530** (0.0850)	-0.9684*** (0.2683)	-0.8719*** (0.1588)
hage	0.4817* (0.2126)	0.7562*** (0.1847)	-0.2780* (0.1172)	-0.3161*** (0.0635)	-0.1318 (0.1597)	-0.5417*** (0.1013)
hage2	-0.0030 (0.0023)	-0.0083*** (0.0021)	0.0025* (0.0012)	0.0031*** (0.0007)	0.0011 (0.0017)	0.0054*** (0.0011)
Iterations	8	14	23	8	10	12
<i>J</i> -statistic	75.20	56.10	80.91	61.85	95.99	90.83
<i>p</i> -value (81 df)	0.6607	0.9842	0.4818	0.9440	0.1223	0.2134
Underident. test	399.22	95.41	85.99	175.74	282.42	199.19
<i>p</i> -value (82 df)	< 0.001	0.1478	0.3599	< 0.001	< 0.001	< 0.001
<i>Short-run elasticities</i>						
Q25	0.62	0.85	1.21	0.68	1.28	1.54
Median	0.72	0.89	1.36	0.84	1.46	2.22
Q75	0.78	0.92	1.71	0.91	1.88	4.19
<i>Long-run elasticities</i>						
Q25	0.62	0.79	1.36	0.63	1.24	1.52
Median	0.72	0.85	1.63	0.81	1.39	2.18
Q75	0.78	0.88	2.23	0.89	1.75	3.96

Equations in first differences: $L(2/5)$.lrxtot, $L(0/5)$.lrhearn, $D.nch$, $D.nad$, $D.hage$, $D.hage2$

Equations in levels: $L(0/5)$.D.lrxtot, $L(0/5)$.D.lrhearn, nch , nad , $hage$, $hage2$

Clustered standard errors in parentheses; household ID used as clustering variable

$nT = 15739$ for equations in levels; $nT = 13290$ for equations in differences; number of households = 2449

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (refers to *t*-test of the null that the coefficient is equal to zero)

Table 2: Replication of Table VI of BC – Robustness check

	foodin	nds	foodout	alct	clo	sdur
lrxtot	-12.0763*** (2.7173)	-0.6388 (2.8456)	2.7530 (1.8120)	-0.9904 (0.5763)	2.8548 (2.4964)	4.0778* (1.6222)
lbs	0.0128 (0.0946)	0.2724* (0.1258)	0.9773*** (0.1008)	0.4573*** (0.0937)	-0.3995** (0.1156)	-0.1542 (0.0930)
nch	1.9685*** (0.2575)	-0.4735* (0.2098)	-0.0834 (0.1143)	0.0597 (0.0438)	-0.2083 (0.1934)	-0.3821** (0.1208)
nad	0.6287 (0.4088)	-0.0065 (0.4332)	-0.3487 (0.2697)	0.2819** (0.0941)	-0.6764 (0.3957)	-0.8569*** (0.2393)
hage	0.6850** (0.2523)	0.6230* (0.2512)	-0.1700 (0.1347)	-0.1625* (0.0682)	0.0813 (0.2212)	-0.5524*** (0.1379)
hage2	-0.0052 (0.0027)	-0.0069* (0.0027)	0.0018 (0.0014)	0.0016* (0.0007)	-0.0012 (0.0024)	0.0055*** (0.0015)
Iterations	10	14	13	23	26	19
<i>J</i> -statistic	41.31	30.10	34.81	41.20	48.44	61.25
<i>p</i> -value (49 df)	0.7745	0.9847	0.9372	0.7782	0.4959	0.1125
Underident. test	79.89	50.54	58.16	51.14	62.83	79.74
<i>p</i> -value (50 df)	0.0046	0.4519	0.2001	0.4288	0.1051	0.0047
<i>Short-run elasticities</i>						
Q25	0.53	0.97	1.17	0.38	1.15	1.50
Median	0.65	0.98	1.30	0.68	1.25	2.13
Q75	0.73	0.98	1.59	0.82	1.47	3.95
<i>Long-run elasticities</i>						
Q25	0.52	0.96	8.68	-0.15	1.11	1.44
Median	0.65	0.97	14.31	0.42	1.18	1.98
Q75	0.72	0.98	27.15	0.66	1.34	3.56

Equations in first differences: $L(0/5)$ *lrhearn*, *D.nch*, *D.nad*, *D.hage*, *D.hage2*

Equations in levels: $L(0/5)$ *D.lrhearn*, *nch*, *nad*, *hage*, *hage2*

Clustered standard errors in parentheses; household ID used as clustering variable

$nT = 15739$ for equations in levels; $nT = 13290$ for equations in differences; number of households = 2449

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (refers to *t*-test of the null that the coefficient is equal to zero)

5 Appendix

Table 3: Replication of Table II of BC – QAIDS Engel curve estimates

	foodin	nds	foodout	alct	clo	sdur
lrxtot	-44.77 (54.85)	-53.38 (59.51)	84.30* (39.65)	-65.55** (25.29)	48.19 (40.44)	31.22 (31.33)
lrxtot2	1.019 (2.085)	2.534 (2.264)	-3.174* (1.508)	2.421* (0.960)	-1.728 (1.540)	-1.073 (1.192)
nch	2.378*** (0.200)	-1.263*** (0.201)	-0.657*** (0.134)	0.101 (0.0695)	-0.192 (0.119)	-0.367*** (0.0912)
nad	1.546*** (0.225)	-1.946*** (0.252)	1.161*** (0.177)	0.534*** (0.0862)	-0.633*** (0.144)	-0.662*** (0.0979)
hage	1.157*** (0.192)	-0.117 (0.224)	-0.304 (0.158)	-0.221** (0.0789)	-0.0512 (0.128)	-0.463*** (0.0894)
hage2	-0.0102*** (0.00214)	0.000784 (0.00251)	0.00252 (0.00177)	0.00202* (0.000857)	0.000388 (0.00143)	0.00451*** (0.000997)
const	409.3 (358.2)	306.4 (388.4)	-541.5* (258.6)	450.8** (165.3)	-320.0 (263.7)	-205.0 (204.4)
$\chi^2(2)$	556.56	218.79	6.53	47.18	26.92	75.57
<i>p</i> -value	< 0.001	< 0.001	0.0382	< 0.001	< 0.001	< 0.001
<i>Income elasticities</i>						
Q25	0.31	1.30	0.93	-0.32	1.12	1.34
Median	0.48	1.40	1.11	0.42	1.24	1.81
Q75	0.58	1.56	1.42	0.83	1.52	3.19

Note, that *lrxtot* and *lrxtot2* are instrumented by *lrhearn* and *lrhearn2*

Clustered standard errors in parentheses; household ID used as clustering variable

$n = 18188$, number of groups = 2449

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (refers to t -test of the null that the coefficient is equal to zero)

Table 4: Replication of Table III of BC – Autocorrelations of residuals

	foodin	nds	foodout	alct	clo	sdur
1st-order	0.3751	0.3572	0.4102	0.5908	0.1184	0.1320
2nd-order	0.3526	0.3348	0.3922	0.5755	0.1627	0.1043
3rd-order	0.3430	0.3254	0.3869	0.5551	0.1146	0.0755
4th-order	0.3892	0.3508	0.4012	0.5567	0.1967	0.1532
5th-order	0.3077	0.2806	0.3499	0.5236	0.1044	0.1137
6th-order	0.2582	0.2627	0.3353	0.5005	0.1258	0.0747
7th-order	0.2851	0.2462	0.3469	0.5009	0.1180	0.0704
Test for 1st-order serial corr.	20.321	21.220	19.871	17.439	10.540	9.522
<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Test for 2nd-order serial corr.	19.384	19.897	19.229	17.325	13.719	9.002
<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table 5: Replication of Table IV of BC – Budget shares in levels

	foodin	nds	foodout	alct	clo	sdur
lrxtot	-13.63*** (1.090)	-0.297 (0.453)	0.140 (0.519)	-0.206 (0.129)	3.190*** (0.530)	2.938*** (0.457)
lbs	0.0008 (0.0587)	1.008*** (0.0550)	0.9901*** (0.0939)	0.5937*** (0.0785)	-0.0596 (0.0712)	-0.1450 (0.0957)
nch	2.138*** (0.260)	0.0670 (0.147)	0.0631 (0.119)	0.0346 (0.0417)	-0.161 (0.185)	-0.553*** (0.113)
nad	1.084*** (0.270)	-0.296 (0.154)	0.117 (0.122)	0.181*** (0.0548)	-0.653*** (0.194)	-0.520*** (0.144)
hage	0.768*** (0.221)	-0.200 (0.139)	0.0475 (0.103)	-0.119* (0.0525)	0.0362 (0.164)	-0.402*** (0.121)
hage2	-0.00612* (0.00241)	0.00204 (0.00155)	-0.000451 (0.00112)	0.00112* (0.000554)	-0.000644 (0.00180)	0.00364** (0.00132)
const	188.2*** (14.72)	6.349 (5.631)	-4.116 (5.060)	6.953** (2.532)	-28.22*** (6.595)	-20.38*** (4.840)
<i>J</i> -statistic	53.10	11.26	8.60	62.74	8.60	19.02
<i>p</i> -value	< 0.001	0.2581	0.4746	< 0.001	0.4746	0.0251
<i>Short-run elasticities</i>						
Q25	0.47	0.99	1.01	0.87	1.17	1.36
Median	0.61	0.99	1.02	0.93	1.28	1.82
Q75	0.69	0.99	1.03	0.96	1.53	3.13
<i>Long-run elasticities</i>						
Q25	0.47	1.88	1.89	0.68	1.16	1.32
Median	0.61	2.15	2.54	0.84	1.26	1.71
Q75	0.69	2.58	4.03	0.91	1.50	2.86

With *lrxtot* and *lbs* instrumented by: $L(1/5)$ *lrxtot*, $L(0/5)$ *lrhearn*

Clustered standard errors in parentheses; household ID used as clustering variable

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (refers to *t*-test of the null that the coefficient is equal to zero)

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