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Testing for Separation in Agricultural Household Models and Unobservable Individual Effects : A Note

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Comments welcome

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Abstract

When market structure is complete, factor demands by households will be independent of their characteristics, and households will take their production decisions as if they were profit-maximizing firms. This observation constitutes the basis for one of the most popular empirical tests for complete markets, commonly known as the "separation" hypothesis. In this paper, we show that all existing tests for separation using panel data are potentially biased towards rejecting the null-hypothesis of complete markets, because of the failure to adequately control for unobservable individual effects. Since the variable on which the test for separation is based cannot be identified in most panel datasets following the usual covariance transformations, and is likely to be correlated with the individual effect, neither the within nor the variance-components procedures are able to solve the problem. We show that the Hausman-Taylor (1981) estimator, in which the impact of covariates that are invariant along one dimension of a panel can be identified through the use of covariance transformations of other included variables that are orthogonal to the individual effects as instruments, provides a simple solution. We furnish an empirical illustration in which separation —and thus the null of complete markets— is strongly rejected using the standard approach, but is not rejected once correlated unobservable individual effects are controlled for using the Hausman-Taylor instrument set.

Keywords: panel data, individual effects, household models, testing for incomplete markets, development microeconomics.

JEL: C230, D130, D520, O120

Résumé

Test de séparabilité dans les modèles de ménage et effets individuels inobservables

Lorsque les marchés sont complets, les demandes de facteurs par ménage sont indépendantes des caractéristiques de ces derniers et les ménages se comportent tels des firmes qui maximisent leurs profits. Cette observation est à la base de l'un des plus célèbre test de l'hypothèse de marchés complets, communément nommée l'hypothèse de « séparabilité ». Dans cet article, nous montrons que l'ensemble des tests de séparabilité utilisant des données de panel sont potentiellement biaisés vers un rejet systématique de cette hypothèse, et ce, en raison de la non prise en compte de l'hétérogénéité inobservable. Les variables sur lesquelles le test de séparabilité repose sont généralement (i) corrélées avec l'effet individuel inobservable et (ii) invariantes dans le temps. Dans ce cas, les différentes méthodes d'estimation en panel (effets fixes ou effets aléatoires) ne nous permettent pas d'identifier sans biais les coefficients associés à ces variables. L'estimateur proposé par Hausman-Taylor (1981) constitue une solution à ce problème, dans la mesure ou il identifie sans biais l'effet de variables invariantes dans le temps corrélées avec l'effet fixe, et ce, même en l'absence d'instruments externes. Nous fournissons une illustration empirique de cet estimateur et nous montrons que contrairement aux résultats traditionnellement obtenus, l'hypothèse de séparabilité n'est pas rejetée dès lors que nous contrôlons pour l'hétérogénéité inobservable.

Mots clés: données de panel, effets fixes, modèles de ménage, test pour les marchés incomplets, micro-économie du développement.

1. INTRODUCTION

One of the most widely-used empirical tests for the presence of market imperfections in developing countries is provided by the so-called "separation" hypothesis. Numerous papers, including the seminal article by Benjamin (1992), have tested the hypothesis that factor demands on a given plot of land will be independent of household characteristics, when market structure is (almost) complete (Singh, Squire and Strauss, 1986; see the summary of the recent literature, as well as two typical applications, in Udry, 1996).[1] Separation implies that the marginal productivity of inputs will be a function solely of plot characteristics and prices, and that households take their production decisions as if they were profit-maximizing firms. In contrast, when factor demands are a function of household characteristics, marginal productivities are not equated across plots and a deviation with respect to the first-best optimum obtains. Moreover, the production and consumption decisions of households can no longer be treated recursively.

The purpose of this note is to demonstrate that: (i) in most cases, the standard test for separation using panel data is biased towards rejecting the null-hypothesis of complete markets because of a problem of unobservable individual effects; (ii) the usual covariance transformations performed on panel data cannot solve this problem; but (iii) the Hausman-Taylor (1981) estimator can. In addition, we provide an empirical illustration in which the rejection of the null-hypothesis of complete markets using the standard approach is overturned once correlated individual effects are controlled for using the Hausman-Taylor estimator.

In the most common version of the test for separation, the typical equation being estimated on plot-level agronomic data is given by :

(1) $Y_{iht} = X_{iht}a + Z_{ht}b + e_{iht}$,

where Y_{iht} is total labor usage (i.e., family and hired labor) on plot i, cultivated by household h, at time t, X_{iht} is a matrix of plot characteristics, Z_{ht} is a matrix of household characteristics, and e_{iht} is a disturbance term that satisfies the usual Gauss-Markov

[1] A concise primer on household models is also provided by Bardhan and Udry (1999), chapter 2. Note that Benjamin (1992) used Indonesian *household*-level data and was therefore unable to control for individual effects at all.

assumptions. Separation is then associated with a simple F-test on the exclusion restriction that $b = 0$. In the prototypical expression of the test for separation (Benjamin, 1992), Z_{ht} is household size.

The main problem associated with this procedure is that the disturbance term e_{iht} can in all likelihood be decomposed into :

(2) $$e_{iht} = m_t + l_h + l_{ht} + h_{iht},$$

where m_t is a shock common to all plots and households at time t, l_h is a time-invariant household effect, l_{ht} is a household-time effect, and h_{iht} is a disturbance term that satisfies the usual assumptions.[2] In most plot-level datasets used in the literature, each household cultivates several plots. This is a standard panel data framework, with one dimension being given by plots, the second by households, and the third by time. Although l_h can be accounted for by a "within" procedure which transforms variables into deviations with respect to their household-specific means (over *all* time periods), there remains l_{ht}. Since it is probable that l_{ht} is correlated with Z_{ht}, the least-squares estimate of b, even after the standard "within" transformation, will be biased with, in the scalar case :

(3) $$\text{plim}\hat{b}_w = b + \text{cov}[l_{ht}, \hat{e}_{iht}] / s_e^2,$$

where s_e^2 is the variance of the residual $\hat{e}_{iht}$ from the auxiliary "within" regression of household size on X_{iht}.[3] If $\text{cov}[l_{ht}, \hat{e}_{iht}] \neq 0$, as is likely in the context of what is essentially a labor demand equation, then *all standard tests of separation are biased towards rejecting the null-hypothesis of complete markets.*

One may therefore reject the null not because market structure is necessarily incomplete, but simply because of a banal problem of unobservable heterogeneity. Another way of putting this is that, in the standard test, the rejection of separation is conditional on the maintained identifying assumption that l_{ht} is the same across all households at a given time t. It is very likely that this assumption is violated.

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[2] In datasets where it is possible to follow plots over time, there may also be a time-invariant plot-specific effect.
[3] Hsiao (1986), p. 64, equation (3.9.3). The corresponding matrix expression obtains when z_{ht} involves several household characteristics.

The usual econometric response to a problem of unobservable individual heterogeneity in panel data is to apply one of the standard covariance transformations, such as the "within" procedure. Here, this would involve expressing all variables as deviations with respect to their household-specific means, *at a given* t. While, under the assumption of exogeneity, this does allow one to recover unbiased estimates of a, it has the regrettable side-effect of eliminating the variable(s) upon which the test for separation is based since, when one sweeps out l_{ht}, one also sweeps out Z_{ht}. Since it is highly likely that l_{ht} is not orthogonal to Z_{ht}, random effects are not an answer, as they too will yield biased estimates of b. Moreover, admissible exogenous instruments that would be correlated with Z_{ht} but are orthogonal to l_{ht} are usually not available or, if they are, should probably already be included in Z_{ht} for theoretical reasons.

The problem, which is similar in spirit to that of consistently estimating the returns to education using panel data when schooling is correlated with the individual effects, can be solved using the Hausman-Taylor (1981, henceforth, HT) instrumental variables estimator, which allows one to control for unobservable individual effects that are correlated with Z_{ht}, while allowing one to identify b.[4]

2. AN EMPIRICAL ILLUSTRATION OF THE UNWARRANTED REJECTION OF THE NULL-HYPOTHESIS OF COMPLETE MARKETS

The Hausman-Taylor instrument set

Let X_{1iht} be those elements of X_{iht} that are uncorrelated with l_{ht}, while X_{2iht} are those that are; Z_{1ht} and Z_{2ht} are defined in a similar manner. The set of instruments proposed by HT (1981), adapted to the three-dimensional panel structure, is :

(4) $A_{HT} = [Q_{vt}X_{iht}; P_{vt}X_{1iht}; Z_{1ht}]$,

where P_{vt} and Q_{vt} are the idempotent matrices that perform the "between" and "within" transformations at time t, respectively.[5] Under the assumption that X_{iht} is uncorrelated with

[4] The problem here becomes *identical* to that considered in HT (1981) when there is no time dimension to the panel and one is left solely with plots and households.

[5] For simplicity of exposition, we express the instrument set as if the data were balanced. In the empirical application, the unbalanced nature of the data will, of course, be taken into account.

h_{iht}, $Q_{vt}X_{iht}$ is a legitimate set of instruments since $E[(Q_{vt}X_{iht})'h_{iht}] = 0$. The basic intuition behind the HT estimator is that only the l_{ht} component of the error term is correlated with $[X_{2iht}\ Z_{2ht}]$, which allows one to use $Q_{vt}X_{2iht}$ as instruments for X_{2iht}, while $P_{vt}X_{1iht}$ furnishes the instruments for Z_{2ht}. The HT estimator therefore allows one to control for unobservable correlated individual effects, while allowing one to identify the parameters of interest (b) in the context of testing for separation. A necessary condition for identification is that the number of elements of X_{1iht} be greater than the number of elements of Z_{2ht} (HT, 1981, PROPOSITION 3.2, p. 1385).[6]

An empirical illustration

In order to illustrate our fundamental point concerning the bias affecting conventional tests for separation in household models, consider the following standard procedure implemented on a typical plot-level dataset. The data come from two surveys (1993, 1995) carried out in the village of El Oulja, Tunisia (see Matoussi and Nugent, 1989, and Laffont and Matoussi, 1996, for descriptions of the village). These data display those properties discussed in the introduction : a Hausman test of random household-time effects (l_{ht}) versus fixed effects in an empirical counterpart to equations (1) and (2) strongly rejects (with a p-value below 0.001) the null of the absence of correlation between l_{ht} and Z_{ht}. The bias identified in equation (3) is therefore manifestly present in conventional tests of the null-hypothesis of complete markets using this panel dataset.

For the purpose of HT estimation, we divide the explanatory variables into two categories: (i) X_{1iht} variables, assumed to be uncorrelated with l_{ht}, include four soil type dummies and a dummy variable that indicates whether the plot is irrigated or not, as well as a set of eight crop dummies;[7] (ii) X_{2iht} variables, assumed to be correlated with l_{ht}, are given by the share of

[6] These results have been extended by Amemiya and MaCurdy (1986) and Breusch, Mizon and Schmidt (1989) who suggest a broader set of instruments that should improve efficiency. Their approach, however, is only possible on balanced data, which is not the case in the dataset used in this paper or, for that matter, in most plot-level agronomic datasets. Notice that the HT instrument set is admissible only if exogeneity is satisfied. This is another potential source of bias in tests for separation, but which is difficult to address because of the lack of admissible plot-level instruments in most datasets.

[7] The soil types are clay, red, sandy and barren, with mixed soil types being the excluded category; the crop dummies are other cereals, potatoes, onions, garden vegetables, tomatoes, beetroots, melon and fodder; the excluded category is wheat. We also include a year dummy.

costs borne by the cultivator, divided by the share of output received, for eight different inputs, as well as log plot size in hectares.[8]

The economic rationale for allowing the variables included in X_{2iht} to be correlated with l_{ht} is that they may, in the context of tenancy contracts (which account for 28 percent of the plots in the sample), be determined as the solution to a principal-agent relationship between a landlord and a tenant, and would then be functions of tenant characteristics, including those unobservable characteristics potentially captured by l_{ht}.[9] Plot size is also assumed to be correlated with l_{ht}, as it too may be chosen by landlords for plots under tenancy contracts. Both of these hypotheses will be subjected to a test of the corresponding overidentifying restrictions below. Our single Z_{2ht} variable is given by log household size. In line with the usual methodology, the dependent variable is log total (hired and family) labor usage on the plot, in person-days per hectare.[10] Table 1 provides summary statistics on all the aforementioned variables.

Estimation results are presented in Table 2. The standard test for separation is presented in column 1, and yields an unambiguous rejection of the null-hypothesis of complete markets in that log household size is highly significant at the usual levels of confidence (p-value below 0.001). In column 2, we control for time-invariant household characteristics (l_h) using the "within" transformation: recall that the impact of household size can be identified here because we have two years of data and household size varies over the two surveys.[11] Again the null of complete markets is strongly rejected by the data (p-value = 0.017).[12] In column 3, we present results which allow for random household-time (l_{ht}) effects: this specification, which also rejects the null of complete markets, can however be dismissed on the basis of the

[8] The output and cost shares both equal 1 on plots cultivated by owner-operators. Values strictly less than or greater than one of the ratio obtain on plots under share tenancy contracts.
[9] An additional, empirical, motivation for using the ratios of cost-shares to the output share is that the data in question come from a single village and that the only source of cross-sectional variation in effective input prices stems from heterogeneity in contractual form on plots under tenancy contracts.
[10] Note that there are no z_{1ht} variables in this specification.
[11] Note, despite a substantial fall in the variance of log household size, which goes from 0.328 in levels, to 0.014 when expressed in terms of deviations with respect to household-specific means (over both periods), that the estimated standard error is still reasonably small, with the associated t-statistic being equal to 2.406. The time-invariant household fixed effects (l_h) used here correspond to the type of specification used by Udry (1996), Table 3, column 2, for a labor demand per hectare equation estimated on the Burkina Faso ICRISAT dataset.
[12] A household-specific random effects specification (l_h, not presented) is strongly rejected by the corresponding Hausman test.

corresponding Hausman test in favor of fixed effects, as mentioned above (p-value of the Hausman test is below 0.001). Of course, household-time (l_{ht}) *fixed* effects would not allow one to test for separation at all in that they would also sweep out the impact of household size.

In column 4, we present results corresponding to the consistent HT estimator.[13] The results are striking. In contrast to what was found in columns 1 through 3, the null of complete markets is *not* rejected at the usual levels of confidence: the point estimate of the parameter associated with household size is statistically indistinguishable from zero (p-value = 0.607).[14] Moreover, the test of the overidentifying restrictions does not lead one to reject, with a p-value equal to 0.418. In column 5, we implement the efficient HT estimator, in which the variables are q-differenced before instrumental variables are applied. As shown by Hausman (1978), q-differencing is equivalent to transforming equation (1), by $\Omega^{-1/2}$, where $\Omega \equiv \mathrm{cov}[e_{iht} \mid X_{iht}, Z_{ht}]$. The results are very similar to those presented in column 4 though, of course, the standard errors are smaller. Again, the null of complete markets is not rejected (p-value = 0.851), and the specification is not rejected by the test of overidentifying restrictions (p-value = 0.524).

In the context of efficient HT estimation, we also tested the hypothesis that plot size was not correlated with l_{ht}: this led to a marginal rejection of the overidentifying restrictions, with a p-value of 0.167. When plot size and the contractual terms were *both* assumed to be uncorrelated with l_{ht}, the overidentifying restrictions were rejected with a p-value of 0.062. Clearly, the specification presented in column 5 is to be preferred, but in all cases the null-hypothesis of complete markets could not be rejected on the basis of the parameter estimate associated with household size, which remained statistically indistinguishable from zero.

The upshot is that, in stark contrast to the usual approach which does not control for unobservable individual effects, HT estimation leads to the non-rejection of the null-hypothesis of complete markets. Moreover the consistency of the HT-based results presented in columns 4 and 5 is ensured, in that they are not rejected by the tests of the corresponding

[13] By "consistent", we mean that the variables are *not* q-differenced before instrumental variables are applied. See HT, section 2.3.

[14] Note that all other point estimates presented in column 4 are fairly close to those obtained using household-specific fixed effects in column 2, except for that associated with the irrigated plot dummy and the seeds cost share.

overidentifying restrictions. As noted by HT, these tests have considerable power, in that the maintained assumptions on which they are based are those needed to ensure consistency of the "within" estimator, which are weak.

3. CONCLUDING REMARKS

This paper has shown that the rejection of the null-hypothesis of complete markets in household models, based on the widely-used test of the exclusion restrictions implied by separation, can be entirely due to the bias stemming from uncontrolled-for unobservable individual heterogeneity. Our results are particularly important for plot-level panel datasets where no time dimension is present, since there is *no* means at all, apart from the HT estimator, of testing for separation while controlling for unobservable individual effects (i) if the latter are correlated with the household-level variable that is the focus of the test, and (ii) if no exogenous instruments are available. As was the case with the dataset considered in our empirical illustration, both of these conditions are likely to hold in practice.

The implications of our results are, moreover, suggestive, in that there may be other received results in applied microeconomics, based on panel data, to which the HT estimator could be fruitfully applied. An obvious example is constituted by tests of the precautionary savings motive, in which empirical measures of the risks faced by households are usually time invariant, and in which no attempt is made to correct for unobservable individual effects.

Our results bring the methodology of testing for separation using panel data into sharper focus. This is because we do not reject the null hypothesis of complete markets, *conditional* on l_{ht}. If one estimates a labor demand function on US individual *firm* data, as in Griliches and Hausman (1986), one finds correlated individual firms effects, as we have found here for households. Thus, by analogy, profit-maximizing behavior by firms is not incompatible with correlated individual effects. However, in our dataset, since labor demand is a function l_{ht}, it is not independent of household characteristics *per se*, although they are *unobservable* characteristics. Another way of putting this is that, in most panel datasets, testing for separation will undoubtedly uncover correlated individual effects. If separation is taken in its strictest sense to mean that factor demands should be independent of household characteristics, *unconditional* on l_{ht}, then we do in fact reject the null-hypothesis of complete markets. Any structural interpretation, in terms of which market failures are binding, of the *pattern* of violations of separation based on observable household characteristics (and thus on those elements of b which are statistically different from zero) will probably, however, be biased unless unobservable individual effects are controlled for using the Hausman-Taylor estimator.

REFERENCES

AMEMYA, T., AND MACURDY, T. (1986), "Instrumental-Variable Estimation of an Error-Components Model," *Econometrica* 54:869-881.

BARDHAN, P., AND UDRY, C. (1999). *Development Microeconomics* (Oxford: Oxford University Press).

BENJAMIN, D. (1992), "Household Composition, Labor Markets, and Labor Demand: Testing for Separation in Agricultural Household Models," *Econometrica* 60:287-322.

BREUSCH, T., MIZON, G., AND SCHMIDT, P. (1989), "Efficient Estimation Using Panel Data," *Econometrica* 57:695-700.

GRILICHES, Z. AND HAUSMAN, J. (1986), "Errors in Variables in Panel Data," *Journal of Econometrics* 3:93-118.

HAUSMAN, J. (1978), "Specification Tests in Econometrics," *Econometrica* 46:1251-1272.

HAUSMAN, J. AND TAYLOR, W. (1981), "Panel Data and Unobservable Individual Effects," *Econometrica* 49:1377-1398.

HSIAO, C. (1986). *Analysis of Panel Data*. Econometrics Society Monographs No. 11 (Cambridge, UK: Cambridge University Press).

LAFFONT, J.-J., AND MATOUSSI, M. (1996), "Moral Hazard, Financial Constraints and Sharecropping in El Oulja," *Review of Economic Studies* 62:381-399.

MATOUSSI, M., AND NUGENT, J. (1989), "The Switch to Sharecropping in Medjez-El-Bab," in NABLI, M. K., AND NUGENT, J. B., EDS., *The New Institutional Economics and Development: Theory and Applications to Tunisia* (New York: Elsevier Science).

SINGH, I., SQUIRE, L., and STRAUSS, J., EDS. (1986). *Agricultural Household Models: Extensions, Applications, and Policy* (Baltimore: Johns Hopkins University Press).

UDRY, C. (1996), "Efficiency and Market Structure: Testing for Profit Maximization in African Agriculture," processed, Yale University, June; available on the Yale Economic Growth Center website at: www.econ.yale.edu/~cru2//pdf/separate.pdf.

Table 1. Summary statistics, El Oulja, Tunisia

447 plots (i), 150 households (h), 196 household-years (ht)

	Mean	Median	Std. dev.
Person-days labor input per hectare (Y_{iht})	190.860	119.0	253.271
Plot characteristics (X_{1iht}):			
Soil type 1 (clay)	0.190	0.0	0.393
Soil type 2 (red)	0.201	0.0	0.401
Soil type 3 (sandy)	0.446	0.0	0.497
Soil type 4 (barren)	0.058	0.0	0.235
Irrigated plot	0.882	1.0	0.322
Contractual terms (X_{2iht}):			
% of costs paid by the cultivator / % of output to the cultivator for :			
Manure	1.008	1.0	0.121
Chemical fertilizer	1.016	1.0	0.145
Irrigation	0.999	1.0	0.150
Plowing	0.984	1.0	0.250
Family labor	1.063	1.0	0.243
Hired labor	1.041	1.0	0.230
Seeds	1.008	1.0	0.094
Transportation	1.006	1.0	0.171
Surface of plot (hectares)	5.615	1.5	13.535
Household size (Z_{2ht})	8.257	7.0	5.117

Note: many households did not engage in crop production in the second survey (1995) because of adverse climatic shocks; this explains why the number of household-years (ht) is much smaller than *twice* the number of households (h).

Table 2. Labor demand equations: Pooling, fixed effects, random effects, and Hausman-Taylor estimators

Dependent variable: log person-days per hectare used on plot

447 plots (i), 150 households (h), 196 household-years (ht)

(t-statistics in parentheses below coefficients, unless otherwise noted)

	Pooling	Fixed effects	Random effects	HT (consistent)	HT (efficient)
Mean of dependent variable = 3.825		l_h	l_{ht}	l_{ht}	l_{ht}
	(1)	(2)	(3)	(4)	(5)
Plot characteristics (X_{1iht})					
Soil type 1 (clay)	-0.012	0.189	0.045	0.164	0.091
	(-0.046)	(0.512)	(0.153)	(0.506)	(0.306)
Soil type 2 (red)	-0.467	-0.310	-0.456	-0.425	-0.404
	(-1.708)	(-0.920)	(-1.618)	(-1.001)	(-1.237)
Soil type 3 (sandy)	-0.170	-0.031	-0.149	0.120	0.015
	(-0.674)	(-0.096)	(-0.557)	(0.370)	(0.059)
Soil type 4 (barren)	0.305	0.377	0.130	0.387	0.176
	(0.819)	(0.886)	(0.344)	(0.998)	(0.476)
Irrigated plot	0.576	0.371	0.563	1.209	0.893
	(2.322)	(1.461)	(2.669)	(3.845)	(3.829)
Joint significance of plot characteristics: c_5^2	15.361	7.031	99.632	22.917	23.138
[p-value]	[0.008]	[0.218]	[0.000]	[0.000]	[0.000]
Contractual terms (X_{2iht})					
% of costs paid by the cultivator / % of output to the cultivator for :					
Manure	0.974	4.175	1.496	2.622	3.089
	(0.998)	(4.217)	(1.657)	(1.303)	(2.966)
Chemical fertilizer	1.069	-0.429	0.973	-0.391	-0.214
	(1.239)	(-0.472)	(1.168)	(-0.242)	(-0.244)
Irrigation	-0.128	1.891	0.333	1.443	1.443
	(-0.191)	(2.658)	(0.525)	(1.472)	(2.227)
Plowing	-0.080	-1.415	-0.428	-0.914	-0.956
	(-0.212)	(-2.931)	(-1.146)	(-1.413)	(-2.753)
Family labor	0.775	-0.230	0.544	0.056	-0.158
	(1.703)	(-0.378)	(1.219)	(0.108)	(-0.369)
Hired labor	-0.619	-0.407	-0.673	-0.612	-0.674
	(-1.246)	(-0.718)	(-1.442)	(-1.252)	(-1.889)
Seeds	-0.674	-2.750	-0.815	0.900	0.399
	(-0.705)	(-2.465)	(-0.891)	(0.496)	(0.441)
Transportation	-1.073	-1.037	-1.304	-1.006	-1.251
	(-1.837)	(-1.732)	(-2.475)	(-1.508)	(-2.427)
Log surface of plot (ha)	-1.008	-0.4561	-0.7416	-0.4789	-0.4542
	(-15.275)	(-4.945)	(-11.024)	(-3.689)	(-5.609)
Joint significance of cost shares : c_8^2	11.569	32.640	15.476	17.527	44.696
[p-value]	[0.171]	[0.000]	[0.050]	[0.025]	[0.000]
Log household size (Z_{2ht})	0.571	1.055	0.408	0.309	0.124
	(4.741)	(2.406)	(2.554)	(0.513)	(0.188)
R^2	0.6934	0.8816	0.6805	0.6334	0.6583
s	1.4263	1.0824	1.4680	1.5657	0.8721
Test of overidifying restrictions	n.a.	n.a.	n.a.	12.347	11.054
[d.f., p-value]				[12, 0.418]	[12, 0.524]

Note: intercept, year dummy, and eight crop dummies included in all specifications (no constant in col. (2)); random effects rejected in favor of fixed effects in columns (2) and (3) by Hausman test with an associated p-values of less than 0.0001. HT estimation carried out by interpreting the HT instrument set (eq. (4)) as a set of orthogonality conditions and applying GMM.