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ARE 251/Econ 270A, Fall 2003
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Household Models

I. The Basic Separable Household Model (Singh, I., Squire, L., and Strauss, J. (eds.) *Agricultural Household Models*. Chapters 1 and 2. Baltimore, MD: The Johns Hopkins University Press, 1986)

Two producer goods: food (a) and cash crops (c)
Two factors of production: labor (l) and other variable inputs (x)
Three consumer goods: food (a), manufactured goods (m), and leisure (l)

Definitions:
q_a production of food crop with price p_a
q_c production of cash crop with price p_c
q_l labor used in farm production with wage p_l
q_x other variable inputs with price p_x
z^q fixed factors in production and producer characteristics

c_a consumption of food product with price p_a
c_m consumption of manufactured good with price p_m
c_l consumption of leisure with price p_l
z^h household characteristics in consumption
l^s time worked
E total time endowment
p_l wage on labor market
y income
S exogenous cash transfers

1.1. The structural model

Assume: perfect markets for all products and factors, including food and family labor.
Household optimization problem:

$$\max_{q_a, q_c, q_l, q_x, c_a, c_m, c_l} U\left(c_a, c_m, c_l; z^h\right)$$

s.t.

(1) $g\left(q_a, q_c, q_l, q_x; z^q\right) = 0$, production function

(2) $p_x q_x + p_m c_m = p_a\left(q_a - c_a\right) + p_c q_c + p_l\left(l^s - q_l\right) + S$, liquidity constraint

(3) $l^s + c_l = E$, time constraint

Substituting l^s in (2) for its value in (3) gives the full income constraint:

$$p_a c_a + p_m c_m + p_l c_l = \left(p_a q_a + p_c q_c - p_l q_l - p_x q_x\right) + p_l E + S$$
$$= \Pi + p_l E + S$$

where $\Pi = p_a q_a + p_c q_c - p_x q_x - p_l q_l$, restricted profit in agriculture.

The household optimization problem can be rewritten as:

$$\underset{q_a, q_c, q_l, q_x, c_a, c_m, c_l}{\text{Max}} \; W \quad = U + \phi g + \lambda\left[\Pi - p'c + p_l E + S\right]$$

Assume interior solution with q and $c > 0$. First order conditions:

(4) $\dfrac{\partial W}{\partial q_i}$: $\phi g_i' = -\lambda p_i$, $i = a, c$ (producer goods)

(5) $\dfrac{\partial W}{\partial q_j}$: $\phi g_j' = \lambda p_j$, $j = l, x$ (factors)

(6) $\dfrac{\partial W}{\partial \phi}$: $g = 0$ (technology constraint)

(7) $\dfrac{\partial W}{\partial c_k}$: $U_k' = \lambda p_k$, $k = a, m, l$ (consumption goods)

(8) $\dfrac{\partial W}{\partial \lambda}$: $p'c - \left(\Pi + p_l E + S\right) = 0$ (full income constraint)

This indicates recursivity, called <u>separability</u>, i.e.:

Equations (4)–(6) ⇒ optimum levels of outputs, inputs, and maximum profit Π^*.

Equations (7) and (8) identical to a pure consumer problem.

Production decisions influence consumption only through profit Π^*.

1.2. Recursive solution: the reduced form

First step: Solve the producer problem for maximum agricultural profit:

$$\underset{q_a, q_c, q_l, q_x}{\text{Max}} \; \Pi = p_a q_a + p_c q_c - p_x q_x - p_l q_l, \quad s.t.\; g\left(q_a, q_c, q_l, q_x; z^q\right) = 0.$$

This gives the reduced form:

Supply functions $q_i = q_i\left(p_a, p_c, p_l, p_x; z^q\right)$, $i = a, c$

Factor demands $q_j = q_j\left(p_a, p_c, p_l, p_x; z^q\right)$, $j = l, x$

Maximum restricted profit $\Pi^* = \Pi^*\left(p_a, p_c, p_l, p_x; z^q\right)$

Second step: Solve the consumer problem for maximum utility given the level of profit Π^* achieved in production

$$\underset{c_a, c_m, c_l}{\text{Max}} \; U\left(c_a, c_m, c_l; z^h\right)$$

s.t. $p_a c_a + p_m c_m + p_l c_l = \Pi^* + p_l E + S$, full income constraint

This gives the reduced form:

Final demand functions: $c_k = c_k\left(p_a, p_m, p_l, y^*; z^h\right)$, $k = a, m, l$

where $y^* = \Pi^*\left(p_a, p_c, p_l, p_x; z^q\right) + p_l E + S$.

Hence: $c_k = c_k\left(p_a, p_c, p_l, p_x, p_m; z^q, z^h, E, S\right)$

Note: under separability, the prices of consumption goods not produced at home (p_m) and the $z^h, E,$ and S variables do not influence production decisions. This will provide a test of separability.

II. Household model with missing markets for food and labor
(de Janvry, A., Fafchamps, M., and Sadoulet, E. "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained." *Economic Journal*, Vol. 101, No. 409 (November, 1991), pp. 1400-1417.)

2.1. The structural model

Market failures for food (*a*) and labor (*l*): non-tradables
Perfect markets for cash crops (*c*), other inputs (*x*), and manufactured goods (*m*):
tradables with exogenous idiosyncratic prices:

p_c farm gate sale price of cash crop
p_x, p_m farm gate purchase prices of other inputs and manufactured goods

$$\underset{q_a, q_c, q_l, q_x, c_a, c_m, c_l}{\text{Max}} U(c_a, c_m, c_l; z^h)$$

s.t.

$p_x q_x + p_m c_m = p_c q_c + S$ cash income constraint,
$g(q_a, q_c, q_l, q_x; z^q) = 0$ production technology.

$p_i = \bar{p}_i$ for $i = c, x, m$ exogenous effective prices for tradables
$\begin{cases} c_a = q_a \\ c_l = E - q_l \end{cases}$ equilibrium conditions for non-tradables

2.2. The first order conditions

$$\underset{q_a, q_c, q_l, q_x, c_a, c_m, c_l}{\text{Max}} W = \left[U + \lambda(p_c q_c + S - p_x q_x - p_m c_m) + \phi g + \mu_a(q_a - c_a) + \mu_l(E - q_l - c_l)\right]$$

First-order conditions:

$\frac{\partial W}{\partial q_c}$: $\phi g_c' = -\lambda p_c$; $\frac{\partial W}{\partial q_x}$: $\phi g_x' = \lambda p_x$ (tradables)

$\frac{\partial W}{\partial q_a}$: $\phi g_a' = -\mu_a$; $\frac{\partial W}{\partial q_l}$: $\phi g_l' = \mu_l$ (non-tradables)

$\frac{\partial W}{\partial c_m}$: $u_m' = \lambda p_m$ (tradables)

$\frac{\partial W}{\partial c_k}$: $u_k' = \mu_k$, $k = a, l$ (non-tradables)

$\frac{\partial W}{\partial \phi}$: $g = 0$ (technology constraint)

$\frac{\partial W}{\partial \lambda}$: $p_x q_x + p_m c_m = p_c q_c + S$ (cash income constraint)

$\frac{\partial W}{\partial \mu_a}$: $c_a = q_a$ (equilibrium condition for food)

$\dfrac{\partial W}{\partial \mu_l}$: $c_l = E - q_l$ (equilibrium condition for labor).

Define decision prices p^* as follows:

$p_a^* = \mu_a / \lambda, p_l^* = \mu_l / \lambda$ shadow prices for the nontradables a and l

$p_i^* = \overline{p}_i$ effective market prices for the tradables c, x, and m.

Combining the last three conditions gives the full income constraint:

$$p_x q_x + p_m c_m + p_a^* c_a + p_l^* c_l = p_c q_c + p_a^* q_a + p_l^* (E - q_l) + S \quad .$$

By analogy with the first-order conditions for the separable model in 1.1, the first order conditions for the non-separable model can be rewritten using decision prices p^* as:

$\phi g_i' = -\lambda p_i^*,\ i = c, a$ products
$\phi g_j' = \lambda p_j^*,\ j = l, x$ factors
$g = 0$ technology

$u_k' = \lambda p_k^*,\ k = m, a, l$ consumer goods
$\sum_{k=a,m,l} p_k^* c_k = \sum_{i=a,c} p_i^* q_i - \sum_{j=l,x} p_j^* q_j + p_l^* E + S$ full income constraint

$$\begin{cases} c_a = q_a \\ c_l = E - q_l \end{cases}$$ equilibrium conditions for non-tradables

2.3. The household's decision structure (semi-structural form)

Production decisions from profit maximization: supply and derived demand:

$$q_i = q_i\left(p_a^*, p_c^*, p_l^*, p_x^*; z^q\right),\ i = a, c, l, x \quad .$$

Profit and full income:

$$\Pi^* = \sum_{i=a,c} p_i^* q_i - \sum_{j=l,x} p_j^* q_j$$
$$y^* = \Pi^* + p_l^* E + S.$$

Consumption from utility maximization (with prices p^* and income y^*)

$$c_k = c_k\left(p_a^*, p_m, p_l^*, y^*; z^h\right),\ k = a, m, l$$

Equilibrium conditions

$$\left.\begin{aligned} c_a\left(p^*, y^*; z^h\right) &= q_a\left(p_a^*, p_c^*, p_l^*, p_x^*; z^q\right) \\ c_l\left(p^*, y^*; z^h\right) &= E - q_l\left(p_a^*, p_c^*, p_l^*, p_x^*; z^q\right) \end{aligned}\right\} \text{ for non-tradables}$$

Solving these equilibrium conditions for the shadow prices of non-tradables:
$p_j^* = p_j^*\left(p_c, p_x, p_m; z^q, z^h, E, S\right),\ j = a, l$.

The p^* for nontradables are function of the prices of tradable consumption goods and of $z^q, z^h, E,$ and S.

The semi-structural solution of the model is thus:

$$q_i = q_i\left(p_a^*, p_c, p_l^*, p_x; z^q\right),\ i = a, c, l, x$$

$$c_k = c_k\left(p_a^*, p_m, p_l^*, y^*; z^h\right),\ k = a, m, l$$

and

$$p_j^* = p_j^*\left(p_c, p_x, p_m; z^q, z^h, E, S\right),\ j = a, l$$

Hence, household characteristics in consumption, z^h, E, and S and consumption prices, p_m, affect production decisions, as opposed to the separable model. The system would be recursive if there were only tradables.

2.4. The reduced form

Substituting the expression just derived for the shadow price p_j^* into the production and consumption decisions give:

$$q_i = q_i\left(p_c, p_x, p_m; z^q, z^h, E, S\right),\ i = a, c, l, x$$

$$c_k = c_k\left(p_c, p_x, p_m; z^q, z^h, E, S\right),\ k = a, m, l$$

2.5. Price elasticities (*E*)

Supply response

$$E^G\left(q_i/p_j\right) = E\left(q_i/p_j\right) + E\left(q_i/p_a^*\right)E\left(p_a^*/p_j\right) + E\left(q_i/p_l^*\right)E\left(p_l^*/p_j\right),\ i = a, c; j = c.$$

where E^G is the global elasticity.

Consumption

$$E^G\left(c_k/p_j\right) = E^H\left(c_k/p_j\right) + E^H\left(c_k/p_a^*\right)E\left(p_a^*/p_j\right) + E^H\left(c_k/p_l^*\right)E\left(p_l^*/p_j\right),\ k = m, l; j = m$$

where E^H is the elasticity in the separable household model with endogenous income effects:

$$E^H\left(c_k/p_k\right) = E\left(c_k/p_k\right) + E\left(c_k/y^*\right)E\left(y^*/p_k\right),\ k = a, m.$$

Simulation Results

	2.1. Impact of a 10 percent increase in the price of cash crops				2.2. Impact of a 10 percent increase in the price of manufactured goods				2.3. Impact of a monetary head tax				2.4. Impact of a 10 percent increase in productivity of food production			
	Market failures				Market failures				Market failures				Market failures			
	Food and labor	Labor	Food	None	Food and labor	Labor	Food	None	Food and labor	Labor	Food	None	Food and labor	Labor	Food	None
	Percentage changes over base				Percentage changes over base				Percentage changes over base				Percentage changes over base			
Consumption																
Food	-0.5	3.0	-0.8	2.1	1.1	1.8	1.0	1.7	-4.9	-9.1	-4.3	-7.0	8.8	4.5	8.8	3.0
Leisure	0.4	0.6	4.0	2.7	0.2	0.3	0.9	0.6	-3.9	-4.2	-10.2	-9.0	0.8	0.5	1.3	3.9
Manufactured good	15.8	7.7	9.5	5.6	-12.8	-14.5	-14.0	-14.8	-33.6	-23.6	-22.3	-18.7	1.0	11.4	0.2	8.0
Production																
Food crop	-0.5	-6.4	-0.8	-5.4	1.1	-0.2	-1.0		-4.9	2.3	-4.3		8.8	16.4	8.8	18.0
Cash crop	1.8	9.3	5.5	9.9	-1.7	-0.1	-1.0		10.7	1.7	4.1		0.7	-8.8	1.2	-7.7
Fertilizer	4.7	2.8	3.1	2.2	0.5	0.1	0.2		-3.7	-1.4	-0.8		0.0	2.4	-0.2	1.5
Labor	-0.6	-1.0	3.9	1.7	-0.4	-0.4	0.5		5.8	6.3	-2.0		-1.2	-0.7	-0.6	3.7
Prices																
Food crop	8.8	--[a]	5.8		1.9	--	1.3		-10.7	--	-5.4		-11.0	--	-11.4	
Cash crop	10.0	10.0	10.0	10.0												
Fertilizer																
Labor	9.3	4.5			1.7	0.7			-16.4	-10.5			1.3	7.4		
Manufactured good					10.0	10.0	10.0	10.0								
Net labor supply[b]			-10.6	-6.1			-1.7	-0.8			15.2	11.7			-1.7	-9.7
Marketed surplus of food[b]		-10.1		-7.9		-2.0		-1.5		11.2		7.0		10.3		12.7

[a]Blanks indicate no change relative to base value.
[b]Net labor supply in percent of household labor effort, and marketed surplus in percent of food production.
Source: A. de Janvry, M. Fafchamps, and E. Sadoulet, "Peasant Household Behavior with Missing Markets: Some Paradox Explained", *Economic Journal*, Vol. 101, No. 409 (November 1991), pp. 1400-17.

III. A one-period household model with market failures and liquidity constraint (de Janvry, A., Fafchamps, M., Raki, M., and Sadoulet, E. "Structural Adjustment and the Peasantry in Morocco: A Computable General Equilibrium Model." *European Review of Agricultural Economics*, Vol. 19 (1992), pp. 427-453.)

Two sub-periods:
Growing season: tradables subject to a liquidity constraint.
Harvest season: no liquidity constraint.
Overall annual liquidity constraint.

3.1. The model

Goods are decomposed into three subsets:

Tradables which are not subject to a growing season liquidity constraint: *TNC*
Tradables which are subject to a growing season liquidity constraint: *TC* (expenditures and sales during the growing season)
Jointly, these two subsets of tradables are indexed as *T*
Nontradables: *NT*
$q > 0$ for products, $q < 0$ for inputs.
S net transfers
K liquidity from past savings, credit, and pre-harvest transfers.

The household's problem is to:

(1.a) $\max_{c,q} u\left(c, z^h\right)$ subject to:

(1.b) $\sum_{i \in T} p_i(q_i + E_i - c_i) + S \geq 0,$ liquidity constraint on overall annual budget,

(1.c) $\sum_{i \in TC} p_i(q_i + E_i - c_i) + K \geq 0,$ liquidity constraint on growing season transactions,

(1.d) $g\left(q, z^q\right) = 0,$ production technology,

(1.e) $p_i = \overline{p}_i, \quad i \in T,$ exogenous market price for tradables,

(1.f) $q_i + E_i = c_i, \quad i \in NT,$ equilibrium for nontradables.

The Lagrangean associated with the constrained maximization problem is written as:

$$L = u(c, z^h) + \lambda\left[\sum_{i \in T} \overline{p}_i(q_i + E_i - c_i) + S\right] + \eta\left[\sum_{i \in TC} \overline{p}_i(q_i + E_i - c_i) + K\right]$$
$$+\phi\, g(q, z^q) + \sum_{i \in NT} \mu_i(q_i + E_i - c_i).$$

First-order conditions

Define endogenous decision prices as follows:

(2.a) $p_i^* = \bar{p}_i, \quad i \in TNC,$

(2.b) $p_i^* = \bar{p}_i(1+\lambda_c), \quad \lambda_c = \eta / \lambda, \quad i \in TC,$

(2.c) $p_i^* = p_i = \mu_i / \lambda, \quad i \in NT.$

The three goods can be treated symmetrically, and the first order conditions are written:

(3.a) $$u_i' = \lambda p_i^* \begin{cases} \text{TNC: } u_i' = \lambda \bar{p}_i = \lambda p_i^* \\ \text{TC: } u_i' = \lambda \bar{p}_i + \eta \bar{p}_i = \lambda \bar{p}_i\left(1+\lambda_c\right) = \lambda p_i^* \\ \text{NT: } u_i' = \mu_i = \lambda p_i^* \end{cases} \quad i \in \text{ all consumer goods},$$

(3.b) $\sum p_i c_i = \sum p_i (q_i + E_i) + S,$ all i, full income constraint,

(3.c) $$\begin{cases} \eta\left[\sum_{i \in TC} p_i(q_i + E_i - c_i) + K\right] = 0, \\ \sum_{i \in TC} p_i(q_i + E_i - c_i) + K \geq 0, \eta \geq 0 \end{cases},$$ liquidity constraint,

(3.d) $\phi\, g_i' = -\lambda p_i^*,$ $i \in$ all producer goods,

(3.e) $g\left(q, z^q\right) = 0,$ technology,

(3.f) $q_i + E_i = c_i,$ $i \in NT$, equilibrium nontradables,

(3.g) $p_i = \bar{p}_i,$ $i \in T$, equilibrium tradables,

where u_i' and g_i' are the partial derivatives of u and g with respect to c_i and q_i, respectively.

Household's Decision Structure

These first-order conditions fall into four blocks of equations:

Block 1: Production decisions, given in equations (3.d) and (3.e), can be solved for:

(4.a) $q = q(p_i^*; z^q).$

(4.b) $\Pi^* = \Sigma p_i^* q_i,$

Block 2: Consumption decisions, given in equations (3.a) and (3.b), can be written in terms of the p^* prices and an income constraint derived from (3.b) and (3.c):

(4.c)
$$y^* = \sum_i p_i^* c_i = \sum_i p_i c_i + \lambda_c \sum_{i \in TC} p_i c_i = \sum_i p_i \left(q_i + E_i\right) + S + \lambda_c \left[\sum_{i \in TC} p_i (q_i + E_i) + K \right],$$
$$= \sum_i p_i^* \left(q_i + E_i\right) + S + \lambda_c K = \Pi^* + \sum_i p_i^* E_i + S + \lambda_c K,$$

which is equivalent to an extended full income constraint.

Equations (3.a) and (4.c) define a demand system

(4.d) $$c = c\left(p^*, y^*; z^h\right)$$

Block 3: The liquidity constraint (3.c) can also be rewritten using a slack variable K_{net} as:

(4.e) $$K_{net} \lambda_c = 0,$$

(4.f) $$K_{net} = K + \sum_{i \in TC} \overline{p}_i \left(q_i + E_i - c_i\right) \geq 0,$$

(4.g) $$\lambda_c \geq 0.$$

In these equations:

- Either the growing season liquidity constraint is effective and $K_{net} = 0$, and $\lambda_c > 0$;
- Or it is ineffective, in which case $K_{net} > 0$ and $\lambda_c = 0$.

(Block 4) Equilibrium conditions for price formation are given by equations (3.f) and (3.g).

Note: If $\lambda_c > 0$, λ_c is a function of z^h if there are *TC* among consumption goods. Hence, the housheold model is non-separable even if there are no NT goods.

Table 2. Simulation of household behavior: ASAP responses, Morocco (percent change over base run unless otherwise indicated)

Experiment	Base Run in 1000 Dirham		ASAP Credit constraint		ASAP No credit constraint	
Farm size	Small	Medium	Small	Medium	Small	Medium
Full income	19.90	44.47	1.56*	7.2	1.6	7.7
Credit						
Credit deficit (1000 Dh)			0.0	0.0	0.4	2.9
Price markup on TC (%)			8.4	16.6	0.0	0.0
Consumption						
Home time men	2.95	7.90	1.4	6.1	2.6	8.4
Home time women	1.60	5.61	–5.4	–9.7	10.3	14.4
Home time children	1.78	3.22	–0.9	–1.9	–0.9	–2.8
Consumption giids	12.25	23.47	1.8	9.8	–0.1	5.4
Production						
Hard wheat	1.99	8.56	1.6	1.8	2.0	1.8
Soft wheat	0.42	6.73	2.1	–0.7	8.5	2.3
Coarse grains**	0.17	6.67	82.5	8.1	98.6	11.5
Forage**	–0.98	–1.83	–2.6	–8.3	–1.5	–3.3
Total crops	3.24	24.54	4.4	1.8	6.5	3.8
Total livestock	9.31	15.67	–1.0	–4.1	–1.0	–1.8
Mach & fertilizer	–0.90	–8.44	3.1	–2.0	7.1	4.0
Labor men	–3.55	–6.60	–0.5	–5.0	1.0	2.2
Labor women	–2.53	–2.55	0.1	–0.4	0.7	5.5
Labor children	–1.76	–1.91	0.9	3.1	0.9	4.7
Shadow prices						
Labor children	1.06	1.02	12.7	17.1	11.2	13.2
Wage labor						
Men	2.36	–1.66	–1.0	9.1	–4.7	48.7
Women	0.31	–1.74	27.5	–31.8	–59.1	54.4
Marketed surplus						
Hard wheat	1.14	6.17	3.6	–0.5	4.9	1.4
Soft wheat	–1.00	5.01	2.7	–1.2	–2.1	0.5
Meat	6.85	10.05	–1.4	–11.2	–0.6	–4.4

IV. Household behavior under transactions costs

4.1. Endogenous labor market strategies when there is moral hazard with hired labor and credit constraints (Eswaran, M., and Kotwal, A. "Access to Capital and Agrarian Production Organization." *Economic Journal*, Vol. 96 (1986), pp. 482-498)

The model and partial equilibrium analysis

- Two market failures, hence non-separability:

  (1) Access to credit limited by availability of land owned which serves as collateral.
  (2) Moral hazard in hiring labor: Supervision by family labor.

  Household problem is defined as follows:

Land: $\overline{A}$ size of ownership unit
A size of operational unit, with $A >$ or $< \overline{A}$ as can rent land in or out,
r land rental rate,

Labor: Fixed total endowment of household labor time, $E = 1$, allocated to:
l_i = work on own farm,
l_o = labor hired out,
$s(h)$ = time spent supervising hired labor,
l_e = leisure.
h hired labor,
Perfect substitution between l_i and h in production.

Capital: $\overline{K}$ fixed start-up cost to enter farming,
Access to credit: $B(\overline{A})$.

Prices: Product price p, wage w, land rental rate r are exogenous.
Markets for product, labor, and land are perfectly competitive, with no transactions costs.

Technology:
- Production function stochastic and homogenous of degree one:
$q = \varepsilon f(L, A)$, $E(\varepsilon)$=1.
- Supervision of hired labor: $s = s(h)$, $s' > 0$, $s'' > 0$, strictly convex.

Objective function: Utility function u separable in income and leisure

$u(y, l_e) = y + u(l_e), u' > 0, u'' < 0$. Linearity in income y implies risk neutrality.

- The household's decision problem:

$$\underset{A, l_i, l_o, h, l_e}{\text{Max}} \; p\, f\left(l_i + h, A\right) + w\left(l_o - h\right) - r\left(A - \overline{A}\right) - \overline{K} + u\left(l_e\right) = Y - \overline{K} + u\left(l_e\right),$$

  subject to the following constraints:

  $l_i + l_o + s(h) + l_e = 1$ time constraint

  $rA + w(h - l_o) + \overline{K} \le r\overline{A} + B(\overline{A}) = B^*$ liquidity constraint

Corresponding Lagrangean:

$$L = p\,f\left(l_i + h, A\right) + w\left(l_o - h\right) - r\left(A - \overline{A}\right) - \overline{K} + u\left(1 - l_i - l_o - s(h)\right) + \lambda\left(B^* - \overline{K} - rA - w\left(h - l_o\right)\right)$$

where λ is the marginal value of liquidity.

- The household's optimal labor strategy depends on its initial asset endowment B^*, defining endogenous social class positions (Roemer, 1982):

Initial assets position $B^*\left(\overline{A}\right)$	Hire out l_o	Own farm work l_i	Supervision $s(h)$	Endogenous social class position
$B^* < B_0^*$	+	0	0	Landless worker
$B_0^* \le B^* < B_1^*$	+	+	0	Worker-peasant
$B_1^* \le B^* < B_2^*$	0	+	0	Family farmer
$B_2^* \le B^* < B_3^*$	0	+	+	Rich farmer
$B^* \ge B_3^*$	0	0	+	Capitalist farmer

The opportunity cost of labor and land by social class are as follows:

	Worker-peasant	Family farmer	Rich and capitalist farmers
Labor	$w(1+\lambda)$	u'	$w(1+\lambda) + u's'$
Land	$r(1+\lambda)$	$r(1+\lambda)$	$r(1+\lambda)$
Labor/land	w / r	$\dfrac{u'}{r(1+\lambda)}$	$\dfrac{w}{r} + \dfrac{u's'}{r(1+\lambda)}$

a. $(l_i + h) / A$ is constant for $B_0^* \le B^* < B_1^*$ and strictly decreasing for $B^* \ge B_1^*$. There is hence an inverse relation between farm size and labor input per hectare.

b. The expected yield q/A is constant for $B_0^* \le B^* < B_1^*$ and strictly decreasing for $B^* \ge B_1^*$. There is hence an inverse relation between farm size and land productivity.

General equilibrium analysis

Analyze the efficiency, welfare, and class composition effects of land reform and credit reform. Assume that labor and land are local non-tradables. Equilibria on these markets determine a wage and a rental rate.

Distribution of land ownership:
N_0 identical landless
N_1 landed farmers ranked by increasing size of farm, each identified by their rank $i = \frac{1}{N_1}, \frac{2}{N_1}, \ldots, \frac{N_1}{N_1}$. $\overline{A}_i$ is the land owned by farmer *i* and *A* total land available.
Access to credit:
For landless households: ϕ
For landed households: $B\left(\overline{A}_i\right)$

Demand for land and labor by household i:

Land: demand by landless households: $A = A(\phi, p, r, w)$

demand by landed households: $A = A\left(B\left(\overline{A}_i\right), p, r, w\right)$

Labor: net demand by landless households:

$$L^*(B, p, r, w) = h\left(B\left(\overline{A}_i\right), p, r, w\right) - l_o\left(B\left(\overline{A}_i\right), p, r, w\right)$$

net demand by landed households:

$$L^*(\phi, p, r, w) = h(\phi, p, r, w) - l_o(\phi, p, r, w)$$

General equilibrium conditions:

Land market: $N_1 \int_0^1 A\left(B\left(\overline{A}_i\right), p, r, w\right) di + N_0 A(\phi, p, r, w) = A$

Labor market: $N_1 \int_0^1 L^*\left(B\left(\overline{A}_i\right), p, r, w\right) di + N_0 L^*(\phi, p, r, w) = 0$

⇒ Solution for r and w

Simulation in the following model:

Production function: $f(l_i + h, A) = f_0 A^{1/2}(l_i + h)^{1/2}$, Cobb-Douglas form

Utility for leisure: $u(l_e) = u_0 l_e^{1/2}$, constant utility form

Access to credit: $B\left(\overline{A}\right) = \theta\overline{A} + \phi$

Supervision function: $s(h) = bh + ch^2$

Land owned by household i: $\overline{A}_i = A\delta(1-i)^{\delta-1}$, where $0 < \delta \leq 1$ is the parameter that measures equality in land distribution.

Comparative statics experiments:

1. Variation in the distribution of classes with level of equality in land ownership (δ)
2. Structural reforms to reduce transactions costs:
   - 2.1. Land reform: increase δ
   - 2.2. Credit reform: total amount constant, but smaller θ and greater ϕ.

Criteria used to assess the reforms:

Class composition effects

Welfare: aggregate output

Poverty level: percentage of households below a poverty line

Inequality: Gini coefficient of income distribution.

4.2. Agricultural supply response under transactions costs in access to markets
Key, Nigel, Elisabeth Sadoulet, and Alain de Janvry. "Transactions Costs and Agricultural Household Supply Response", *American Journal of Agricultural Economics*, Vol. 82, No. 2, (May 2000), pp 245-59.

- Transactions costs include:
  - proportional transactions costs t_p^s, t_p^b, which are additional cost per unit of quantity transacted. Hence effective prices are: $\bar{p} + t_p^b$ for purchase and $\bar{p} - t_p^s$ received for sale.
  - fixed transactions costs: t_f^s, t_f^b, incurred for access to market, independently of the quantity transacted

- Assume: - one agricultural commodity on which there are transactions costs
  - other goods (set *J*) are either purchased (inputs or consumer goods) or sold (outputs) at given prices *p*. Output and input represented by *q*, and consumption by *c*.
  - all other sources of income are exogenous transfers *S*
  - fixed productive assets z^q, households characteristics in consumption z^h.

- The household's optimization problem:

$$\max_{c,q} U\left(c; z^h\right)$$

s.t. $g(q; z^q) = 0$, production function

$$\left[(\bar{p} - t_p^s)\delta_s + (\bar{p} + t_p^b)\delta_b\right]\left(q + E - c\right) + \sum_{j \in J} p_j\left(q_j + E_j - c_j\right) - t_f^s\delta_s - t_f^b\delta_b + S = 0,$$

budget constraint

$$\left(q + E - c\right)\left(1 - \delta_s - \delta_b\right) = 0,$$ internal equilibrium if non-traded

The $\delta_s(\delta_b)$ are equal to 1 if sales (purchases) are positive, 0 otherwise.

- Define decision price for the agricultural commodity:

$$p = \begin{cases} \bar{p} + t_p^b, \text{ if } \delta_b = 1 \\ p^* = \dfrac{\mu}{\lambda}, \text{ if } \delta_b = 0 \text{ and } \delta_s = 0 \\ \bar{p} - t_p^s, \text{ if } \delta_s = 1 \end{cases}$$

where μ and λ are the Lagrange multipliers associated with the internal equilibrium and the budget constraint respectively. For the other commodities, there is only one price: $p = p^* = \bar{p}$.

- Using these decision prices, the FOCs within each regime are formally similar to the FOCs resulting from a separable model:

  1) profit maximization subject to the technology constraint leading to the output supply equation:
  $q = q(p, z^q)$
  2) utility maximization subject to the income constraint:
  $p'c = y = p'\left(q + E\right) - t_f^s\delta_s - t_f^b\delta_b + S$

  which leads to a demand equation: $c = c(p, y, z^h)$.

- We then need to compare the solutions under the different regimes to choose among the regimes.

Maximum indirect utility $V\left(p, y = p'(q+E) - t_f^s\delta_s - t_f^b\delta_b + S, z^h\right)$ in each regime:

$$
\begin{aligned}
&V^a(\bar{p}) = V\left(p^*, y = p^*(q+E) + S, z^h\right) && \text{if autarkic}\\
&V^s(\bar{p}) = V\left(\bar{p} - t_p^s, y = \left(\bar{p} - t_p^s\right)(q+E) - t_f^s + S, z^h\right) && \text{if seller}\\
&V^b(\bar{p}) = V\left(\bar{p} + t_p^b, y = \left(\bar{p} + t_p^b\right)(q+E) - t_f^b + S, z^h\right) && \text{if buyer}
\end{aligned}
$$

V^s is increasing in $\bar{p}$ for sellers while V^b is decreasing for buyers.

With no FTC, $V^s = V^a$ for $\bar{p} - t_p^s = p^*$ (point C_0)

$V^b = V^a$ for $\bar{p} + t_p^b = p^*$ (point B_0)

With FTC, shift of utility curve to the left: V^b and V^s.

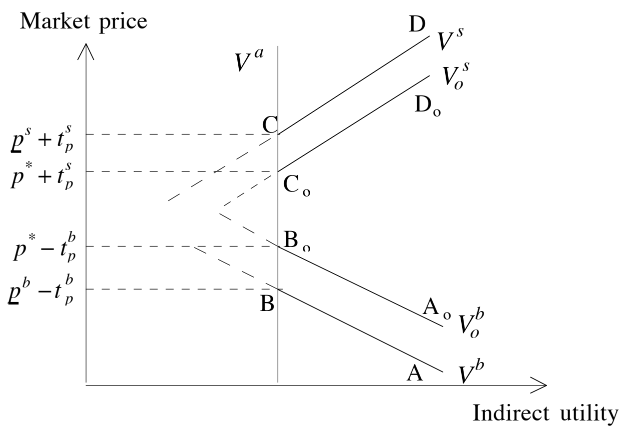

Figure 1. Indirect utility under alternative market participation regimes

- The market participation decision for the household is therefore:

  If there are PTC only, as decision price increases, the household follows the path $A_oB_oC_oD_o$:

  $\bar{p} + t_p^b < p^*$, the household is a buyer

  (1) $\bar{p} - t_p^s < p^* < \bar{p} + t_p^b$, the household is autarkic

  $p^* < \bar{p} - t_p^s$, the household is a seller

  If there are both PTC and FTC, the household follows the path ABCD:

$\overline{p} + t_p^b < \underline{p}^b$, the household is a buyer

$\underline{p}^b - t_p^b < \overline{p} < \underline{p}^s - t_p^s$, the household is autarkic

$\underline{p}^s < \overline{p} - t_p^s$, the household is a seller

where the threshold decisions price $\underline{p}^s$ and $\underline{p}^b$ are defined by:

$$V^s\left(\underline{p}^s, y = \underline{p}^s(q+E) - t_f^s + S, z^h\right) = V^a$$
$$V^b\left(\underline{p}^b, y = \underline{p}^b(q+E) - t_f^b + S, z^h\right) = V^a$$

Note: threshold decisions price $\underline{p}^s$ and $\underline{p}^b$ pices are functions of the household assets z^q, z^h, E, S and the fixed transactions costs t_f^b and t_f^s, but not of the proportional transactions costs.

- The corresponding supply functions are represented in Figure 2.

  With no TC: $q = q(\overline{p}, z^q)$, represented as SS

  With PTC (Figure 2.a): Supply functions in the three regimes are:

  $$q^b(\overline{p}) = q\left(\overline{p} + t_p^b, z^q\right) \text{ if buyer,}$$
  $$q^s(\overline{p}) = q\left(\overline{p} - t_p^s, z^q\right) \text{ if seller,}$$
  $$q^a(\overline{p}) = q\left(p^*, z^q\right) \text{ if self - sufficient,}$$

  Note that, at $\overline{p} = p^* - t_p^b$ and $\overline{p} = p^* + t_p^s$, supply is identical on both sides of the thresholds (curve ABCD).

  With PTC and FTC (Figure 2.b), supply functions are the same, but the transition from self-sufficiency to seller occur at a threshold price $\underline{p}^s + t_p^s$ above $p^* + t_p^s$, and similarly on the buyer's side (broken line AA′B′C′D′D).

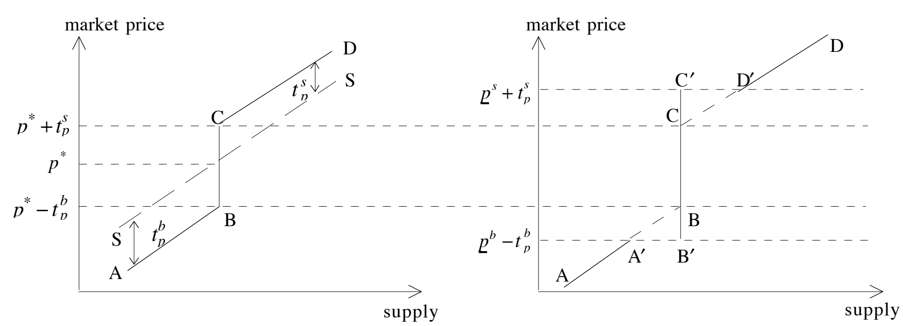

Figure 2.a.
Proportional transactions costs

Figure 2.b.
Fixed and proportional transactions costs

Figure 2. Supply Curve under Transactions Costs

V. Production decision of household under price risk (Finkelshtain, Israel, and Chalfant, James A. "Marketed Surplus Under Risk: Do Peasants Agree with Sandmo?" *American J. of Agricultural Economics*, Vol. 73, No. 3 (1991), pp. 557-567.

No price bands, no self-sufficient farmers, sellers and buyers only.

- Intuition of why households are protected against price risk, compared to producers or consumers

  Two possible realizations for p: low p_l (high p_h) and corresponding y_l (y_h)
  Two consumption goods: agricultural and non-agricultural (price $\overline{p}$).
  Real incomes:
  - pure producer $y/\overline{p}$.
  - consumer with exogenous income $\overline{y}$: $\overline{y}/\left(s_a p + s_{na}\overline{p}\right)$, where s_a and s_{na} are the share of the two commodities in consumption..
  - household: $y/\left(s_a p + s_{na}\overline{p}\right)$.

  Assume that the average of y is equal to $\overline{y}$, and the average of p is equal to $\overline{p}$.

  Compare real incomes of a household and a pure producer:

  $$\frac{y_l}{\overline{p}} < \frac{y_l}{\left(s_a p_l + s_{na}\overline{p}\right)} \text{ and } \frac{y_h}{\left(s_a p_h + s_{na}\overline{p}\right)} < \frac{y_h}{\overline{p}}$$

  Hence fluctuations of the real income for the household is lower than for the pure producer. Consumption of what you produce subjects the household to less risk. It protects its real income in bad years, but also reduces the benefits of high prices.

  Comparing real incomes of a household and a consumer, we have:

  $$\frac{\overline{y}}{\left(s_a p_h + s_{na}\overline{p}\right)} < \frac{y_h}{\left(s_a p_h + s_{na}\overline{p}\right)} \text{ and } \frac{y_l}{\left(s_a p_l + s_{na}\overline{p}\right)} < \frac{\overline{y}}{\left(s_a p_l + s_{na}\overline{p}\right)}$$

  Hence the fluctuation of the real income of the household is lower for the consumer. Production of what you consume protects you in years of high prices (because your income increases also) , but also reduce the benefits when prices are low.

  Conclusion:
  The correlation between income and price reduces the exposure to risk.

- Structural model:

  $$\max_q \; EV(y,p)$$

  where $y = pq - c(q) + T$.

  The first order conditions are:

  $$EV_y p = EV_y \cdot c'(q)$$
  $$\Rightarrow EV_y(p - \overline{p}) = EV_y(c'(q) - \overline{p})$$
  $$\Rightarrow \operatorname{cov}(V_y, p) = EV_y(c'(q) - \overline{p})$$

  The paper establishes the following:

1) $\text{cov}(V_y, p) < 0$ iff $\frac{dV_y}{dp} < 0$.

2) Sign of $\frac{dV_y}{dp} = \underbrace{V_{yy}\frac{dy}{dp}}_{\substack{\text{income effect}<0 \\ \text{so sign of this whole term is amgiguous}}} + \underbrace{V_{yp}}_{\text{usually } +}$

Using Roy's identity, the above can also be written:

$$\frac{dV_y}{dp} = \underbrace{-R\frac{V_y}{y}q}_{\substack{p\uparrow \Rightarrow \text{higher income} \Rightarrow \text{lower marginal utility} \\ <0}} - \underbrace{\frac{q^c}{y}V_y(\underset{<1}{\eta} - \underset{1-4}{R})}_{\substack{p\uparrow \Rightarrow \text{lower real income} \Rightarrow \text{higher marginal utility} \\ \text{usually } > 0}}$$

where the income elasticity of food consumption is: $\eta = E\left(\frac{q^c}{y}\right)$ and relative risk aversion is: $R = -y\frac{V_{yy}}{V_y}$.

Hence:

$$\boxed{\frac{dV_y}{dp} = -\frac{1}{p}V_y\left(Rs_q - s_c(R-\eta)\right) = -\frac{1}{p}V_y\left(R\left(s_q - s_c\right) + s_c\eta\right)}$$

Sandmo's: $\frac{dV_y}{dp} < 0 \Leftrightarrow c'(q) < \bar{p} \Rightarrow$ production is lower than for a profit maximizer.

- Conclusions: s_c, s_q, and R are critical in determining the level of production.

  a) if $R = 0$, $\frac{dV_y}{dp} < 0 \;\Rightarrow$ "Risk-neutral" farmers produce less than profit maximizers.

  Note: "Risk-neutral" is $V_{yy} = 0$, but $V_{yp} < 0$.

  b) Net sellers $\left(s_q < s_c\right)$ produce less than profit maximizers.

  c) Net buyers produce less than profit maximizers if *R* is not too large.
  If *R* is large, then produce more than a profit maximizer.

  d) Compared to a pure producer ($s_c = 0$), households produce more.

  Consumption reduces $\left|\frac{dV_y}{dp}\right|$ which reduces the magnitude of the movement in V_y which reduces the impact of risk.

  e) A broader conclusion is that risk implies non-separability because it causes production to depend on consumption. Here the missing market is the availability of insurance to smooth consumption.

- Extension of the basic framework (Fafchamps, M. "Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World." *American J. of Agricultural Economics*, Vol. 74, No. 1 (1992), pp. 90-99.

  Main results: The proportion of land in food crop increases with the share of food in consumption.

VI. Empirical analyses: Testing for separability / Estimation of production behavior

- Reduced form method

  a) Production decisions in the non-separable models are functions such as:

  $$q(p_T^q, p_T^c, z^q, z^h, S, K, E)$$

  Recall that for the separable model production decision were:

  $$q(p^q, z^q)$$

  Dwayne Benjamin (*Econometrica*, 1992)
  Demand for pre-harvest labor in a sample of 1443 farmers in Java.

  $$\ln\ q_L = \alpha + \beta \ln p_L^* + \gamma \ln p_T + \delta \ln z^q$$
  $$p_L^* = p_L e^{\eta' z^h},$$

  where the exogenous variables are:
  p_L the market wage for planting,
  p_T the prices of inputs (pesticides, fertilizer),
  z^q land and soil characteristics (harvested area, irrigation, soil quality, climate),
  and z^h demographic variables (household size and composition, education)

  Finds that each demographic coefficient is not significantly different from zero and a joint F test on z^h cannot reject their joint non-significativity. Thus he cannot reject separability. (Lopez (*European Economic Review*, 1984) rejects separability in Canadian household decisions)

  b) By switching regression on an a-priori splitting of the households in two regimes (a separable and a non-separable) (Feder, Lau, Lin and Luo (*AJAE*, 1990), Sadoulet, de Janvry, and Benjamin (*Industrial Relations*, 1998), and Dutilly-Diagne, Sadoulet and de Janvry (2002). Jointly estimate participation to the regime and estimation of the production behavior (accounting for potential selectivity bias):

  $I = 1$ if $I^* = \gamma' z + v > 0$, 0 otherwise
  $y = \beta_1' x_1 + u_1$, observed if $I = 0$
  $y = \beta_2' x_2 + u_2$, observed if $I = 1$

Table 4. Land allocated to crop production - Robust IV

(Dependent variable: logarithm of land in ha)

Variables	Average	Food buyers Coefficient	t-stat	Average	Food self-sufficient Coefficient	t-stat
Price and transactions costs						
Distance to market (kms)	17.6	0.011	2.6			
Shifters in consumption						
Number of dependents				4.5	-0.05	-1.5
Transfers +				0.13	-0.83	-2.7
Shifters in crop production						
Yield (ln) - instrumented[1]	5.6	0.70	2.0	6.0	-1.09	-2.4
Agriculturalist ethnic group +	0.45	0.17	1.8	0.52	-0.14	-0.4
Shifters in production						
Formal cooperation	0.23	0.29	0.9	0.23	1.54	1.5
Effective cooperation	0.66	-0.36	-1.4	0.73	-1.13	-1.6
Land availability (ha per household)	35.8	-0.002	-1.5	35.9	-0.004	-0.9
Age of household head (ln)	3.9	0.20	1.3	3.8	0.80	2.7
Public education +	0.09	0.47	2.8	0.21	0.17	0.7
Literacy +	0.08	0.06	0.4	–	–	–
Shifters in production and consumption						
Number of men 16-60 years old	2.4	0.13	3.2	4.4	0.26	4.3
Number of women 16-60 years old	2.2	0.13	3.2	–	–	–
Oudalan+	0.46	0.47	2.4			
Constant term		-4.40	-2.0		4.63	1.5
Average land allocated to crop (ha)	4.28			5.25		
Number of observations	313			48		
Second stage F statistic : p -value			0.000			0.000
Joint significance of instruments F statistic : p -value			0.02			0.08
Hansen J-statistic (OID test): p -value			0.58			0.38
Hausman exogeneity test for fomal cooperation: p -value			0.11			0.50
Hausman exogeneity test for effective cooperation: p -value			0.36			0.29

[1] Instruments for yield in the buyers of food equation are percentages of land of different quality in the village.
Instruments for yield in the self-sufficient in food equation are stone bunds in the village, low rainfall, and their product.
– Indicates that public education stands for "public education or literacy", and that men stands for men and women 16–60 years old.
+ Indicates dummy variable.

Source: Dutilly-Diane, Sadoulet, and de Janvry. "How Improved Natural Resource Management in Agriculture Promotes the Livestock Economy in the Sahel." Forthcoming in *Journal of African Economies*. (2003)

c) By switching regression with unknown sample separation, when no a priori on which group each household belongs.
Estimated by a joint estimation of the probability of participation to a regime and the behavior:

$$I^* = \gamma' z + v$$

$$y = \beta_1' x_1 + u_1 \text{ , observed if } I^* \leq 0$$

$$y = \beta_2' x_2 + u_2 \text{ , observed if } I^* > 0$$

Example: labor market segmentation in Chile (Bash and Paredes-Molina, *JDE* 1996). Carter and Olinto (mimeo, 1996) for identifying which households are credit constrained and not credit constrained in a sample from Uruguay.

- Direct approach method

a) Based on the comparison of the shadow price p_{NT}^* with the market price.
Recall the F.O.C. (with $q > 0$ for outputs and < 0 for inputs):

$$g(q, z^q) = 0,$$
$$\frac{g_i}{g_j} = \frac{p_i}{p_j}$$

where the decision price p_i is:

$$p_i = \begin{cases} \overline{p}_i \text{ if } i \text{ is tradeable} \\ \overline{p}_i(1+\lambda_c) \text{ if } i \text{ is under the liquidity constraint} \\ p_i^* \text{ ,the shadow price of } i, \text{ if } i \text{ is nontradeable} \end{cases}$$

- Estimate the production function $g(q, z^q) = 0$
- Derive marginal productivity of the input i,
- Compare it to the market price $\overline{p}_i$.

$$p_i^* = \alpha + \beta\overline{p}_i$$

Jacoby (*Review of Economic Studies*, 1993) for labor in a sample of 1034 Peruvian households, and rejects $\alpha = 0$, $\beta = 1$. Similar analyses are done by Thijssen and Geert (*European Review of Economics*, 1988) on 230 Dutch farms over 1970 to 1982, and by Skoufias (*AJAE*, 1994) on 166 households over 1975-1979 from the ICRISAT Indian data.

b) Sylvie Lambert and Thierry Magnac (1996):
- Estimate a production (or cost) function.
- Compute marginal productivity of the factor and a standard deviation for each household.
- Then classify households in "separable" and "non-separable"

VII. Empirical analyses: Estimation of transactions costs, tightness of liquidity constraints, etc.

- Based on the estimation of shadow prices as above, provided we have a good observation on the market price.
- Direct detail survey on transactions costs additional to the price (many studies in credit marlet)
- Decomposition of the effective received price into "market price' and transactions costs (Javier Escobal, 2002)
- Identification of fixed and proportional transactions costs in the product market (Key, Sadoulet, and de Janvry, 2000).

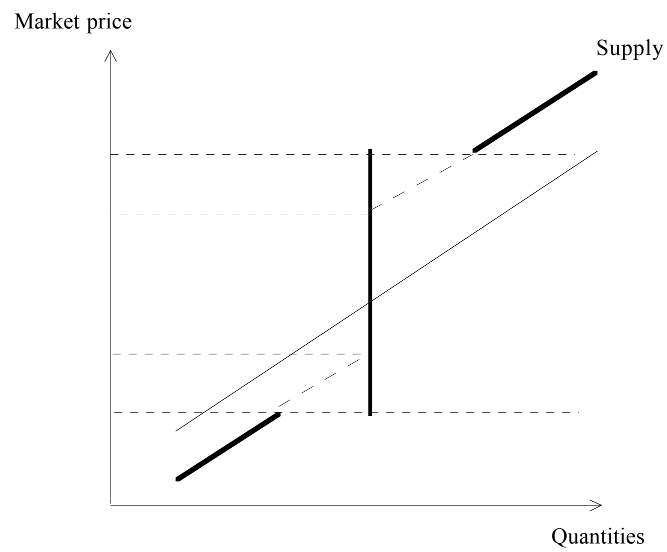

Figure 2. Supply and demand under transactions costs

Threshold decision prices $\underline{p}^s$ and $\underline{p}^b$ functions of FTCs, not PTCs.

$\Rightarrow$ $\underline{q}^s$ and $\underline{q}^b$ functions FTCs, not PTCs

q^s and q^b functions PTCs, not FTCs

Determinant of transactions costs: z_t^b and z_t^s:

$t_p^b = z_t^b \beta_p^b$, $t_f^b = z_t^b \beta_f^b$, $t_p^s = z_t^s \beta_p^s$, and $t_f^s = z_t^s \beta_f^s$

System to estimate:

$$q^{b*} = \left(\bar{p} + z_t^b \beta_p^b\right)\beta_m + z_q \beta_q \qquad \text{linear supply function}$$

$$q^{s*} = \left(\bar{p} - z_t^s \beta_p^s\right)\beta_m + z_q \beta_q$$

$$q^{a*} = z^q \beta_q^a + z^h \beta_h^a$$

$$\underline{q}^b = x^b \alpha_b \qquad \text{linear approximations}$$

$$\underline{q}^s = x^s \alpha_s,$$

$$q^s = \begin{cases} q^{s*} & \text{if} \quad q^{s*} > \underline{q}^s \text{ and } q^{b*} > \underline{q}^b \\ \text{unobserved} & \text{otherwise.} \end{cases}$$

$$q^b = \begin{cases} q^{b*} & \text{if} \quad q^{b*} < \underline{q}^b \text{ and } q^{s*} < \underline{q}^s \\ \text{unobserved} & \text{otherwise.} \end{cases}$$

$$q^a = \begin{cases} q^{a*} & \text{if} \quad q^{s*} < \underline{q}^s \text{ and } q^{b*} > \underline{q}^b \\ \text{unobserved} & \text{otherwise.} \end{cases}$$

Adding errors to the 5 equations, model with unobserved censoring thresholds, estimated by maximum likelihood.
Now done without correlation between the errors. Need to be done!

- Remarks on identification of transactions costs

In a switching regression framework, supply is only function of PTCs, but market participation is a reduced form that includes both PTCs and FTCs. Hence the role of PTCs can be identified from the supply equations, but FTCs cannot be identified if the determinants of PTCs and FTCs are the same.

In Key, Sadoulet, and de Janvry, by estimating supply with a censored regression, we can identify separately the role of FTCs and PTCs. If the supply function is properly specified, one could precisely estimate the PTCs themselves and not only whether their determinants are significant. By contrast it is clear from the theory that there is no close form for threshold quantities. Hence the linear expression that we have used above is necessarily an approximation, and the level of the fixed transaction costs cannot be computed from the estimated parameters α.

• More general functional form that would allow to identify the proportional transactions costs themselves?
• Estimating the fixed transactions costs?

$$V^s\left(\underline{p}^s, y = \underline{p}^s(q+E) - t_f^s + S, z^h\right) = V^a\left(p^a, y = p^a(q+E) + S, z^h\right)$$

• Similar estimation using consumption and production in a survey of net sellers?

VIII. Empirical analyses: Joint estimation of preference and technology in a structural model. Kurosaki, Takashi and Marcel Fafchamps. «Insurance Market Efficiency and Crop Choices in Pakistan, *JDE*, 2002.

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