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CHAPTER SIX

Household Models

6.1. Household Behavior and Policy Analysis

Probably no less than a quarter of the world population belongs to farm (peasant) households, and most of this population is in the less developed countries (Ellis, 1988). Agricultural production is often importantly dependent on their performance as farmers, and world poverty is disproportionately found among them, making understanding the determinants of their welfare a prime concern in any strategy of poverty alleviation. The specificity of these households is that they integrate in a single institution decisions regarding production, consumption, and reproduction over time. These households are only semicommercialized in the sense that, even if all markets work, at least some of their production is kept for home consumption and some of their labor resources are used directly for home production. Food produced in excess of household consumption is sold on the product market, and family labor supplied in excess of use on the home plot is sold on the labor market. If production is less than consumption and/or labor supplied less than needs for the plot, the household is a net buyer of food and/or a net employer of labor. In this case, cash expenditures to buy food have to come from other sources of income such as the sale of cash crops or of labor. When not all markets work, some households may be completely autonomous in food and/or labor, even when they participate to markets for other goods such as cash crops and other factors such as fertilizers or credit. Other specificities of peasant households are the importance of behavior toward risk, existence of household members with different opportunity costs and eventually captive within the household, a life cycle that differentially redefines the opportunity costs of family members over time, and a great multiplicity of activities both in agriculture and off-farm, including wage labor and microenterprises (von Braun and Pandya-Lorch, 1991; Reardon, Delgado, and Matlon, 1992). As we will see in Chapter 9, peasants usually belong to agrarian communities which offer them contractual opportunities to access factors, insurance, and credit when markets fail.

The analysis of peasant households is important for policy analysis. When all markets work, the only linkage between production and consumption decisions is through the level of farm income achieved in production. When not all markets work, there are direct interrelations between production and consumption decisions. In both cases, policies that affect the price of goods (factors) both produced (used) and consumed (sold) thus have complex implications for production and welfare. Important policy questions this raises are whether peasant households will over time tend to differentiate in landless workers and commercial farmers, and thus disappear as a social category, or whether they can be competitive and, if so, which category of peasants will tend to dominate, starting from a heterogenous set of households. As we shall see, the answers to these questions very much depend on the nature of transactions costs that characterize different households and the quantity of productive assets they control. Politically, disappearance or permanence of a peasantry has often had serious implications on policy making, as exemplified by the Mexican reforms of the land tenure system, Japanese and French agricultural trade policy, and transitions to socialism in many African and Asian countries.

The construction of household models started with the work of Chayanov in the 1920s as part of the debate between populists and Bolsheviks in Russia, where households faced no labor market and had flexible access to land, yielding the concept of demographic differentiation as the optimum work effort changed through the life cycle (Harrison, 1975). More recently Becker (1965) formalized in the "new home economics" the process of time allocation within the household when labor has an opportunity cost and utility is derived not directly from goods purchased, but from Z-goods produced in the household with purchased goods and family time. The full version of the neo-classical farm household model was developed by Barnum and Squire (1979) and further elaborated by a series of authors in a book edited by Singh, Squire, and Strauss (1986).

6.2. Integrating Producer, Consumer, and Worker Decisions into a Household Problem

In economic theory, the problems of production decisions, consumption decisions, and labor supply decisions are usually analyzed separately through the behavior of three classes of agents:

a. Producers, who maximize net revenues with respect to levels of products and factors, subject to constraints determined by market prices, fixed factors (private assets and public goods), and technology. This was examined in Chapter 2.

b. Consumers, who maximize utility with respect to the quantities of goods consumed, subject to constraints determined by market prices, disposable income, household characteristics, and tastes. This was analyzed in Chapter 3.

c. Workers, who maximize utility with respect to income and home time (often referred to as leisure), subject to the constraints determined by the market wage, total time available, and worker characteristics.

Formally, this has been modeled as three separate agents who solve the following three problems:

6.2.1. Producer Problem

Definitions:

One product: q_a with price p_a

Two variable factors: x with price p_x

l (labor) with price w

Fixed factors and firm characteristics: z^q (fixed capital, farm size).

Structural form of the model:

$$\underset{q_a, x, l}{\text{Max}}\ \pi = p_a q_a - p_x x - wl, \text{ profit}$$

$$\text{s.t.: } g(q_a, x, l; z^q) = 0, \text{ production function.}$$

Reduced form of the model:

Supply function: $q_a = q_a(p_a, p_x, w; z^q)$

Factor demands: $x = x(p_a, p_x, w; z^q)$

$l = l(p_a, p_x, w; z^q)$

Maximum profit: $\pi^* = \pi^*(p_a, p_x, w; z^q)$.

6.2.2. *Consumer Problem*

Definitions:

Two products: c_a with price p_a (agricultural good)
c_m with price p_m (manufactured good)

Disposable income: y

Household characteristics: z^c.

Structural form of the model:

$$\underset{c_a, c_m}{\text{Max}}\ u(c_a, c_m; z^c),\ \text{utility function}$$

$$\text{s.t.:}\ p_a c_a + p_m c_m = y,\ \text{budget constraint.}$$

Reduced form of the model:

Demand functions: $c_i = c_i(p_a, p_m, y; z^c),\ i = a, m.$

6.2.3. *Worker Problem*

Definitions:

Home time: c_l

Time worked: l^s

Total time endowment available: E

Worker characteristics: z^w.

Structural form of the model:

$$\underset{c_l, y}{\text{Max}}\ u(c_l, y; z^w),\ \text{utility function}$$

$$\text{s.t.:}\ y = wl^s,\ \text{income equation,}$$

$$c_l + l^s = E,\ \text{time constraint.}$$

These two constraints can be collapsed into one equation:

$$w\, c_l + y = w\, E,\ \text{full income constraint.}$$

Reduced form of the model:

Demand function for home time: $c_l = c_l(w, E; z^w)$.

Because the worker is also a consumer, these last two problems can be integrated into one single decision taken by the consumer-worker.

6.2.4. *Consumer-Worker Problem*

Definitions:

Characteristics of the consumer-worker: z^{cw}.

Structural form of the model:

$$\underset{c_a, c_m, c_l}{\text{Max}} \ u(c_a, c_m, c_l; z^{cw}), \text{ utility function}$$

$$\text{s.t.: } p_a c_a + p_m c_m = w l^s = y, \text{ budget constraint,}$$

$$c_l + l^s = E, \text{ time constraint.}$$

These two constraints can be collapsed into one equation:

$$p_a\, c_a + p_m\, c_m + w\, c_l = w\, E, \text{ full income constraint.}$$

Reduced form of the model:

Demand functions: $c_i = c_i(p_a, p_m, w, E; z^{cw}),\ i = a, m, l.$

6.2.5. Household Problem

In the case of a household, the decision maker is engaged simultaneously in production, consumption, and work decisions. The three problems must be integrated into one single household problem.

Definition:

Characteristics of the household: z^h.

Structural form of the model:

$$\underset{q_a, x, l, c_a, c_m, c_l}{\text{Max}} \ u(c_a, c_m, c_l; z^h), \text{ utility function}$$

$$\text{s.t.: } g(q_a, x, l; z^q) = 0, \text{ production function,}$$

$$p_x x + p_m c_m = p_a(q_a - c_a) + w(l^s - l), \text{ cash constraint,}$$

$$c_l + l^s = E, \text{ time constraint.}$$

The last two constraints can be collapsed into one equation:

$$p_a c_a + p_m c_m + w c_l = \pi + wE = y^*, \text{ full income constraint,}$$

where $\pi = p_a q_a - p_x x - wl$, farm restricted profit.

6.3. Specification of a Household Model

Before analyzing the solution of the household model, it is important to clarify the nature of the assumptions which are made in the construction of the structural form of the model.

6.3.1. Home Time

A household model integrates production, consumption, and work decisions. Consumption decisions include the choice of home time in trade-off with the consumption of goods that would need more income and hence more work. Home time is time which is not spent in directly productive and labor market activities. It includes family maintenance (cooking, fetching wood and water, tending the house); family reproduction (pregnancies, rearing the children, attending the elders); socialization (relationships within the family and with neighbors and the community, festivals, religious practices); and leisure (relaxation, pleasure, and sleep). Only a small fraction of home time is thus "time off," particularly for women, and it is evidently quite different from the concept of leisure often identified with this allocation of time (Ellis, 1988).

6.3.2. Definition of the Household Unit

The concept of household varies widely across cultures. It ranges from the Western nuclear household to the African extended family system. Definition of the unit of analysis thus requires careful prior description of the subject analyzed. The key element in defining the household is identifying the decision-making unit which sets the strategy concerning the generation of income and the use of this income for consumption and reproduction. It is thus in general associated with the group that shares the same abode or hearth. There are no simple rules, however, and careful understanding of the decision-making process being analyzed must be obtained in each case, calling for an interdisciplinary approach to the specification of the unit of analysis.

6.3.3. Who Decides?

We consider here only models where there is a single decision-making process. This excludes highly relevant bargaining models where the household has several decision makers with unequal bargaining strengths who interact in a cooperative repeated game (Bourguignon and Chiappori, 1992; McElroy, 1990). As we have seen in Chapter 2, income may not be pooled under bargaining and consumption choices may be quite different for income controlled by women and men. In this chapter, the single decision-making process we consider characterizes either a situation where a single household member decides on behalf of the others (a patriarch or matriarch) or one where there is enough consensus among members to treat internal dissensions as a minor consideration. In this consensual household, resources are pooled into a unique strategy and consumption is shared, although by no means necessarily equally between household members, as we shall see.

6.3.4. Net Buyers versus Net Sellers of Food and/or Labor

Because production and work decisions affect the level of income achieved, whether a household is a net seller or a net buyer of a commodity (food or labor) whose price has changed has vastly different consequences for its welfare. A higher price for a food item thus lowers the welfare of a net buyer of food while raising the welfare of a net seller, usually a large farmer with a marketable surplus. For net sellers of labor, typically smallholders with little land and large families, a higher wage raises welfare while lowering it for net buyers for whom it is a production cost. In situations where perfect markets exist for all products and factors, most of the action in household models thus comes from whether households are net buyers or net sellers of products and factors. This differential position is principally determined by inequalities in access to productive assets and differential transactions costs in relating to markets.

6.4. Separable Household Model with Perfect Markets

6.4.1. The Model and Its Solution

If perfect markets exist for all products and factors, including the different categories of family labor, all prices are exogenous to the household and all products and factors are tradables with no transactions costs. In this case, production and consumption/work decisions can be taken in terms of these prices, which determine the opportunity costs of all products and factors owned by the household. As is typical when all markets work and there are no transactions costs, it is immaterial whether the household consumes its own products or sells them to buy what it needs to consume. Similarly, it is immaterial whether the household uses its own labor or sells it to hire what it needs to produce. Under these conditions, the household behaves as if production and consumption/work decisions were made sequentially. Perfect markets are sufficient, but not necessary for separability. As we shall see later, there is separability whenever prices are exogenous and markets are used, even if sale and purchase prices are not identical. When a household model is separable, it can be solved recursively in two steps:

a. First, the *production problem* is solved:

$$\underset{q_a, x, l}{\text{Max}}\ \pi = p_a q_a - p_x x - wl$$

$$\text{s.t.: } g(q_a, x, l; z^q) = 0, \text{ production function.}$$

Reduced form of the model:

Supply function: $q_a = q_a(p_a, p_x, w; z^q)$

Factor demands: $x = x(p_a, p_x, w; z^q)$

$l = l(p_a, p_x, w; z^q)$

Maximum profit: $\pi^* = \pi^*(p_a, p_x, w; z^q)$.

b. Second, the *consumption/work problem* is solved, given the level of profit π^* achieved in production:

$$\underset{c_a, c_m, c_l}{\text{Max}}\ u(c_a, c_m, c_l; z^h), \text{ utility function}$$

$$\text{s.t.: } p_x x + p_m c_m + w c_l = \pi^* + wE, \text{ full income constraint,}$$

$$c_l + l^s = E, \text{ time constraint.}$$

Reduced form of the model:

Demand functions: $c_i = c_i(p_a, p_m, w, y^*; z^h)$, $i = a, m, l$,

where $y^* = p_a\, q_a - p_x\, x - w\, l + w\, E$.

This recursive solution can be visualized in Figure 6.1, which gives the causal ordering through which variables are determined. Note that the only hinge between production and consumption decisions is π^*. Because p_a and w enter into both production and consumption decisions, the key issue for policy analysis is whether these prices represent a benefit or a cost to a particular household. This depends upon whether the household is a net seller of agricultural goods and/or labor, or a net buyer.

Figure 6.1. Causal ordering in the separable household model

Production decisions

Exogenous variables

$p_a \; p_x \; w \; z^q$

$\downarrow$

$q_a \; x \; l$

$\downarrow$

π^* hinge

Consumption/labor decisions

$\downarrow$

Exogenous variables

$w \; E$

$y^* \leftarrow$

$\downarrow$

Exogenous variables

$p_a \; p_m \; w \; z^h$

$c_a \; c_m \; c_l \leftarrow$

Derived indicators

Marketed surplus	$= q_a - c_a > 0,$	net seller,
	$< 0,$	net buyer
Labor supply	$= l^s = E - c_l$	
Labor balance	$= l - l^s > 0,$	hire in,
	$< 0,$	hire out.

6.4.2. Comparative Statics Results

Though it is not always unambiguous, we can frequently predict analytically what the household's response to price changes will be.

6.4.2.1. Elasticity of Consumption for Food with Respect to the Price of Food

Differentiating the demand function for food with respect to the price of food yields:

$$\frac{\partial c_a}{\partial p_a} = \left.\frac{\partial c_a}{\partial p_a}\right|_{y^*=const} + \frac{\partial c_a}{\partial y^*}\frac{\partial y^*}{\partial p_a} = \left.\frac{\partial c_a}{\partial p_a}\right|_{y^*=const} + q_a \frac{\partial c_a}{\partial y^*}.$$

The first term on the right-hand side can be decomposed into substitution and income effects using the Slutsky equation (see Appendix):

$$\frac{\partial c_a}{\partial p_a} = \left.\frac{\partial c_a}{\partial p_a}\right|_{u=const} - c_a\frac{\partial c_a}{\partial y^*} + q_a\frac{\partial c_a}{\partial y^*} = \left.\frac{\partial c_a}{\partial p_a}\right|_{u=const} + (q_a - c_a)\frac{\partial c_a}{\partial y^*}.$$

The first term on the right is the substitution effect and is negative. Because food is a normal good, $\partial c_a/\partial y^*$ is positive. Consequently, the sign of the second term is determined by the household status as a net seller, $(q_a - c_a) > 0$, or a net buyer, $(q_a - c_a) < 0$, of food. The net of the two terms on the right thus gives the following result: for net buyers, such as landless workers and small farmers, the result $\partial c_a/\partial p_a < 0$ is unambiguous. However, if the marketed surplus of net sellers is large enough, the second term may overwhelm the first, and $\partial c_a/\partial p_a$ can be > 0.

6.4.2.2. Elasticity of Demand for Home Time with Respect to Wage

Differentiating the demand function for home time with respect to wage, and decomposing as before, yields:

$$\frac{\partial c_l}{\partial w} = \left.\frac{\partial c_l}{\partial w}\right|_{u=const} + (E - c_l - l)\frac{\partial c_l}{\partial y^*} = \left.\frac{\partial c_l}{\partial w}\right|_{u=const} - (l - l^s)\frac{\partial c_l}{\partial y^*}.$$

Again, the first term on the right-hand side is negative. The second term $(l - l^s)$, the household's labor balance, may be positive for large farmers who hire in labor and negative for small farmers who hire out labor. While this elasticity may have either sign, we can conclude the following:

For households who hire in, the elasticity is unambiguously negative. Thus, wage is a cost. A rising wage leads to a fall in income and to less consumption of home time.

For landless workers and small farmers who hire out, the elasticity can be of either sign. Wage is a revenue. At low levels of income, it is likely that the income elasticity of leisure will be high, since so little of it is consumed. In this case, the consumption of leisure may well increase as wage rises and the household becomes more accommodated.

6.4.2.3. Elasticity of Marketed Surplus with Respect to the Price of Food

When very poor farmers produce a marketed surplus of food, it may happen that this surplus falls when the price of food rises, creating a perverse response for policy makers. For this reason, forced deliveries of cereals have frequently been imposed on peasants in Egypt and in India. This can be seen as follows:

Define the marketed surplus of food (ms_a) as: $ms_a = q_a - c_a > 0$. The response of marketed surplus to price is:

$$\frac{\partial ms_a}{\partial p_a} = \frac{\partial q_a}{\partial p_a} - \left.\frac{\partial c_a}{\partial p_a}\right|_{u=const} - ms_a\frac{\partial c_a}{\partial y^*}.$$

The first term on the right-hand side is the supply response in production and is positive. The second term is unambiguously positive. The third term, for a normal good, is negative. While the net will generally be positive, very poor households may have such a high income elasticity of food consumption that the entire expression is negative. This effect will be reinforced by a low elasticity of supply response and a low substitution effect between food and other goods. A negative marketed surplus response for foodgrains has been observed by Bardhan (1970) for a sample of villages in Punjab and Uttar Pradesh and for small farmers in the Delhi Territories by de Janvry and Kumar (1981).

6.4.3. *Empirical Results with Separable Models*

Table 6.1 gives a compilation of household responses to changes in the price of food and in the wage in seven low-income countries (Singh, Squire, and Strauss, 1986). Two households are contrasted, a pure consumer/worker household (landless) and a farm household with a marketed surplus of food (landed). The results show that consumption of food by the landless always falls when the price rises, but that consumption by the landed rises in Taiwan, Malaysia, Korea, and Nigeria, where marketed surpluses are sufficiently large to create positive income effects that overwhelm the direct negative price effect. Consumption of the nonagricultural commodity always rises among the landed, who have a positive marketed surplus and hence rising incomes. Consumption of the nonagricultural commodity rises among the landless when

Table 6.1. Empirical results with separable household models (price elasticities)

	Demand for food		Demand for nonagricultural commodity		Labor supply	
Countries	Landless	Landed	Landless	Landed	Landless	Landed
With respect to the price of food (p_a)						
Taiwan	–0.72	0.22	0.13	1.18	0.21	-1.59
Malaysia	–0.04	0.38	–0.27	1.94	0.08	–0.57
Korea	–0.18	0.01	–0.19	0.81	0.03	–0.13
Japan	–0.87	–0.35	0.08	0.61	0.16	-1.00
Thailand	–0.82	–0.37	0.06	0.51	0.18	–0.62
Sierra Leone	–0.74	–0.06	–0.03	0.14	0.01	–0.09
Northern Nigeria	–0.05	0.19	–0.14	0.57	0.03	–0.06
With respect to the wage rate (w)						
Taiwan	0.14	–0.03	0.05	–0.12	–0.12	0.17
Malaysia	0.06	–0.08	0.29	–0.35	–0.07	0.11
Korea	0.16	0.01	0.77	0.05	0.00	0.11
Japan	0.29	0.15	0.39	0.25	0.15	0.45
Thailand	0.57	0.47	0.62	0.52	0.08	0.26
Sierra Leone	0.47	0.37	0.78	0.57	0.14	0.26
Northern Nigeria	0.06	0.02	0.04	0.01	0.01	0.01

Source: Singh, Squire, and Strauss, 1986.

it is a substitute for food, as in the case of Taiwan, Japan, and Thailand, but falls when it is a complement. Finally, labor supply, which is the complement to home time, always rises among the landless when the price of food rises as their real incomes fall. By contrast, it always falls among the landed as incomes rise, indicating an increased consumption of home time.

When it is the wage that rises, the landless increase food and nonagricultural consumption as their incomes improve. While the effect is small, labor supply falls with wage in Taiwan and Malaysia, suggesting that the income elasticity of leisure is very high. However, it increases in all other countries. Among the landed, only in Taiwan and Malaysia does wage appear to be a cost, indicating that the landed are net buyers of labor. This leads to a fall in the consumption of food and the nonagricultural commodity. The landed of all other countries represented behave as net sellers of labor, so consumption rises when the wage increases. Household labor supply always increases with wage: in Taiwan and Malaysia, family labor substitutes for hired labor; in the other countries, hiring out increases.

These examples show that, in separable household models, contrasted responses across households come from differential status regarding the net sale of products and labor. While this is interesting, it is clear that there is much more to household behavior than the transmission of income effects in production to consumer response. We now turn to this richer specification of household models.

6.5. Household Model with Market Failures

6.5.1. Why Markets Fail

Up to this point, the household model has been developed under conditions where perfect markets exist; that is, where all products and factors are tradables and where the opportunity cost of any product or factor held by the household is its market price. Under this condition, separability holds, and the producer side of the model can be solved prior to the consumer/worker side, with farm profits serving as the hinge between the two problems. Ownership of the variable factors is irrelevant for production decisions and affects consumption decisions only through income level, which is itself determined by ownership.

The farm household is, however, typically located in an environment characterized by a number of market failures for some of its products (e.g., some foods, particularly the most perishable or bulky, or those with high price risk) and for some of its factors (e.g., child labor or family labor with low access to the labor market or facing discrimination). An extreme case of market failure is simply nonexistence of a market, for example, due to a fully enforced legal prohibition on certain transactions. Typically, however, some type of market exists for any good or factor, be it only abroad or in the underground economy. In spite of this, a market may fail for a particular household when it faces wide price margins between the low price at which it could sell a commodity or factor and the high price at which it could buy that product or factor. Faced with this wide price band, the household may be better off choosing self-sufficiency in that good or factor if its subjective price (defined as the price which equates its supply and demand) falls inside the band. The magnitude of the price band may be increased by one or more of the following factors:

a. *Transactions costs*, which include distance from the market and poor infrastructure that increase transportation costs, high marketing margins due to merchants with local monopoly power, high search and recruitment costs due to imperfect information, and supervision and incentive costs on hired labor.

b. *Shallow local markets*, which imply a high negative covariation between household supply and effective prices. In this case, when the harvest is good and the household could have a marketed surplus, the price falls because all other households also have plentiful harvests and the subjective equilibrium price remains within the price band. Conversely, when there is a drought and household supply falls, so does the supply of all other households. The ensuing sharp rise in price may force the household to remain self-sufficient.

c. *Price risks and risk aversion* influence the effective price used for decision making. As we saw in Chapter 5, the certainty equivalent price used for decision making is the expected price discounted by a markup that reflects the level of risk and the degree of risk aversion. Sales prices are discounted negatively to hedge against risk. Purchase prices are discounted positively for the same reason. The greater the level of price risk and the greater the aversion to risk, the wider the effective price band becomes and the higher the likelihood of market failure.

A frequent cause of market failure is limited access to working capital credit. The seasonality of agricultural expenditures and revenues implies that the household not only has to satisfy an annual cash income constraint, with total expenditure less or equal to total revenue, but also to balance its budget during the lean season when there are high expenditures for consumption and input purchase and few revenues. With limited access to credit, the budget balance becomes a constraint, where expenditures have to remain less or equal to the sum of revenues during the period, accumulated savings, and credit availability. Hence, a credit constraint limits the optimum production or consumption choices. The price of any good that enters the credit constraint, either to relax the constraint as it creates liquidity or to tighten it as it uses liquidity, is marked up by the shadow value of credit. The decision prices of goods that relax the credit constraint—the daily sale of milk or family labor, for example—are marked up positively, increasing their production and/or sale. Conversely, the decision prices of goods that require credit—such as chemical fertilizers and hired labor—are also marked up positively, reducing their purchase and inducing import substitution. Exogenous market prices are consequently no longer the full opportunity cost of the goods that enter the credit constraint. If the household is facing a price band for any of these goods, the price band is now shifted upward for the goods and factors that enter into the credit constraint, and greater credit scarcity increases the magnitude of the shift.

With market failure, the corresponding good or factor becomes a nontradable. Its "price" is no longer determined by the market but internally to the household as a shadow price. When a household needs to decide what to produce and how to earn income in different activities in a situation where some markets fail, then there is no longer "separability" between production and consumption decisions. The household's production/income problem must be determined simultaneously with its consumption decisions. This is when the household approach to policy analysis becomes essential. In this case, we can no longer study separately the farm/firm side of the household without looking at its consumption decisions at the same time.

In Figure 6.1, nonseparability appears in the fact that the determination of shadow prices is based on endogenous variables that are on both sides of the income hinge. If there is market failure for food, the shadow price of food p_a^* is obtained by equilibrium between production q_a and consumption c_a of food. If there is a market failure for labor, the shadow wage w^* is determined by equality between farm production labor needs l and household labor supply l^s.

The contrast between separability and nonseparability can thus be summarized as follows:

a. If the market is used for a transaction, the household behaves *as if* it were deciding sequentially: production first and consumption/work after. Production decisions are identical to those of a pure producer. Consumption decisions are affected by the level of income reached in production. For both decisions, *market prices* serve as decision prices. The relevant price is the sale price if the household is a net seller and the purchase price if it is a net buyer.

b. If the market is not used for a transaction, that is, when the subjective equilibrium price falls within the price band, the household behaves *as if* a market existed within the household for the nontradable. Equilibrium of supply and demand on this fictitious market determines a *shadow price* that serves as the decision price for the household.

6.5.2. A Household Model with Market Failures and Credit Constraint

6.5.2.1. Definitions

Goods produced, including both food and cash crops: $q > 0$

Factors used, including both family labor and purchased factors: $q < 0$

Goods consumed, including food, purchased goods, and home time: $c > 0$

Household initial endowment, including time available to each household member: E

Net transfers received, including remittances: S

Access to credit: K

Exogenous effective market prices: $\overline{p}$

Endogenous decision prices: p^*

Number of goods: n products and factors, m consumption goods, t tradables, and nt nontradables.

6.5.2.2. Classification of Goods and Factors

Goods, and equivalently factors, are decomposed into three categories, each with a different rule for price formation which will be established in section 6.5.2.3:

Tradables which are not subject to a credit constraint, *TNC*. For these goods, the decision price is the farm-gate price, also referred to as the effective market price.

Tradables subject to a credit constraint, *TC*. For these goods, we will see that the decision price is the effective market price marked up by the shadow value of credit as determined by the credit constraint.

Nontradables, *NT*. For these goods, the decision price is the endogenous shadow price as determined by equilibrium between supply $(q_i + E_i)$ and demand (c_i) within the household.

The two tradable categories (*TNC* and *TC*) together constitute the tradable category *T*.

To which of these three categories a particular good pertains is an endogenous choice. In what follows, we nevertheless specify the household model as if this classification had already been achieved. At the end of the chapter, we address the issue of testing for the tradability or nontradability of each good and factor.

6.5.2.3. The Model and Its Solution

The household's problem is to:

$$(1a) \qquad \operatorname*{Max}_{c,q} \; u(c, z^h)$$

subject to the following constraints:

(1b) $\sum_{i \in T} p_i(q_i + E_i - c_i) + S \geq 0,$ cash constraint,

(1c) $\sum_{i \in TC} p_i(q_i + E_i - c_i) + K \geq 0,$ credit constraint,

(1d) $g(q, z^q) = 0,$ production technology,

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

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

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

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

The three types of goods can be treated symmetrically in the solution of the model by defining endogenous decision prices p^* as follows:

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

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

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

After manipulation of the first-order conditions, the reduced form of the model can be written as follows. Production decisions regarding all tradables and nontradables are represented by a system of supply and factor demand functions in the decision prices p^*:

(3a) $q = q(p^*, z^q).$

On the production side, the household thus behaves as if it were maximizing profit using the p^* prices. Optimum levels of products and factors yield maximum profit:

(3b) $\pi^* = \sum p_i^* q_i.$

On the demand side, decisions are also made in terms of the p^* prices. Using (1b), (1c), (1d), (1e), (1f), and (2), the full-income constraint in p^* prices is written:

(3c) $\sum_i p_i^* c_i \leq \pi^* + \sum_i p_i^* E_i + S + \lambda_c K = y^*,$

and the demand system is:

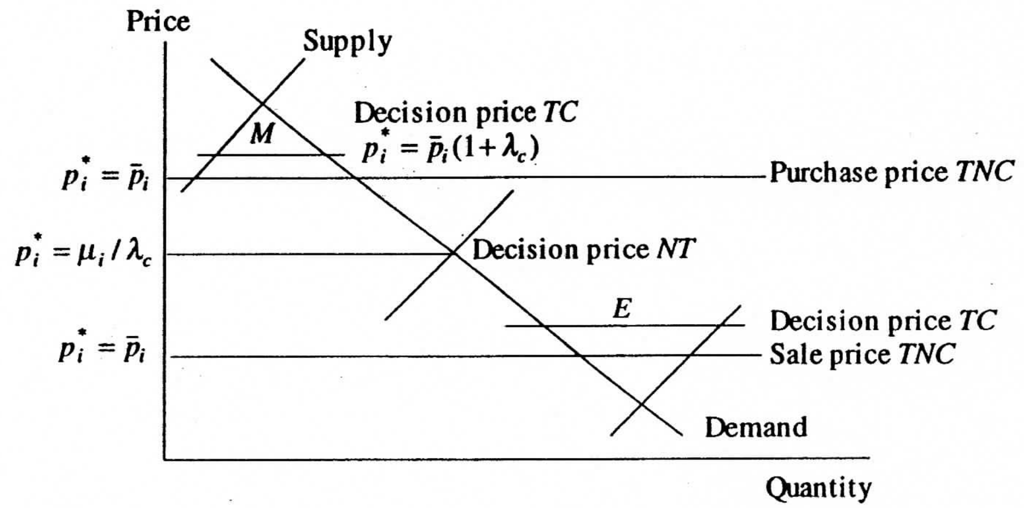
(3d) $c = c(p^*, y^*, z^h).$

On the consumption side, the household thus behaves as if it were maximizing utility using the p^* prices and y^*.

For tradables, the decision prices are the effective market prices, or farm-gate prices, $\bar{p}_i$ given in equation (1e). For the nontradables, the decision prices are the shadow prices μ_i/λ, where λ is the marginal utility of cash given by constraint (1b) and μ_i the marginal utility of endowment in nontradable i given by equilibrium condition (1f). For the credit-constrained tradables, the decision prices are given by the market prices and the marginal utility of credit λ_c (or η) introduced by the credit constraint (1c).

The roles of these prices in decision making are illustrated in Figure 6.2. The endogenous markup λ_c on the price of the credit-constrained tradables serves to raise the decision price of

Figure 6.2. Price bands and credit constraint



E = exports (sales)
M = imports (purchases)
NT = nontradable
TC = tradable credit-constrained
TNC = tradable not credit-constrained
p^* = decision prices
p = effective farm-gate prices
λ_c = price markup on credit-constrained transactions

both credit-constrained tradable products and factors with a positive marketed surplus. Even though these goods are transacted at the market price $\bar{p}$, their supply increases and their home use falls, since $p^* > \bar{p}$, reflecting the fact that higher sale of these goods and factors helps ease the credit constraint. Similarly, the endogenous markup λ_c raises the decision price of the credit-constrained tradables of which the household is a net buyer, inducing it to produce more of them for import substitution and to use less of them in production and consumption. Even though the transaction occurs at the market price $\bar{p} < p^*$, purchases of these goods and factors are reduced to accommodate the credit constraint.

The model to be solved is thus composed of the following five blocks of equations:

Production decisions: n equations (3a) for n products and factors, and one equation (3b) for profits.

Consumption decisions: one equation (3c) for full income and m equations (3d) for m consumption goods.

Cash constraint: equation (1b).

Credit constraint: equation (1c).

Equilibrium conditions for price formation: t equations (1e) for the tradables and nt equations (1f) for the nontradables.

The model thus has $n + m + t + nt + 4$ equations to solve for n product and factor levels, m consumption levels, t decision prices of tradables, nt nontradable decision prices, profits, full income, and the shadow prices of cash and credit.

Because the decision prices of nontradables and of credit-constrained tradables are endogenous, production and consumption decisions are not separable. This system of equations consequently needs to be solved simultaneously. Since this is analytically intractable, as is often the case in models with policy relevance, a computable version of this model needs to be specified, which we will discuss in section 6.6.4.

6.5.3. Empirical Results with Nonseparable Models

6.5.3.1. Market Failures in Food and Labor in Africa

We present first in Table 6.2 results from a nonseparable model that captures the structure of an African household with the following features (de Janvry, Fafchamps, and Sadoulet, 1991):

Products: a cash crop and a food crop,

Factors: labor and fertilizer,

Consumption: food, manufactured goods, and home time.

The study is motivated by the observation that peasants appear to governments as unresponsive to price incentives in the production of cash crops, while peasants perceive themselves as constantly trying to adjust to labor shortages or food scarcities, leading a life of great instability. These contradictory visions of the peasantry are reconciled by analyzing the role of market failures that occur as a consequence of eventually wide price bands in food and labor. For that purpose, four alternative structural conditions are considered (there is no credit constraint in this model):

Market failures for both food and labor,

Market failure for labor only,

Market failure for food only,

Absence of market failure.

The model questions how households respond to a 10% increase in the price of cash crops under these different structural conditions. The results in the last column of Table 6.2 show that, when there are no market failures, the household increases factor use and shifts its resources from food, with a 5.4% decline in production, to cash crops, which increase by 9.9%. As real income increases, more food, manufactured goods, and leisure are consumed. Since both home time and labor used in production rise, the hiring of outside labor increases by 6.1% to fill the deficit. And since less food is produced while more is consumed, demand for food on the market increases by 7.9%. These results are analogous to those observed in Table 6.1, with no market failures and transmission of income effects from production to consumption. Here, at the initial equilibrium point, the household is exactly self-sufficient in labor and food.

When both markets fail, by contrast, the elasticity of supply response of cash crops drops from 0.99 to 0.18, showing very little response. This is due both to an inability to reduce food production by any significant amount, since the family needs to feed itself while income rises, with only some substitution in consumption between food and the manufactured good, and to an inability to use more labor in production since the consumption of leisure rises slightly as income improves. Output response mainly comes from increased use of fertilizers. On the consumption side, the only reward to peasants is increased consumption of manufactured goods.

Table 6.2. Household model with market failures, Africa: Impact of 10% increase in price of cash crops (percentage change over base)

	Market failures			
	Food and labor	Labor	Food	None
Consumption				
Food	–0.5	3.0	–0.8	2.1
Leisure	0.4	0.6	4.0	2.7
Manufactured goods	15.8	7.7	9.5	5.6
Production				
Food crop	–0.5	–6.4	–0.8	–5.4
Cash crop	1.8	9.3	5.5	9.9
Fertilizer	4.7	2.8	3.1	2.2
Labor	–0.6	–1.0	3.9	1.7
Prices				
Food crop	8.8	—[a]	5.8	—
Cash crop	10.0	10.0	10.0	10.0
Fertilizer	—	—	—	—
Labor	9.3	4.5	—	—
Manufactured goods	—	—	—	—
Residual balances				
Net labor supply[b]	—	—	–10.6	–6.1
Marketed surplus of food[b]	—	–10.1	—	–7.9

Source: de Janvry, Fafchamps, and Sadoulet, 1991.
[a]No change relative to base value.
[b]Net labor supply in percent of household labor effort and marketed surplus in percent of food production.

No wonder, thus, that peasants appear to government as unresponsive to price incentives. Internally, by contrast, the perception of food and labor scarcities is represented by the sharp rises in shadow prices, by 8.8% and 9.3%, respectively. It is thus not at all surprising that peasants consider themselves stressed to respond to external incentives, however imperceptible this response may be to outsiders.

When the labor market fails but the food market is used, the shock can be exported on the food market. The household responds by shifting out of food production and buying food instead, as demonstrated by an elasticity of cash crops production of 0.93%. This allows an increase in food consumption, but without a corresponding increase in leisure, since the family needs to produce the labor effort.

Finally, when it is only the food market that fails, response in cash crops is enhanced, as revealed by an elasticity of 0.55%, by hiring labor from the outside. This allows an increase of the consumption of leisure, but not that of food, which declines slightly as resources are shifted to cash crops.

Other questions that can be asked with this type of model are: How does the household adjust to a fall in the price of manufactured goods? Can, in particular, cheaper manufactured goods serve as an incentive for peasants to increase production of cash crops (see Berthélemy and Morrisson, 1987; Azam and Besley, 1991) or is the desired increased production of cash crops better induced through imposition of a monetary head tax? How does technological change in the production of food affect the use of family labor in food production and hence the supply of cash crops? These questions are analyzed in de Janvry, Fafchamps, and Sadoulet (1991).

6.5.3.2. Market Failure for Child Labor and Credit Constraint in Morocco

The response of Moroccan households to a sharp rise in the price of cereals brought about by an agricultural structural adjustment program (ASAP) is analyzed in a model with the following features (de Janvry, Fafchamps, Raki, and Sadoulet, 1992):

Products: hard wheat, soft wheat, coarse grains, fruits and vegetables, animal forage, milk, meat, and handicrafts.

Factors: coarse grains used as animal feed, animal forage, machinery, and fertilizers; male, female, and child labor; and fixed factors to which correspond depreciation costs.

Consumption: hard wheat, soft wheat, coarse grains, fruits and vegetables, milk, meat; male, female, and child home time; other consumption goods; and savings.

Table 6.3 shows how the base information for two types of households—small and medium farmers—is organized. This information is derived from household surveys in the Haute Chaouia. An important feature of these farms is that animal production is partly done by using child labor for herding small flocks in common grazing lands. Nontradable child labor can thus be used as a substitute for tradable coarse grains and animal forage in meat and milk production. Goods are partitioned into three groups:

Nontradables: milk and child labor.

Tradables, credit-constrained: animal forage, machinery, fertilizer, and male and female hired labor.

Tradables, not credit-constrained: all other products and factors.

The model is completed with a system of supply and factor demand deriving from a generalized Leontief profit function and a demand system that derives from a translog indirect utility function.

When cereals prices rise, other prices rise as well, in particular that of animal forage, due to competition in production. Hence, the ASAP policy is specified as a vector of exogenous price changes (given in footnote to Table 6.4) for most tradable goods and factors. The results in Table 6.4 show that medium farmers, whose economy is largely cereals oriented, gain much more than small farmers, whose economy is largely livestock oriented. The credit constraint is highly binding on the medium farmers: all credit-constrained factors are marked up by 16.6%,

Table 6.3. Structural characteristics of small and medium farms, Haute Chaouia, Morocco (in 1000 dirham unless otherwise indicated)

Farm types	Small	Medium	Small	Medium	Small	Medium	Small	Medium	Small	Medium
Structural characteristics	*Total resources*		*Resources per hectare*							
Average farm size (ha)	5.1	22.8								
Capital	3.0	12.0	0.59	0.53						
Animals (livestock units)	4.9	7.1	0.96	0.31						
Product and factor use	*Production or availability*		*On–farm use*		*Consumption and home time*		*Net sale*		*Family labor used on farm*	
Hard wheat	2.00	8.56			0.85	2.38	1.15	6.17		
Soft wheat	0.44	6.73			1.43	1.72	–0.99	5.01		
Coarse grains	2.95	12.07	2.78	5.40	1.61	1.55	–1.44	5.13		
Fruits and vegetables	1.64	4.40			2.18	4.48	–0.54	–0.08		
Forage (*TC*)	0.41	0.92	1.39	2.74			–0.99	–1.83		
Milk (*NT*)	0.74	1.54			0.74	1.54				
Meat	8.54	14.09			1.71	4.04	6.83	10.05		
Handicrafts & services	1.20	2.92					1.20	2.92		
Machinery (*TC*)			0.04	3.42			–0.04	–3.42		
Fertilizers (*TC*)			0.85	5.02			–0.85	–5.02		
Male labor (*TC*)	8.86	12.84	3.56	6.60	2.94	7.90	2.36	–1.66	3.56	4.94
Female labor (*TC*)[a]	4.43	6.42	2.54	2.55	1.60	5.61	0.30	–1.74	2.54	0.81
Child labor (*NT*)[a]	3.73	5.24	1.82	1.95	1.91	3.28			1.82	1.95
Depreciation of fixed factors			–1.94	–3.53			–1.94	–3.53		
Other consumption goods					3.72	7.72	–3.72	–7.72		
Savings					1.33	4.29	–1.33	–4.29		
	Total		*Income shares*							
Total net income	13.55	27.71								
Net crops income	5.93	19.74	43.8	71.2						
Net animal income	3.76	5.05	27.8	18.2						
Off-farm income	3.86	2.92	28.5	10.5						

Source: de Janvry, Fafchamps, Raki, and Sadoulet, 1992.

Table 6.4. Simulation of household behavior: ASAP responses, Morocco (percent change over base run unless otherwise indicated)

	Base run (in 1000 dirham)		ASAP Credit constraint		ASAP No credit constraint	
Farm size	Small	Medium	Small	Medium	Small	Medium
Full income	20.01	44.58	1.56[a]	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	2.94	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	1.91	3.28	–0.9	–1.9	–0.9	–2.8
Consumption goods	12.24	23.43	1.8	9.8	–0.1	5.4
Production						
Hard wheat	2.00	8.56	1.6	1.8	2.0	1.8
Soft wheat	0.44	6.73	2.1	–0.7	8.5	2.3
Coarse grains[b]	0.17	6.67	82.5	8.1	98.6	11.5
Forage[b]	–0.98	–1.82	–2.6	–8.3	–1.5	–3.3
Total crops	3.27	24.54	4.4	1.8	6.5	3.8
Total livestock	9.28	15.63	–1.0	–4.1	–1.0	–1.8
Machinery and fertilizer	–0.89	–8.44	3.1	–2.0	7.1	4.0
Labor men	–3.56	–6.60	–0.5	–5.0	1.0	2.2
Labor women	–2.54	–2.55	0.1	–0.4	0.7	5.5
Labor children	–1.82	–1.95	0.9	3.1	0.9	4.7
Shadow prices (index)						
Labor children	1.05	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	0.30	–1.74	27.5	–31.8	–59.1	54.4
Marketed surplus						
Hard wheat	1.15	6.17	3.6	–0.5	4.9	1.4
Soft wheat	–0.99	5.01	2.7	–1.2	–2.1	0.5
Meat	6.83	10.05	–1.4	–11.2	–0.6	–4.4

Source: de Janvry, Fafchamps, Raki, and Sadoulet, 1992.
Note: Exogenous price changes: hard wheat 17.8%, soft wheat 14.4%, coarse grains 27.8%, fruits and vegetables 8.7%, animal forage 24%, meats 12.8%, handicrafts 6.1%, machinery and fertilizers 1.5%, other consumption goods 5%, and wages 6.7%.

[a]Equivalent variation in full income to the change in indirect utility at base prices.

[b]Net of intermediate use.

while the markup is 9.4% on small farmers. This reflects the ability of small farmers to relax the credit constraint by selling labor. In contrast, hiring out labor has a high opportunity cost for medium farmers. The credit constraint severely limits the ability of medium farmers to hire labor and to rent machinery and buy fertilizers. The credit constraint thus decreases their supply response on crops from 3.8% to 1.8%. On small farms, the credit constraint induces household members, particularly women, to work more on the labor market. Relaxing this constraint allows women to remain on the farm and allows for the hiring of outside workers.

ASAP induces the redefinition of the farm economy from livestock to crops, resulting in a falling production of milk and meat. Paradoxically, however, rising forage prices induce a substitution in meat production from the use of animal forage to the use of grazing in the commons and hence intensified need for child labor. As a result, the use of children in production increases, their shadow price rises sharply, and their home time falls. Market failure for child labor and access to commons increase the negative effect of ASAP on the livestock economy. In addition, the long-run consequence is increased school absenteeism and increased overgrazing in the commons, thus intensifying two of the traditional aspects of Moroccan underdevelopment.

6.6. When and How to Use a Household Model

6.6.1. When to Use Which Approach?

If there are no market failures and we are interested only in the production side of the farm household, the separability condition eliminates the need for a household approach. Even though production decisions are taken by a household, resources are allocated exactly as proposed in the pure production theory of the firm.

If there are no market failures and we are interested in the consumption side of the household, a household approach may be useful to link the consumption side to the production side ex post through income effects. The gain from use of the household approach as opposed to modeling the consumption side as a pure consumer problem will, however, only be worthwhile if:

a. Farm profit effects due to price changes are large. This will not be the case for minor crops or if there are high substitution effects among products, or among factors if it is the price of a factor that changes, as this allows the household to mitigate the income effect of the price change.

b. Farm profits are a large share of full income. This will not be the case if the household does not farm as its primary economic activity, or if the net income contribution of the farm is small because the farming activity is underpriced.

c. The income elasticity of the commodity that is of interest to the analyst is high. In general, the income elasticity of staples is less than that of luxury foods and nonagricultural commodities. Consequently, transmission of income into quantity effects will be less important for staples than for luxury goods and nonagricultural commodities.

If there are market failures, a household approach is necessary due to breakdown of the separability condition. If, however, the good for which the market fails is secondary in production and consumption, then the loss of studying the household in a nonseparable fashion or of studying producer and consumer/worker decisions separately may not be worth the cost of building a complicated model. Additionally, if the width of the price bands is small, so that neglecting market failures does not significantly misrepresent household behavior, separability may again be acceptable.

When market failures are important, then a nonseparable household approach should be followed.

6.6.2. *Econometric Estimation of Household Models and Tests of Separability**

If the household model is separable, its econometric estimation can be divided into two independent parts, the production and the consumption systems. Each of these systems is estimated with the standard consumer and producer approaches seen in Chapters 2 and 3. For the consumption side, this requires measurement of a consistent demand system such as the LES or the AIDS as described in Chapter 2. For the production side, this can be done with a production function, a linear programming specification of the production system (Ahn, Singh, and Squire, 1981), or a profit function approach (Lau, Lin, and Yotopoulos, 1978).

If the model is not separable, the estimation of production and consumption behavior must be done simultaneously. Because the structural model can be written in explicit form only with the use of the nonobservable implicit prices, its estimation is quite complex, and for that reason it is not usually done. Two different approaches to the estimation of the reduced form are found in the literature, and with each of them a corresponding test of separability is associated.

6.6.2.1. *Reduced Form Approach*

The first approach considers the fully reduced form of the model (Lopez, 1984; Benjamin, 1992). Take the solution of the nonseparable household model given in section 6.5.2.3. Equations (3a) and (3d) give production and consumption decisions as functions of the decision prices p^*, decision income y^*, and the household characteristics z^q and z^h associated with production and consumption decisions. The endogenous p^* and y^* themselves are functions of the exogenous prices $\overline{p}$, the characteristics z^q and z^h, exogenous transfer S, and credit K if the credit constraint is binding. Eliminating p^* and y^* gives the fully reduced forms:

$q = q(\overline{p}, z^q, z^h, S, K)$ for production, and

$c = c(\overline{p}, z^q, z^h, S, K)$ for consumption.

These functions may be estimated as such. With these reduced forms, however, none of the original parameters and hence the constraints that they are supposed to satisfy can be identified. There is no justification for any specific restrictive forms for the system, and any flexible form for the function q and c can be chosen. In particular, one can estimate the demand for a subset of inputs or the supply function without having to deal with a full system. The distinguishing feature of these equations is that the production decisions depend on characteristics z^h of the consumption decisions, as opposed to what would be found in a pure producer model. Hence, one can develop a test of separability of the household model: if the parameters of the z^h variables jointly are significantly different from zero in the production equations, separability is rejected. Following this approach, Lopez (1984), using Canadian data, and Benjamin (1992), with rural Javanese data, have estimated labor demand functions and tested for the significance of demographic variables in these equations. Empirically, Lopez found that production decisions are indeed not separable from consumption decisions, while Benjamin could not reject the separability hypothesis.

In order to measure the importance of the credit constraint on agricultural production, Feder, Lau, Lin, and Luo (1990) contrast the behavior of unconstrained and constrained Chinese households. Since whether households are credit constrained or not is determined by variables which also influence production and consumption decisions, the econometric model is a switching regression with endogenous criterion, which consists of the joint estimation of the probability of being constrained or unconstrained and the production decision:

$$\text{prob(credit constrained)} = f\left(z^q, z^h\right),$$

$$q = q\left(\bar{p}, z^q\right) \text{ if the credit constraint is not binding,}$$

$$q = q\left(\bar{p}, z^q, z^h, K\right) \text{ if the credit constraint is binding.}$$

Note that K is total liquidity available during the period and not only credit. It includes the cash value of inventories, deposits, and credit. A frequent error of studies that attempt to measure the impact of credit on production decisions is to divide the sample into borrowers and non-borrowers, as opposed to the correct criterion of constrained/unconstrained used here. Indeed, some households may not need credit and hence are not constrained even if they are not borrowing, while other households may have access to credit although they are limited in the amount which they can borrow. The findings of the Feder, Lau, Lin, and Luo study suggest that credit to the constrained households has a small effect on production. This, however, does not mean that credit has a small effect on consumption and welfare.

6.6.2.2. Predicted Endogenous Prices

The second approach, followed by Lambert and Magnac (1992), relies on a variation of the explicit form of the solution (3a) and (3d). Consider again the nonseparable model of section 6.5.2.3. Production decisions are taken as if the household was maximizing profit at given characteristics z^q and prices p^*. Equivalently, one can say that the household's production decisions on inputs correspond to a cost minimization:

$$\underset{q}{\text{Min}} \left(\sum_i p_i^* q_i\right)$$

for a given level of output, and subject to the production technology constraint $g(q, z^q) = 0$. Because of its additivity, this global cost minimization can be written as:

$$\underset{q_j}{\text{Min}} \left(\underset{q_i}{\text{Min}} \sum_{i \in T} \bar{p}_i q_i + \sum_{j \in NT} p_j^* q_j\right)$$

where the internal minimization problem $C = \text{Min} \sum \bar{p}_i q_i$ is a cost minimization on the tradable inputs, conditional on the choice of the nontradable inputs. Write this cost function $C = C[\bar{p}, z^q, (q_j)_{j \in NT}, q_{output}]$. A duality theorem very similar to the one we saw for the profit function in Chapter 3 establishes that the optimum q_i are first derivatives of this cost function with respect to their prices. The solution to this minimization problem can be written:

$$q_i = q_i\left[\bar{p}, z^q, (q_j)_{j \in NT}, q_{output}\right], \quad i \in T.$$

In this system, the nontradables q_j play the same role as fixed inputs in a more standard analysis. As they are in fact also variable and endogenous, they are called quasi-fix inputs. Standard functional forms for cost functions and their associated input demand systems are similar to those used for profit functions (Chambers, 1988). The estimation can be done with standard estimation procedures, since all variables are observed. Note, however, that the nontradables q_j of the right-hand side and the output level q_{output} are endogenous. Hence, one needs to correct for potential bias by using instrumental variables. The procedure is then to regress the nontradable q and output level on a number of instruments, substitute their predicted values in the supply system for the tradable inputs, and then estimate the system by OLS.

The solution of the cost minimization for the use of nontradables is:

$$p_j^* + \partial C / \partial q_j = p_j^* + \sum_{i \in T} \bar{p}_i \ \partial q_i / \partial q_j = 0,$$

from which one can derive for each household an estimation of the endogenous implicit price p_j^* of the quasi-fix variables.

As discussed in section 6.5.3 above, these implicit prices give an interesting measure of the relative scarcity of the factor for the household. Comparison and test of equality of these implicit prices with effective market prices, if they are observed, also give a test of separability for the household.

6.6.3. Econometric Estimation of Supply or Marketed Surplus When There Are Price Bands

An important implication of the existence of price bands and nonseparability is that market participation of the different households is endogenous, and also is the influence of market prices on their supply. This has strong consequences for the estimation of supply response. Each household is responsive to its own decision price, and only when it is participating in the market as buyer or seller is its decision price determined by the market price. Hence, there is a difference between the true underlying supply elasticity of a household, as characterized by its supply function, and the apparent supply response to market price. In fact, the elasticity of the regional supply response will only be a fraction of the underlying true household-level elasticities, as it reflects the impact that market price has only on those households that participate to the market. Standard estimation procedures (as in Chapter 4), which typically ignore this fact, attribute to all households the market price, and directly estimate the regional elasticity of supply response, will underestimate the households' true underlying supply elasticity. With market participation varying across regions, it is not surprising to find in the literature estimations of supply elasticities which are highly inconsistent and generally low (for an elaboration of this subject, see de Janvry and Sadoulet, 1992).

One way to take into account this decision is to jointly estimate the probability of participation in the market (as supplier or as buyer) and the output supply as a function of the market price for those who do participate. Since the two decisions of (1) whether to participate in the market, which results from the joint decision of production and consumption, and (2) how much to produce, are jointly made, estimation of this system has to be performed with proper correction for selection bias (see Maddala, 1983, for a general presentation of estimation with selectivity bias). Using this methodology to estimate marketed surplus of coarse grains in Senegal, Goetz (1992) found that the regional effect of market price on marketed surplus is substantially lower than the underlying true elasticity.

Beyond the important issue of improving the estimation of supply elasticities, this remark stresses the potential for policy entry points alternative to market-level price incentives. It emphasizes in particular the role of policies that increase market participation as an instrument to increase the aggregate response of production to market incentives.

6.6.4. Calibration and Simulation with a Household Model

As usual, the parameters of the household model can either be estimated econometrically (the academic approach) or be guesstimated (the policymaker's approach). If guesstimated, the systems must be calibrated ex post to satisfy all the constraints on parameters.

When the full nonseparable model is not simultaneously estimated, a pragmatic approach consists in calibrating the model as though it were separable, implying that all prices are observed and credit constraints not effective at the base point, and of simulating responses to changes in the exogenous variables and parameters using the nonseparable model. While this is clearly inconsistent, comparing the solutions with and without market failures at least gives us a qualitative idea of the importance of these failures to household behavior.

We proceed as follows. Functional forms are specified for the production system, through specification of a profit function from which supply and factor demand equations are derived, and for the consumption system through specification of an indirect utility function from which a demand system is derived. As we have seen in Chapter 3, a convenient functional form for the profit function is the generalized Leontief:

$$\pi = \sum_{i,j} b_{ij}\sqrt{p_i p_j} + \sum_{i,m} b_{im} p_i z_m^q.$$

Its derived system of output supply and factor demand is:

$$q_i = \sum_j b_{ij}\sqrt{p_j / p_i} + \sum_m b_{im} z_m^q, \text{ with } b_{ij} = b_{ji}.$$

To determine the values of the b_{ij} and b_{im} parameters of this system, we typically start from a set of first-guess price and fixed factor elasticities derived from the literature. These elasticities are then calibrated to satisfy the constraints that a generalized Leontief profit function implies. This can be done by using an algorithm that minimizes, with respect to b_{ij} and b_{im}, the sum of the squares of the discrepancies between this initial set of elasticities and a set of new elasticities that derive from the generalized Leontief, keeping constant the diagonal values in which we tend to have the greatest confidence.

First-guess values are also chosen for the price and income elasticities in consumption. They are calibrated using the same algorithm as above to satisfy all the additivity and symmetry constraints implied by a translog indirect utility function:

$$v = \sum_i \alpha_i \ln(p_i / y^*) + \frac{1}{2}\sum_{i,j} \beta_{ij}(p_i / y^*)\ln(p_j / y^*),$$

where $y^* = \pi + \sum_i p_i E_i + S$, full income.

The expenditure system that derives from the translog is:

$$\frac{p_i c_i}{y^*} = \frac{\alpha_i + \sum_j \beta_{ij} \ln p_j / y^*}{\alpha_y + \sum_j \beta_{yj} \ln p_j / y^*},$$

where $\alpha_y = \sum_i \alpha_i = -1$, $\beta_{yj} = \sum_i \beta_{ij}$, and $\beta_{ij} = \beta_{ji}$.

With the nonseparable household model thus quantified, we can proceed to solve the model numerically.

Numerical solution of the separable model is easy, since the reduced-form equations are explicit with a profit function and so are the demand equations. If the production side is a linear program, a simplex-type algorithm must be used. If the model is nonseparable, and some prices thus endogenous, the system of reduced-form equations is nonlinear. It can be solved either with a nonlinear equations package or by log-linearizing the model around the initial base point. In the latter case, only small changes around the base point can be simulated. However, it has the advantage of requiring only inversion of the matrix of endogenous variables coefficients, an operation that can be done on a spreadsheet.

6.7. Intertemporal Household Models

The analyses of household models in previous sections have all concerned choices within one unit of time as function of assets, prices, and household characteristics of the same period. An important other class of household behavior models relates to decisions over time. Consumers have characteristics such as family size and composition that change over time and justify an optimal intertemporal pattern of consumption. Hence, when the life-cycle income flow does not correspond to this desired consumption pattern, or when income fluctuates with external shocks, individuals try to "smooth" their consumption through borrowing and lending and through insurance mechanisms. If, however, this ex post smoothing is difficult to achieve, individuals then adopt income strategies which match as closely as possible their desired consumption path. When ex post consumption smoothing is feasible, there is separability between production and consumption akin to what we found in static models. When imperfect insurance or credit markets prevent perfect smoothing, separability breaks down as production decisions are affected by the desired pattern of consumption (Besley, 1993; Deaton, 1992a).

6.7.1. Basic Intertemporal Consumption Model under Certainty: Life-Cycle Model

The simplest intertemporal model, the life-cycle model, explains how consumption and savings evolve over the life-span of individuals and households. We assume that the individual lives T periods, receives an exogenous flow of income y_t, for $t = 1, \ldots, T$, and that he has the possibility in any year t to save or borrow at an interest rate r. We assume that he starts with an endowment A_0 and that he is not allowed to be in debt at the end of his life. If we abstract from bequest motives, then assets A_T will be equal to zero at the end of his life. The intertemporal utility of a stream of consumption c_t is assumed to be additively separable in its arguments and take the form:

$$u(c_1,\ldots,c_T)=\sum_{t=1}^{T}\frac{1}{(1+\delta)^{t-1}}u(c_t,z_t),$$

where z_t are variables that affect the desired level of consumption, and δ is the discount rate. The discount rate measures the impatience of consumers, in the sense that consumption in the future is given less weight than consumption now, with a decline in weight of $1/(1+\delta)$ for each additional period.

The consumer problem is to choose the optimal level of consumption, and correspondingly of savings or borrowing s_t, that maximizes his utility:

$$\begin{aligned}
&\underset{c_t}{\text{Max}}\sum_{t=1}^{T}\frac{1}{(1+\delta)^{t-1}}u(c_t,z_t),\\
&\text{s.t.}\quad c_t=y_t-s_t,\\
&\qquad A_t=(A_{t-1}+s_t)(1+r),\\
&\qquad A_T=0,
\end{aligned}$$

where A_t represents assets at the end of period t. The second condition represents the evolution of assets, with savings s_t (borrowing, if negative) combining with previous asset holdings and earning an interest rate r.

Substituting y_t-c_t for s_t in the second constraint and replacing $A_{T-1},\ldots,A_1$ by their expression gives the life-time budget constraint:

$$\sum_{t=1}^{T}\frac{c_t}{(1+r)^{t-1}}=A_0+\sum_{t=1}^{T}\frac{y_t}{(1+r)^{t-1}}.$$

The left-hand side of this expression is the sum of the discounted value of all future consumption, also called the *net present value* of the stream of consumption c_t. The right-hand side is similarly initial assets plus the net present value of the stream of income y_t. What this unique constraint expresses is that, when there is no constraint to saving or borrowing, the only budgetary constraint that applies to consumption is that the total value of consumption over the whole life-time (with yearly value properly discounted) is equal to the total resources available to the consumer. Maximizing utility subject to this life-time budget constraint gives:

$$u'(c_t,z_t)=\left(\frac{1+\delta}{1+r}\right)u'(c_{t+1},z_{t+1})=\left(\frac{1+\delta}{1+r}\right)^{t-1}\lambda,$$

where λ is the Lagrange multiplier associated with the life-time budget constraint (Deaton, 1992a). This says that if the discount rate δ is equal to the interest rate r, marginal utility of consumption should be constant over time. Hence, consumption in any period depends on the life-cycle characteristics z_t but not on current income y_t.

6.7.2. *Permanent Income Model under Income Uncertainty*

When income is uncertain, the standard approach is to replace utility by expected utility, so that the first-order conditions become:

$$u'(c_t, z_t) = \left(\frac{1+\delta}{1+r}\right) Eu'(c_{t+1}, z_{t+1}).$$

This last expression links consumption in year t to expected consumption in year $t+1$. It shows that expected consumption in year $t+1$ only depends on the evolution of life-cycle variables z, and not on the income or wealth in period t or earlier, once c_t is known (Deaton 1992a). In the particular case of a quadratic utility function,

$$u(c_t) = -\frac{1}{2}(\bar{c} - c_t)^2,$$

and a discount rate δ equal to the interest rate r, the optimal consumption path is given by:

$$c_t = f(r)\left(A_t + \sum_{k=1}^{T-t} \frac{Ey_{t+k}}{(1+r)^k}\right).$$

This expression shows that consumption at time t only depends on the expected life time wealth at time t, which is composed of wealth at time t and the discounted expected flow of income over the future. Consumption is therefore sensitive to any "permanent" change in income, but not to fluctuations or transitory income variations. By the same token, all "transitory" income should be saved.

6.7.3. Liquidity Constraint and Household Strategies to Mitigate Risk

Suppose that borrowing is limited ($s_t \geq -b_0$) and that asset levels must always be non-negative ($A_t \geq 0$). This liquidity constraint implies that the maximum the consumer can spend is his cash in hand, the sum of assets and current income. The liquidity constraint alters fundamentally consumer behavior. First, when the liquidity constraint is binding, consumption is below the optimal level that a nonconstrained consumer would have chosen. This contradicts the permanent income model, and one should observe a relationship between current income and consumption. Second, even if the constraint is not binding on one particular year, the risk that the borrowing constraint might bind in the future induces consumers to save and accumulate assets in provision for such eventualities. Without access to insurance or external credit, consumers must provide for this by accumulating additional assets. It can be shown that increasing variability of future income increases the rate of savings.

Households facing a potential borrowing constraint resort to a wide range of mechanisms beyond savings to mitigate risk. Alderman and Paxson (1992) usefully classify possible strategies into risk management and risk-coping strategies. Risk management strategies are actions undertaken by households to reduce the variability of income. In agriculture, this might include landholdings fragmented in scattered plots, crop diversification, and choice of less risky techniques. Households can also reduce income risk by engaging in diversified activities, participating in the labor market, or through the migration of certain family members. Some contracts such as sharecropping reduce the cost of risk through risk sharing, while others protect households from extreme adversity through limited liability clauses. Risk-coping strategies are ex post actions that smooth consumption given income shocks. Households can spread their income risk intertemporally through savings management as discussed above, or engage in relationships with other households to spread their income shocks across households at any given point in time. Intertemporal smoothing is accomplished through lending and borrowing in formal or informal financial markets, accumulation and sales of assets, and storing of goods for future consumption. Risk sharing across households occurs through formal institutions such as crop insurance, or through informal arrangements of mutual insurance, state-contingent transfers, and gifts among friends and neighbors.

Although it is easier to conceptualize these mechanisms as sequential, the household's decision on how much risk management to do depends on its risk aversion and its ability to smooth consumption through risk-coping mechanisms. Not having access to perfect consumption smoothing techniques forces the household to modify its income generation strategy. Hence, a liquidity constraint breaks the separability between consumption and production decisions over time in intertemporal models as it does in static models.

6.7.4. Empirical Evidence on Risk Coping and Risk Management

Tests of the liquidity constraint and measurements of its impact on production and consumption decisions have recently received considerable attention. A number of studies have tried to directly test for the permanent income model by regressing consumption or savings on a measure of permanent income. The main challenge in this type of analysis is to properly distinguish between the permanent and transitory components of income. Using weather variability as the main determinant of transitory income, Paxson (1992) finds that shocks to the income of Thai farmers are largely saved, although she rejects the strict version of the permanent income hypothesis. Alderman (1992) also finds substantial evidence of consumption smoothing among Pakistani farmers, although to a lesser degree by poorer households.

Alternatively, the ability to smooth consumption can be tested directly from the observation of consumption patterns over time, as derived from the relationship established between marginal utilities above. Using this method on Indian panel data, Morduch (1992) finds contrasts among income groups, with evidence of a borrowing constraint and imperfect consumption smoothing for the landless and small farmers in most villages, but not for the richer farmers.

A perfect risk-sharing mechanism among members of a community would imply that all the households pool and redistribute among each other the fluctuations affecting their income. This does not mean that consumption will be perfectly smooth over time, but that it is protected from households' idiosyncratic shocks and is only affected by the group-level fluctuations in income. In particular, where households in the same community face similar production risks, output price risks, and consumer prices, there is little scope for insurance at the community level. A strong empirical implication of the full risk-sharing model is that controlling for community changes in consumption, the consumption and the income of an individual will not be correlated. Perfect sharing is most likely impossible to achieve because of the intrinsic limit imposed by opportunistic behavior. However, it is still interesting to see whether consumption patterns evidence some degree of sharing. An important issue for these studies is to define the appropriate community: is it the village, a subgroup within the village, the ethnic group, or the family with geographically dispersed members? Empirical analyses include Townsend (forthcoming) and Morduch (1991) for India, Alderman and Garcia (1992) for Pakistan, Deaton (1992b) for Côte d'Ivoire, and Udry (1990) for Nigeria. All these studies reject the full insurance model, but many of the results are consistent with some degree of risk sharing.

A different approach has been taken by Udry (forthcoming), who directly tests for the presence of partial risk sharing attached with one specific transaction: lending-borrowing interpersonal transfers. His findings support the hypothesis that credit contracts have state-contingent repayment obligations, according to which a borrower will repay less if he is facing a negative shock and more if it is the lender who is facing a bad shock.

The hypothesis of risk management behavior by households predicts that income-generating decisions are influenced by risk aversion and consumption decisions if there is a liquidity constraint that prevents ex post optimal consumption smoothing. The main empirical difficulty here is to identify whether the household is constrained or not and the tightness of this constraint. This is similar to what we have seen in the static model where what influences production decisions is the amount of available liquidity if the constraint is binding, or equivalently the shadow price of the liquidity constraint. Furthermore, in the case of an intertemporal model, decisions are affected by the liquidity constraint not only in the years in which the constraint is binding but also in the other years. Hence, it is really the potentiality of being constrained in the future which should be captured. Following his identification of a class of constrained households, Morduch (1992) shows that potentially constrained households display more crop and plot diversification than do other households. Using the data from the same Indian villages, Rosenzweig and Binswanger (1994) show that households with greater wealth opt for a more risky (presumed more profitable) portfolio of activities.

A final remark concerns the direct interaction that may take place between risk-coping actions and income generation when assets used for saving/insurance mechanisms are also productive assets. This is explored by Rosenzweig and Wolpin (1993) in the same Indian villages where savings for the purpose of hedging against future needs and credit constraints is done via the holding of bullocks. The impact of this is twofold. On the one hand, the fact that these productive assets are used for insurance gives them some extra value beyond their marginal productivity in production. This is like a positive externality, and it induces a higher level of accumulation. On the other hand, any sales made in times of negative shocks have negative consequences on future income and, hence, can increase the severity of future occurrence of negative shocks.

Exercise 6
Household Responses to Price Incentives

In this exercise (file 6HHOLD), we use a separable model to simulate the production and consumption behavior of a landed household and compare it with the behavior of a landless household, where income does not derive from agricultural profit. We also look at one case of nonseparability induced by a labor market failure and show how it affects the responsiveness of the household to crop price increases. This exercise is largely based on a model built by Lau, Yotopoulos, Chou and Lin (1981), with producer and consumer behavior estimated with household data from the Province of Taiwan in 1967-68. The first part of Table 6E.1 gives the parameters of a demand system and a profit function for a household. The demand system is a Linear Logarithmic Expenditure System, which is derived from a translog indirect utility function:

$$p_i c_i = y^* (\alpha_{i0} + \sum_k \alpha_{ik} \ln p_k + \alpha_{id} \ln A_d),$$

where y^* is the full income of the household, p_k are the prices of the different goods (agricultural commodity, nonagricultural commodity, and home time), A_d is the number of members in the household, and c is the vector of consumption. Note that the restrictions on these parameters are:

$$\sum_i \alpha_{i0} = 1, \ \sum_k \alpha_{ik} = 0, \text{ and } \sum_i \alpha_{ik} = \sum_i \alpha_{id} = 0 .$$

The full income is the sum of profit, the value of the time of all the workers, and exogenous transfers:

$$y^* = \pi + p_l E A_w + S,$$

where p_l is the wage rate, A_w the number of workers, E the total time endowment available per worker, and S net transfers (positive or negative).

The estimated normalized restricted profit function is the Cobb-Douglas:

$$\ln(\pi / p_a) = \beta_0 + \sum_j \beta_j \ln(p_j / p_a) + \sum_k \gamma_k \ln z_k,$$

where the p_j are the prices of the different variable inputs and the z_k are the fixed inputs. In our case variable inputs are labor, animal labor, machine labor, and fertilizer, and fixed inputs are land and capital. The homogeneity constraint is automatically satisfied in this formulation, and the only restriction on the parameters is:

$$\sum_k \gamma_k = 1.$$

Note that the parameter ($-\sum \beta_j$) has been assigned to the price variable p_a in the corresponding cell of the table.

Output supply q and factor demand x_i are obtained by derivation of the profit function as follows:

$$q = \frac{\partial \pi}{\partial p_a} = \left(1 - \sum_j \beta_j\right) \frac{\pi}{p_a} = (1 + \beta_a) \frac{\pi}{p_a}$$

and

$$x_j = -\frac{\partial \pi}{\partial p_j} = -\beta_j \frac{\pi}{p_j}.$$

Exogenous variables include the structural characteristics of the household (number of dependents and number of workers), its endowment of the fixed inputs of land and capital, transfers S, and all the prices. The household used for the first set of experiments has 7.3 members, among which 3.7 are workers, one hectare of land, and NT$43,045 of capital. It receives a negative net transfer of NT$10,000, which corresponds to other income that do not derive from agricultural production net of fixed rent and household savings (considered exogenous in this simplified model). Its profit income of NT$38,690 represents 52% of its full income. It is this

	A/B	C	D	E	F	G	H	I	J	K	L
1	**Table 6E.1. Household response to price incentives**										
2											
3											
4	**Parameter values in equations**										
5		Exogenous variables									
7		Intercept	Agr.	Nonagric.	Wage	Animal	Mechanical	Fertilizer	Number		
8			price	price		labor price	labor price	price	dependents	Capital	Land
9			(Pa)	(Pna)	(wage)	(Panimal)	(Pmech.)	(Pfert)	(Ad)	(K)	(T)
11	Consumption										
12	Agricultural commodity	0.145	0.025	0.042	-0.067				0.063		
13	Nonag. commodity	0.580	0.042	0.139	-0.181						
14	Home time	0.275	-0.067	-0.181	0.248				-0.063		
15	Production										
16	Profit / Pa	10.550	1.112		-0.826	-0.045	-0.020	-0.221		0.072	0.928

		Base household		Subfamily farm	Elasticities for the base household				Family farm	
20	**Observed exogenous values**		Pa +10%	Pa +10%	Pna	Panimal	P fert.	Wage	Base	Pa +10
22	Other income to landed (NT$)	-10000	-10000							
23	Other income to landless (NT$)	28690	28690							
24	Time per worker (days)	365	365							
26	Agric. com. price (NT$/kg)	3.4	3.7							
27	Nonag. com. price (NT$/kg)	26.8	26.8							
28	Home time price, wage (NT$/day)	33.6	33.6							
29	Animal labor price (NT$/day)	46.7	46.7							
30	Mechan. labor price (NT$/hour)	53.2	53.2							
31	Fertilizer price (NT$/kg)	2.3	2.3							
33	Number of workers	3.7	3.7							
34	Number of dependents	7.3	7.3							
35	Quantity of capital (NT$)	43045	43045							
36	Quantity of land (ha)	1.00	1.00							
38	**Endogenous variables**									
41	Landless household									
42	Total time value (NT$)	45377	45377							
43	Full income (NT$)	74067	74067							
44	Consumption:									
45	Agricultural commodity (kg)	4432	4077							
46	Nonagric. commodity (kg)	1250	1261							
47	Home time (days)	759	745							
48	Labor supply (days)	592	606							
51	Landed household									
52	Producer model									
53	Profit (NT$)	38690	47317							
54	Production (kg)	24033	26720							
55	Labor demand (days)	951	1163							
56	Animal labor (days)	37	46							
57	Mechanical labor (hours)	15	18							
58	Fertilizer (kg)	3718	4547							
60	Full income (NT$)	74067	82694							
61	Consumption:									
62	Agricultural commodity (kg)	4432	4552							
63	Nonagric. commodity (kg)	1250	1408							
64	Home time (days)	759	831							
65	Total labor supply (days)	592	519							
67	Marketed surplus (kg)	19601	22169							
68	Net market labor supply (days)	-359	-644							

	B	C	D	E	F	G	H	I	J	K	L
69	**Table 6E.1. Household response to price incentives (cont.)**										
70		Base household		Subfamily farm		Elasticities for the base household				Family farm	
71			Pa +10%		Pa +10%	Pna	Panimal	P fert.	Wage	Base	Pa +10
72											
73		Comparing columns									
74			D to C	E to C	F to E	G to C	H to C	I to C	J to C	K to C	L to K
75	Growth rates in production										
76	Production		11.2								
77	Labor demand		22.3								
78	Profit		22.3								
80	Growth rates in consumption										
81	Landless household										
82	Agricultural commodity		-8.0								
83	Nonagric. commodity		.9								
84	Home time		-1.9								
85	Labor supply		2.4								
87	Landed household										
88	Agricultural commodity		2.7								
89	Nonagric. commodity		12.6								
90	Home time		9.6								
91	Marketed surplus		13.1								
92	Net labor supply		79.2								

relatively large share of full income which clearly qualifies the household as a peasant household. Remember that the profit income does not include the value of the household labor, even when working on its own land, but rather is a concept of return to the fixed factors only. In each simulation, we will compare two households, a landless household and a landed household. The two households have the same characteristics and, in particular, the same initial income. However, for the landless household all nonlabor income is constant, while the landed household earns part of its income from profits. The transfer S for the landless household is set to NT$28,690, which is equal to the initial value of profit and transfer of the landed household in order to make them perfectly comparable. This is entered in row 23.

From this set of equations and the exogenous variables, one can simulate the decisions of the household in production and input demand, and in consumption and labor supply. The first block of endogenous variables gives those of the landless household. The next block gives the behavioral variables of the landed household, decomposed into production and consumption. Profit, production, and input demand are first calculated using the formulae above. The full income is then calculated as the sum of the profit, the value of time available to the household, and transfer (other income). Consumption of agricultural and nonagricultural commodities and of home time is then derived. Labor supply is the complement of home time in total time. Marketed surplus of agricultural product is calculated as the difference between output and household consumption, and net labor supply as the difference between total labor supply by the household and demand for labor for production on its own land.

Experiments can be conducted by copying the set of exogenous variables and equations of the first column into adjacent columns and modifying exogenous variables.

1. Agricultural Price Increase

Suppose the price of the agricultural product increases by 10%. What would be the increase in supply? What would be the change in consumption? Compare the results given by the landless household model and by the landed household model. With this landed household, you should see that the income effect may dominate the price effect, resulting in an increase of consumption of agricultural products concurrent with a rise in price. Use rows 73 to 91 to compute percentage changes in production and consumption.

By changing the endowment of the household, one can reduce the importance of its profit income. In the third column repeat a base calculation for a household owning only 0.4 ha of land and NT$17,218 of capital, and in the fourth column simulate the 10% agricultural price increase for this last household. Make sure to compare this subfamily farm to a landless household of the same income. For that purpose, reset the landless household transfer S at its new value. The consumption of agricultural goods by the subfamily farm should decline in response to a price increase, as it would for a landless household, although to a lesser extent. Be careful, in rows 73 to 91, to compute the percentage change between column F and column E.

2. Price Elasticities

For the base household types, calculate and compare the price elasticities of consumption with respect to the price of nonagricultural products, the wage, and the input prices for animal labor and fertilizer.

3. Marketed Surplus

Analyze the elasticity of marketed surplus with respect to the agricultural price. From the first two columns, you can compute the elasticity of marketed surplus for the original household. Explain why it is larger than the production elasticity. Save your file, as you will soon be modifying this model.

Suppose now that the household has a very low supply elasticity, a large share of production used for home consumption, and a low (absolute) consumption price elasticity for the agricultural product. As a result, an increase in price will induce a small increase in production, an increase of income due principally to the value increase of the crop, and a strong increase in consumption. This may result in the "perverse" effect of a decline of the marketed surplus. To simulate this, you must change the parameters of the model. Note that the direct price elasticity of consumption of the Linear Logarithmic Expenditure System is:

$$\frac{p_i}{c_i}\frac{dc_i}{dp_i} = -\left(1-\alpha_{ii}\frac{y^*}{p_i c_i}\right).$$

To decrease the price elasticity of consumption of the agricultural product with respect to its own price, increase the parameter α_{ii} from 0.025 to 0.260. Adjust the intercept α_{i0} to 0.720 to increase the initial level of consumption. Modify the supply elasticity. As the elasticity with respect to p_a is the sum of the cross-price elasticities, you must change them as well. Try different values that will decrease the agricultural price elasticity to about 0.2. Then, adjust the intercept until the base value of profit is equal to the initial value of NT$38,690. You can compute the base equilibrium for this household in the first column and simulate a price increase of 10% in the second column. Explain the negative change in marketed surplus by analyzing the share of home consumption in production and the changes in these two quantities.

Save this file under a different title than your first, as it has different parameters.

4. Missing Market for Labor

Retrieve the file with the original set of parameters. Define in column K a landed household that is exactly self-sufficient in labor. We suggest starting this from the base household of column C and proportionately decreasing capital and land until labor demand is equal to labor supply. Simulate the impact of a 10% increase in the agricultural price in column L and in the nonagricultural price in column M. When the price of agriculture increases in column L, labor demand increases. The household is thus forced to hire workers from outside. Conversely, when the price of the nonagricultural good increases, home time decreases, labor supply increases, and the household sells some labor on the labor market. Suppose now that the household does not use the labor market. This implies that the household adjusts its behavior to maintain the equilibrium between demand and supply of labor. This constrained behavior can be replicated by using a shadow price for labor which adjusts and acts as a market price to influence the household's behavior. To perform this simulation, first copy columns L and M into new blank columns N and O. Calibrate the shadow wages until supply and demand for labor are in equilibrium. Compare the behavior of this household with a missing labor market and that of the household with perfect markets. Under conditions of missing market, the increase in agricultural price induces a decrease in agricultural production, not an increase. Explain why this occurs. Contrast this behavioral response to that induced by an increase in the nonagricultural price on these two households.

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