Household Inventories and Marketed Surplus in Semi-Subsistence Agriculture

by

Mitchell A. Renkow

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Approved By:

Walter N. Thurman	[illegible]
Michael K. Wohlgenant	Gerald A. Carlson
	Chairman of Advisory Committee

Abstract

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A theoretical model of semi-subsistence agricultural households was developed which explicitly accounted for the ability of households to store key food staples over the period between harvests. First order conditions for the model yielded a simple inventory demand equation in which carryout stocks are a linear function of current consumption of the stored commodity and the difference between its current and expected prices. These were interpreted as indicators of the strength of arbitrage and food security motives for holding stocks.

Applying an appropriate single-equation technique to panel data from three villages in southern India, inventory demand equations for five groups of stored food staples were econometrically estimated. In each village households were grouped according to wealth status, with separate regressions being estimated for each village-commodity-farm type combination. In all villages, food security motives generally dominated arbitrage motives in determining the level of inventory demand. Empirically significant arbitrage motives were found to exist only in the poorest of the three villages.

These econometric results corroborated hypothesized

inter-village differences in the motives for holding inventories of staple foods, namely that food security motives are positively related to the harshness of the agro-climatic environment and that the strength of arbitrage motives is inversely related to the availability of cash cropping alternatives. The empirical evidence was mixed concerning the importance of food security motives within villages.

Comparative statics analysis based on the theoretical model yielded a new method for calculating own-price elasticities of demand and marketed surplus for stored commodities. It was shown that in addition to conventional substitution and income effects, stocks and expected revenue from future production will have wealth (or profit) effects on current consumption. It was further demonstrated that stocks affect the own-price response of marketed surplus through their effects on consumption and via the price response of inventory demand. Using the derived methods, seasonal own-price elasticities of demand and marketed surplus for stored commodities were computed. To do this, the parameters of commodity demand were econometrically estimated using a Rotterdam model. These were then combined with the estimated structural coefficients of inventory demand and outside estimates of output supply response. In two of the three study villages profit effects were sizeable. Seasonal differences in the computed demand elasticities were generally rather small, but seasonality in the relative magnitude of stock effects and production effects was pronounced. Where the share of stocks in perceived household wealth was quite large, profit effects were strong enough to cause demand elasticities to be positive.

Computed marketed surplus elasticities were quite variable, both within and across villages. In several instances -- the same ones for which demand elasticities were positive -- these were found to be negative. While the possibility of backward-bending market supply curves in semi-subsistence agriculture has long been recognized as a theoretical possibility, they have seldom been observed in empirical analyses. The finding of negative marketed surplus elasticities for a rather large proportion of the households considered is therefore noteworthy.

A comparison of the elasticities computed using the methods developed here with those computed using a more traditional methodology revealed that the traditional method yields larger elasticities for both commodity demand and marketed surplus. This is largely attributable to the inclusion of stock effects in the new method. In several cases, these differences were dramatic, the most important being that all marketed surplus elasticities calculated using the earlier method are positive.

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Finally, this study is dedicated with love and affection to my parents, Joe and Margie Renkow.

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Chapter 1

SEMI-SUBSISTENCE AGRICULTURE

Two features characterizing nearly all developing countries are that most agricultural households produce a significant portion of the staple foods that they consume and a large proportion of staple foods entering marketing channels is produced by such households. This seems to be the case across a wide cross-section of geographical locations, levels of technological advancement, and land tenure arrangements. How these households allocate output of staple foods between domestic consumption and market sales is a question that has been the subject of considerable analysis by economists, one that has important implications for the determination of aggregate market supply, food disappearance patterns, and the attendant nutritional consequences for rural and urban dwellers.

Farmers in developing countries (as elsewhere) reap a limited number of harvests -- in many cases only one -- per year. A fruitful way to begin examining this issue of how agricultural output is allocated between various uses is to pose the following question: How do farmers in developing countries ensure that their everyday household consumption requirements are met in the face of once- or twice-yearly production of food staples?

There would appear to be a number of possible answers to this question. One is that at the time of harvest all output -- including both staple food and cash crops -- is sold, and then over the course of the year households purchase food in the marketplace as the need arises. This might be termed purely commercial agriculture, a scenario characteristic of agriculture in developed nations but unlikely to be observed in most developing country settings.

Another possibility is that farmers grow only enough food to meet household consumption requirements until the next harvest or, obversely, consume only that amount of food that they are able to produce themselves. In this scenario, consumption flows might be maintained through the steady drawing down of inventories of harvested food. At the same time, harvests might be drawn out over an extended period with some storage of food in the ground occurring -- an example being the delayed harvest of manioc and other root crops in many parts of Africa. This type of pure subsistence agriculture is likely to exist only in the most primitive areas in which markets for basic staples are practically non-existent.

Agriculture in most areas of most developing countries is best characterized as lying somewhere between the purely commercial and purely subsistence scenarios sketched above, and has been termed semi-subsistence agriculture by a number of authors [Nakajima; Strauss (1984)].[1] Semi-subsistence

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[1] Other authors -- e.g. Behrman and Murty (1985) -- have used the term "near-subsistence" agriculture in this context.

farm households satisfy some if not all of their consumption of basic staples via their own productive activities. In many instances staple food crops are grown both to satisfy subsistence and to generate income (through market sales) with which to purchase other consumption goods and inputs into the production process. Such sales of "marketable surpluses" of own-produced food crops might occur all at once (e.g. immediately after harvest) or they may be staggered over time, and income received in this way may or may not contribute significantly to total household income relative to other income-producing activities (e.g. sales of cash crops and off-farm labor).

The specific form that a semi-subsistence agricultural household's economic behavior takes -- that is, where it lies on the continuum between purely commercial and purely subsistence agriculture -- will be conditioned by two fundamental constraints. The first is the market environment in which it operates -- how certain it is of its ability to buy and sell what it wants when it wants, the proximity and accessibility of local markets to its farm, institutional constraints on marketing channels, and the like. The second constraint lies in its ability to store staple foods -- the availability of on-farm or village storage capacity, the opportunity costs of storage, and the storability of the produced commodities (including the incidence of pests and other factors contributing to storage losses).

The central working hypothesis underlying the present study is that any attempt to explain the economic behavior of semi-subsistence farm households must be based on an understanding of the nature of these constraints as faced by the particular households under observation. Moreover, the various activities related to the production, consumption, storage, and marketing of staple foods grown by such households must be analyzed together in order to come up with satisfying answers to questions concerning the timing and level of both consumption and market sales of those foods. The reason for this latter assertion is simply that an action regarding any one of the activities listed above will necessarily affect one or more of the others as well.

In the pages that follow, a framework for jointly analyzing the production, consumption, storage, and marketing of staple foods in the context of semi-subsistence agriculture is developed. Within this framework, the economic behavior of a number of agricultural households located in three villages in semi-arid tropical India is analyzed. The analysis focuses on two sets of questions having to do with the inventory-holding behavior of these households. First, what are the determinants of household inventory demand and how do these determinants vary between villages and across different socio-economic groups within villages. Second, what is the precise nature in which inventory demand interacts with other observable household activities such as consumption and marketing of staple foods, and how is the responsiveness of these other activities to price and policy variables modified by the existence of household inventories.

1.1 Household Inventories in Semi-subsistence Agriculture

Two factors may be surmised as motivating farm households to hold onto some of their output of staple foods rather than selling it all immediately after harvest. The first is related to possible risk aversion of farm households with regard to food consumption and may be termed a food security motive. Households decision-makers might want to minimize their reliance on markets for the satisfaction of basic food needs and hold stocks of food as a contingency against potential supply disruptions over which they have no control. Likewise, food stocks might be held as a form of insurance against drought or other natural phenomena which would adversely affect future harvests in their own fields.

A second possibility is that inventories of own-produced food staples are the result of speculative profit-seeking behavior on the part of household decision-makers perceiving opportunities to take advantage of intra-seasonal price movements for a particular storable commodity. It has been widely noted in a number of developing countries that market prices of basic staples typically follow a saw-toothed pattern in the period between harvests, with prices at their lowest in the period immediately following harvest and steadily rising until the next harvest (Lele and Candler; Keeler, et al.) Subject to limitations on on-farm storage capacity and storage costs, such price movements may well give rise to arbitrage opportunities that would influence the timing of market sales.

To the author's knowledge, no work concerning household inventory demand in developing countries exists in the literature. A likely reason for this is that inventory data is notoriously difficult to obtain. While the existence of household inventories of staple foods are often acknowledged, it is generally assumed that such stocks do not vary from year to year. If one's focus is on year-to-year changes in consumption and marketing, then such an assumption is both plausible and useful. If one is interested in a more temporally disaggregated view of consumption and marketing, however, this assumption may no longer be tenable.

The present work borrows from theoretical microeconomic studies of inventory demand by Holt, et al., Belsley, and Blinder, as well as from the empirical treatments found in Thurman (1985) and Wohlgenant. At the core of these studies is the idea that observed demand for carryout inventories is the result of an agent's trading off between costs and benefits of holding inventories. The costs include both the physical and opportunity costs of storage, while the benefits include perceived arbitrage opportunities and the value of having stocks on hand when one wants them.

1.2 Marketed Surplus Response

A major focus of much of the research on semi-subsistence agriculture has been on the estimation of the response of marketed supply (or "marketed surplus") of foodgrains to prices and other exogenous variables. Typically, analyses have begun with an identity setting marketed surplus equal to the difference between output and consumption. Differentiation of this identity and some algebraic manipulation then allows the elasticity of marketed surplus with respect to a variable of interest to be expressed as a function of the output and demand elasticities with respect to that variable.

Due to a lack of time series data on marketed quantities, early work relied on estimates of output and demand response drawn from existing research in order to estimate marketed surplus elasticities (Krishna (1962); Behrman). Later work used cross-sectional village-level data to estimate marketed surplus response directly (Bardhan; Haessel; Toquero, et al.). More recently, Strauss (1984) criticized previous work as being flawed either because consumption demand was assumed to be completely inelastic (Behrman, Krishna), or because output was assumed to be fixed (Bardhan, Haessel, Toquero, et al.). Using cross-sectional household data from Sierra Leone, he estimated the marketed surplus elasticities of several outputs (including family labor) with respect to price and non-price variables. Strauss' analysis represents a distinct improvement over earlier efforts because it accounts for the additional income effects on consumption and marketed surplus caused by a price-induced change in farm profits.

Implicitly, all work on marketed surpluses to date has assumed that households costlessly store exactly the amount of home-produced staple foods allocated to home consumption over the period between harvests. Arguably, this is a relatively harmless simplification, especially if the marginal cost of storage is low. A more serious conceptual problem, however, is that existing models take consumption, output, and sales as occurring simultaneously. Thus, a change in the price of a commodity that is produced by the household affects marketed surplus through its impact on both contemporaneous consumption and production. This is not normally the case, however; rather, the output from which marketed surplus is drawn is generally predetermined and exists in the form of currently held inventories which have been either carried over from an earlier period or recently harvested. The value of stocks on hand and expected _future_ output may well influence current marketing decisions, but only through wealth effects on consumption.

The analysis to be conducted here accounts more carefully for the timing of activities undertaken by semi-subsistence households in regard to the production and disappearance of staple foods. Whether or not this extra attention yields markedly different estimates of marketed surplus elasticities is one of the important empirical questions to be addressed.

1.3 Agricultural Household Models

The theoretical model to be developed and tested here follows in a long tradition of household-firm models as applied to subsistence or semi-subsistence households. The essence of this class of models is that both the consumption and production activities of such households are incorporated into a single analytical framework. Typically, households are modeled as maximizing household utility subject to constraints on allocation of time, production technology available to them, and sources and uses of funds (a budget constraint). Solution of these models yields results that differ somewhat from those of standard microeconomic analyses. In particular, the comparative statics implications for price response of demand for home-produced commodities are different since income effects are modified to include the effect of a price change on farm profits.

Household-firm models date back at least as far as the 1920's. At that time, the operation of peasant farms was much studied by a number of Russian agricultural economists, notably A.V. Chayanov. Using the principles of marginal analysis, Chayanov (1925) demonstrated that simply maximizing profits was not an optimal strategy for Russian peasant households because virtually no rural labor markets existed at that time. Instead, he argued, each household operated at a subjective equilibrium equating the marginal utility of consumption with the marginal utility of leisure.

The concept that peasant households have a subjective equilibrium which is jointly determined by underlying behavioral parameters describing both utility and technological relationships was developed further by a school of Japanese economists in the 1950's and 1960's. Foremost among these was Nakajima (1969) who formulated a number of models of different types of peasant households, ranging from complete self-sufficiency to complete commercialization. One of these models -- that of the "semi-subsistence" family farm consuming some but not all of its own output -- has been the theoretical basis of most work in this area in the past twenty years.

A paper presented by Jorgensen and Lau at an Econometrics Society meeting in 1969 was seminal with regard to empirical analysis of this class of models. Jorgensen and Lau were the first to demonstrate formally that the production decisions of a semi-subsistence household will be made independently of consumption and labor supply decisions so long as (a) complete markets exist for all commodities that are both produced and consumed and for all inputs used in production; (b) the household is a price-taker in all product and factor markets and there are no taxes or transactions costs attached to market activities; and (c) family and hired labor are perfect substitutes. The reverse is not true, however, since production outcomes will affect consumption and labor supply through income effects attributable to profits from farming. This result has greatly expedited empirical analysis since the recursiveness in household decision-making means that demand and supply side parameters may be consistently estimated independently of one another. Of course, this is not the case if any of the necessary conditions for recursiveness fail to hold -- e.g. if the agricultural labor market is absent or incomplete. However, practically all empirical analyses to date have maintained that recursiveness holds.[2]

Numerous empirical applications of household-firm models have been conducted over the past ten years. The best known of these (Lau, Lin, and Yotopoulos; Barnum and Squire) used linear expenditure systems to model household commodity demand, and equally simple functional forms -- Cobb-Douglas production function for the latter, a normalized restricted profit function for the former -- to model the supply side. All studies have employed cross-sectional

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[2] An exception is a paper written by Lopez (1986) in which he estimates a non-separable model of Canadian family farms. The source of non-separability in his model is imperfect substitutability of household and hired labor.

data that has been highly aggregated with regard to commodities considered and/or households. Strauss (1982a, 1982b, 1984) used household data from a cross-section of households in Sierra Leone and a quadratic expenditure system. In a nested test, his data strongly rejected the linear expenditure system. Strauss also incorporated a wide range of demographic variables into his analysis to account for inter-household differences in socio-economic characteristics.

The focus of the empirical studies cited above was on estimating the elasticities of demand and supply with respect to price and non-price variables. Strauss' work in particular stands out in its careful attention to the wealth effect (or "profit effect" in his parlance) of farm profits on both commodity demand and marketed surplus sales. If strong enough, this profit effect could actually give rise to positive own-price response of demand for a home-produced commodity over some ranges of prices, even if the commodity is normal. This might occur if, for example, an individual household had a good harvest of a staple food crop for which the price was unusually high (say, because of a widespread drought affecting most other farmers). In this event, the profit effect might dominate normal income and substitution effects in consumption and lead to a situation where higher prices were accompanied by more consumption.

The focus of research based on household-firm models has broadened considerably of late. A recent World Bank publication (Singh, Squire, and Strauss) contains a collection of papers addressing such diverse issues as multiple cropping, production risk, health and nutrition, and credit. The diversity of topics contained in that volume highlights the flexibility of the household-firm framework in modeling the behavior of agricultural households in developing countries. The present study represents yet another extension of this analytical framework by explicitly considering household inventories of important staple foods.

1.4 Organization of the Study

This study consists of six chapters. In the next chapter a theoretical model is proposed which describes the general household allocation problem of a representative semi-subsistence household. The model lies firmly within the tradition of the household-firm models discussed above, but represents a departure from these models in that it explicitly incorporates inventory holdings as elements of the household decision-making process. Explicit consideration of inventories adds an inter-temporal dimension to the model whereby price expectations assume an important role. The model's solution provides a basis for measuring the determinants of household inventory demand. Also in Chapter 2, expressions describing the own-price response of consumption demand and marketed surplus sales are analytically derived.

These expressions are examined against comparable (but quite different) expressions derived from earlier models.

In Chapter 3 a two-step procedure is proposed for empirically testing the theoretical model of Chapter 2. This procedure consists of first using appropriate single equation techniques to estimate one of the first order conditions describing inventory demand, and then combining these results with estimates of the parameters associated with commodity demands and output supplies. The first step allows direct measurement of the relative strength of food security and arbitrage motives for holding inventories, while the second allows computation of the price response of consumption demand and marketed surplus.

Chapter 3 also contains a discussion of the data to be used in the econometric implementation of the theoretical model. Panel data for a number of households in three villages located in southern India is described. Some general features of these three villages -- agro-climatic conditions, the marketing environment, and various socio-economic features -- are discussed. Some summary statistics describing their agricultural economies are presented which lead to the formulation of a set of hypotheses concerning the motives for holding inventories for different classes of households.

Empirical results from the estimation of the inventory demand equations for the three villages are presented in

Chapter 4. Various hypotheses concerning the importance of inventories across differing socio-economic groups and across villages are tested, along with more general tests of the validity of the model. These results indicate that the model performs best in cases where the households involved have limited agricultural options in terms of both the productivity of their land and cash cropping alternatives. Food security motives are found to dominate arbitrage motives for holding stocks of staple foods for the most part.

In Chapter 5, demand systems for each of the three villages are estimated using a Rotterdam model. The parameter estimates are combined with the inventory demand parameters estimated in Chapter 4 and the parameters of output supply functions drawn from existing research to compute uncompensated demand and marketed surplus elasticities. These are then compared with elasticities computed using the methods advocated in the most recent work on semi-subsistence agriculture. This motivates a discussion of the methodological improvement represented by the new formulation.

The concluding chapter summarizes the findings of the study. The importance of including inventory demand into models of semi-subsistence agriculturalists in different locations of the Third World is discussed and likely avenues for future research are suggested.

Chapter 2

AN ECONOMIC MODEL OF SEMI-SUBSISTENCE HOUSEHOLDS

In this chapter a theoretical model of the economic behavior of semi-subsistence farm households is developed. This model follows in the tradition of the household-firm literature described in the previous chapter. A representative household is assumed to maximize a well-behaved utility function subject to a budget constraint, a production function describing the relationship between agricultural outputs and inputs, and identities pertaining to the allocation of harvests and total available time among competing uses.

The key feature distinguishing the current model from previous work is the explicit recognition of the ability of households to store important consumption items (specifically, staple foods). Inclusion of inventories introduces an intertemporal dimension to the model whereby price expectations assume an important role. Thus, the household's problem is cast here as a dynamic one, in which the maximand of the objective function is the expected present value of the household's current and future utility (until the end of an arbitrary planning horizon). The budget constraint is augmented to include the cost of holding inventories, and a stock identity is introduced as a new constraint.

First order conditions for the model suggest a method of empirically distinguishing between food security and profit motives for holding inventories. They also indicate which variables will appear as arguments of the household's Marshallian demand functions. Second order conditions demonstrate the independence of production from the rest of the household's allocation problem given the model's underlying assumptions regarding the exogeneity of prices, factor substitutability, and risk.

Finally, a new method is introduced for estimating the responsiveness of commodity demands and marketed surplus to both contemporaneous and expected price movements which accounts for the income (or "profit") effects of those movements. The formulae that are derived differ substantially from those found in existing work because the model represents more explicitly the timing of the various activities engaged in by the household and the mechanism by which price expectations are formed.

2.1 Some Basic Assumptions

Consider a representative semi-subsistence household that produces some (or all) of the foods it consumes. It is assumed that the household maximizes the expected (discounted) value of a stream of current and future utilities up to the end of an arbitrary planning horizon. The planning horizon is based on the cropping cycle of the major food staple consumed by the household, and each planning horizon is composed of T+1 periods (0,...,T) extending from harvest to harvest. Moreover, horizons overlap in the sense that period T of one coincides with period 0 of the next.

The one-period household utility function is given by

$$(2.1) \qquad U_t = U(X_{1t}, X_{2t}, X_{3t}, X_{Lt}),$$

where U(·) is twice-differentiable, continuous, quasi-concave, and increasing in all arguments. Utility is assumed to be inter-temporally strongly separable, with the household discounting future utility on the basis of a subjective rate of time preference taken to be constant and equal to the market interest rate. The arguments of the utility function are quantities of commodities and leisure consumed by the household in period t.[3] X_{1t} is a storable home-produced food commodity, X_{2t} is a non-storable home-produced food commodity, X_{3t} is a commodity that the household procures exclusively from the market, and X_{Lt} is leisure.[4] Here, as elsewhere in this study, the subscript t refers to the time period in which the good is consumed.

The household produces three kinds of agricultural products: a storable food crop (Q_1); a non-storable food crop (Q_2) that is either consumed or sold in the period in

[3] For expositional clarity, the model is presented in terms of individual goods. These may be thought of as composites representing various classes of goods, or as vectors of commodities. Regardless of the interpretation, the implications of the model carry through.

[4] A list of the notation used in this chapter is found in Appendix 2.1.

which it is harvested; and a non-storable cash crop (Q_c) of which all output is sold at harvest. Outputs are produced using labor (L), one other variable input (V), and land (A_o). Family and hired labor are assumed to be perfect substitutes, while land is taken as quasi-fixed.

Sources of cash income for the household include sales of agricultural output, off-farm labor earnings, and non-wage exogenous income (Y) from sources such as remittances and gifts. Households are also assumed to be able to borrow at a one-period interest rate r. Household expenditures consist of commodity purchases, storage costs, production costs, and loan repayments. It is assumed that markets exist for all commodities and production inputs, and that the household is a price taker in these markets.

The household is able to store a key staple food. The one-period cost of holding inventories given by the quadratic function

$$(2.2) \qquad C(I_{t+1}, X_{1t}) = a_o + \tfrac{1}{2}f^{-1}(I_{t+1} - g_o - gX_{1t})^2,$$

where I_{t+1} is the quantity of home-produced commodities carried over into the next period, and a_o, f, g_o, and g are parameters. This specification -- discussed in Holt, et al. and Belsley, and more recently employed by Wohlgenant -- posits inventory costs as being composed of two offsetting components. The first is the physical cost of holding stocks, which is increasing in I_{t+1}. The second is the convenience yield the household derives from having stocks on hand with which to satisfy consumption demand. In the production oriented inventory literature this latter component typically refers to the opportunity cost of stock-outs and back-ordering. Here the emphasis is on consumption, but the logic is nonetheless the same: convenience yields may be thought of as the cost of unmet demand for the stored commodity when stocks are exhausted.

In the context of semi-subsistence agriculture, it seems likely that the cost of stock-outs rises more steeply than the physical cost of holding inventories. This would certainly be true if a market for the stored commodity was absent, as then a stock-out would mean doing without. Alternatively, the existence of covariate production risk over a large geographical area might cause marginal stock-out costs to be high, even in the presence of complete markets. In this event, an individual household's poor harvest would tend to be correlated with diminished aggregate supply (and attendant higher prices).

In light of the preceding discussion, equation 2.2 may be regarded as a reasonable approximation to the household's true storage costs. This is demonstrated in Figure 2.1. Inventory holdings are plotted on the x-axis and costs on the y-axis. For positive inventory holdings, storage costs rise in proportion to the quantity held. To the left of the

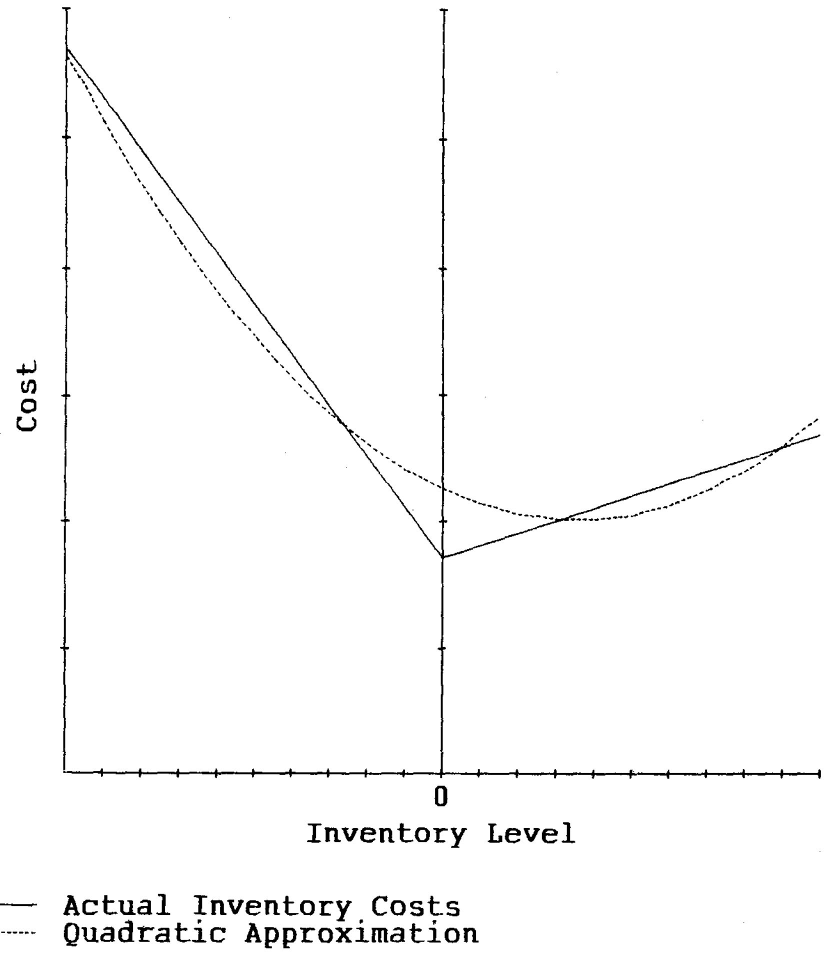

Figure 2.1 Quadratic Approximation of Inventory Cost

y-axis the cost of not having stocks on hand to meet demand rises more steeply. The quadratic specification of equation 2.2 -- shown as a dotted line -- approximates the "true" inventory cost function.

2.2 Objective Function and Constraints

It is assumed that in each period the household attempts to maximize the following objective function:

$$(2.3) \qquad E_t \sum_{s=t}^{T} b^{s-t}[U(X_{1s}, X_{2s}, X_{3s}, X_{Ls})],$$

where $E_t Z_t = E(Z_t | \Omega_t)$ is the mathematical expectation of Z_t conditional on information Ω_t available at time t; $b = (1+r)^{-1}$ is the discount term (assumed to be constant); and T is the terminal period in the current cropping cycle. This objective function is maximized subject to the following six constraints:

$$(2.4) \quad F_t = T^* - X_{Lt}$$

$$(2.5a) \quad M_{1t} = Q_{1t} - X_{1t} + I_t - I_{t+1}$$

$$(2.5b) \quad M_{2t} = Q_{2t} - X_{2t}$$

$$(2.6a) \quad P_{1t}M_{1t} + P_{2t}M_{2t} + P_{ct}Q_{ct} + P_{Lt}[F_t - L_t] + Y_t + B_t = P_{3t}X_{3t} + C(I_{t+1}, X_{1t}) + (1+r)B_{t-1}$$

$$(2.6b) \quad E_t \sum_{s=t+1}^{T} b^{s-t}\{P_{1s}M_{1s} + P_{2s}M_{2s} + P_{cs}Q_{cs} + P_{Ls}[F_s - L_s] + Y_s + B_s - P_{3s}X_{3s} - C(I_{s+1}, X_{1s}) - (1+r)B_{s-1}\} = 0$$

$$(2.7) \quad H(Q_{1t}, Q_{2t} Q_{ct}, \{L\}_1^t, \{V\}_1^t; A_0, \{L\}_0^{t-1}, \{V\}_0^{t-1}) = 0.$$

Equation 2.4 is a time constraint stating that the total time available to the household (T^*) must be allocated either to family labor (F_t)[5] or leisure. Equation 2.5a is a stock identity equating stocks on hand at the beginning of a period (carryin plus new production) to the sum of the uses of those stocks (carryout, market sales (M_{1t}), and current consumption).[6] Equation 2.5b states that non-storable home-

[5] F_t includes both on- and off-farm labor of family members.

[6] Note that depreciation in product value due to storage losses is omitted from this formulation. An alternative would be to assume proportional losses. In this case,

produced goods are either consumed or sold in the period in which they are produced. Note that in any given period a particular M_j may be greater or less than zero, with a positive (negative) value implying that the household is a net seller (buyer) of the commodity. Since $Q_{2t} = 0$ for $t = 1,\ldots,T-1$ (by assumption), the household will be a net purchaser of non-storable commodities in most periods.

Equations 2.6a and 2.6b are budget constraints equating the sources and uses of the household's funds for both the present period and all future periods within the planning horizon. Within a given period, sources of household funds include market sales of the agricultural commodities, net family labor income,[7] exogenous income, and borrowed funds (B_t); uses of these funds include market purchases of consumption items, outlays for hired labor (L_t), inventory holding costs, and loan repayments.[8]

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equation 2.5a would become $Q_{1t} + (1-\delta)I_t = I_{t+1} + M_{1t} + X_{1t}$, where δ is the proportionate rate of depreciation per unit time from storage losses. The only difference this specification would make in the resulting first order conditions would be to replace the discount factor b with $b^* = b(1-\delta)$.

[7] If $F_t - L_t > 0$ then the household is a net supplier of labor to the market and vice versa. No distinction is made here between labor demand for different uses (e.g. labor allocated to different crops).

[8] Note that the model assumes that borrowings must be paid back after one period. The first order conditions are invariant to different term structures, however, due to the assumption of (1) a perfectly elastic supply of loanable funds and (2) equality of the household's subjective rate of time preference and the market rate of interest. Moreover, the model admits of the possibility of households being net lenders; in this case $B_t < 0$.

In addition to the sources of funds found in the current-period budget constraint, the expectational budget constraint (equation 2.6b) contains the discounted expected value of future output. This accounts for the impact planned agricultural output on current consumption. That expected future output is linked to current consumption is due to the existence and availability of borrowed funds. Borrowing opportunities allow the household to meet its budget constraint in each period by borrowing against expected future income, a major component of which is expected agricultural production. In the absence of credit, this linkage would not exist since the household would then have to satisfy its budget constraint out of household earnings in each period.

Finally, equation (7) is an implicit production function which ties together agricultural output and the sequential allocation of inputs into the production process. This is a general formulation which allows for jointness among some subset of inputs and outputs. The production function is assumed to be quasi-convex, non-decreasing in all outputs and non-increasing in all inputs.

2.3 First Order Conditions

Equations 2.3-2.7 above define an optimization problem to be solved in each period by the household. To obtain a solution, first substitute 2.4, 2.5a, and 2.5b into the budget constraints. Next, form the Lagrangian

$$(2.8) \quad J = E_t \sum_{s=t}^{T} b^{s-t}\{U(X_{1s}, X_{2s}, X_{3s}, X_{Ls})\} + \lambda_1 [P_{Lt}(T^* - X_{Lt} - L_t)$$

$$+ P_{1t}(Q_t + I_t - I_{t+1} - X_{1t}) + P_{2t}(Q_{2t} - X_{2t}) + P_{ct}Q_{cT}$$

$$+ Y_t + B_t - C(I_{t+1}, X_{1t}) - P_{3t}X_{3t} - (1+r)B_{t-1}]$$

$$+ \lambda_2 \{E_t \sum_{s=t+1}^{T} b^{s-t}[P_{1s}(Q_{1s} + I_s - I_{s+1} - X_{1s})$$

$$+ P_{2s}(Q_{2s} - X_{2s}) + P_{Ls}(T^* - X_{Ls} - L_s) + P_{cs}Q_{cs} + Y_s$$

$$+ B_s - C(I_{s+1}, X_{1s}) - P_{3s}X_{3s} - (1+r)B_{s-1}]\}$$

$$+ \lambda_3 H(Q_{1T}, Q_{2T}, Q_{cT}, \{L\}_t^T, \{V\}_t^T; A_o, \{L\}_0^{t-1}, \{V\}_0^{t-1}).$$

Differentiation of this Lagrangean with respect to the eleven control variables -- X_{1t}, X_{2t}, X_{3t}, F_t, I_{t+1}, B_t, L_t, V_t, Q_{1T}, Q_{2T}, and Q_{cT} -- yields the following first order conditions:[9]

$$(2.9) \quad U_{1t} - \lambda_1(P_{1t} + C_X) = 0$$

$$(2.10) \quad U_{2t} - \lambda_1 P_{2t} = 0$$

$$(2.11) \quad U_{3t} - \lambda_1 P_{3t} = 0$$

$$(2.12) \quad U_{Lt} + \lambda_1 P_{Lt} = 0$$

$$(2.13) \quad \lambda_2(bE_t P_{1t+1}) - \lambda_1[P_{1t} + C_I] = 0$$

$$(2.14) \quad \lambda_1 - \lambda_2 = 0$$

$$(2.15) \quad -P_{Lt} + (\lambda_3/\lambda_1)\partial H/\partial L_t = 0$$

---

[9] Note that this procedure for solving the optimization problem relies on the first-order certainty equivalence result derived in Malinvaud (1969). There it is demonstrated that as long as the objective function is twice-differentiable and random disturbances of forcing variables (such as prices) have zero means, neglecting these random disturbances (i.e. replacing random variables by their expected values) yields results which, to a first order of approximation, are identical to those for a problem in which there is no uncertainty.

(2.16) $-P_{vt} + (\lambda_3/\lambda_1)\partial H/\partial V_t = 0$

(2.17) $b^{T-t}E_t P_{1T} + (\lambda_3/\lambda_1)\partial H/\partial Q_{1T} = 0$

(2.18) $b^{T-t}E_t P_{2T} + (\lambda_3/\lambda_1)\partial H/\partial Q_{2T} = 0$

(2.19) $b^{T-t}E_t P_{cT} + (\lambda_3/\lambda_1)\partial H/\partial Q_{cT} = 0$

plus the two budget constraints and the production function (equations 2.6a, 2.6b, and 7). Here, C_I and C_X denote the partial derivatives of the inventory cost function with respect to I_{t+1} and X_{1t}, and λ_1, λ_2, and λ_3 are the Lagrange multipliers associated with the current and expectational budget constraints and the production function, respectively.

Given the assumed inventory cost function (equation 2.2), equations 2.13 and 2.14 imply that optimal inventory holdings will be a linear function of the current and (discounted) expected value of the next period's price for the stored commodity and the household's demand for the commodity in the current period.[10] This can be seen by substituting (2.2) and (2.14) into (2.13) and re-arranging terms:

(2.20) $I_{t+1} = f[bE_tP_{1t+1} - P_{1t}] + g_0 + gX_{1t}$.

[10] Note that 2.14 implies that households equate the marginal utilities of current and future income. Browning, Deaton, and Irish derive a similar result in the context of a life-cycle model of household labor supply. In the current model, this result hinges on the assumption that the household's utility rate of time preference (ρ) is equal to the market interest rate (r). In general, equation 2.14 is of the form $\lambda_1 - \lambda_2(1+r)/(1+\rho)$.

This result provides an empirically tractable way of distinguishing between motives for holding inventories which will be a focus of the statistical analysis of Chapter 4. Given suitable data on inventories, consumption, and prices, and a model of how price expectations are formed, estimation of 2.20 will allow an investigation into the determinants of inventory demand, with the parameters f and g indicating the strength of arbitrage and food security motives for holding stocks of key staples.

Taken together, equations 2.9 - 2.12 yield the standard result that at the optimum the marginal rate of substitution between any pair of goods (including leisure) will be equated to the ratio of the prices of those goods. Note however that the full price of the storable commodity includes the marginal convenience yield (C_x) associated with it. The sign of C_x is ambiguous, depending on current demands for consumption and inventories of the produced commodity, and the parameters describing convenience yields (g and g_o).

The nature of the full price of the storable commodity is more readily apparent by expressing the marginal rates of substitution involving the stored commodity solely as functions of current and expected prices. Differentiating 2.2 with respect to X_{1t}

(2.21) $C_x = -gf^{-1}(I_{t+1} - g_o - gX_{1t})$.

Using the expression for I_{t+1} from 2.20 in 2.21 and substituting into 2.9, the marginal rate of substitution between the storable commodity and any other good can be expressed as

$$(2.22) \quad \frac{U_{1t}}{U_{jt}} = \frac{(1 + \kappa)P_{1t} - \kappa b E_t P_{1t+1}}{P_{jt}}, \qquad j = 2,3,L,$$

where $\kappa = g \cdot f^2$. Finally, 2.22 can be re-arranged to yield

$$(2.23) \quad \frac{U_{1t}}{U_{jt}} = \frac{P_{1t} + \kappa b \cdot [rP_{1t} - (E_t P_{1t+1} - P_{1t})]}{P_{jt}}, \; j = 2,3,L.$$

The portion of this expression within the square brackets represents the user cost of a unit of inventory capital (Jorgensen), composed of interest foregone less expected capital gains. Thus the full price of the stored commodity includes its market price and the (possibly negative) marginal cost of stocking it.

Equation 2.22 illustrates how inter-temporal substitution effects may enter into the household's decision-making process. Given that g and f (and therefore κ) are positive and that marginal utility is decreasing in all arguments, a ceteris paribus increase in the (appropriately discounted) expected price of the storable commodity will cause an increase in current consumption of that commodity relative to any other commodity. If either f or g are zero, however, these inter-temporal effects vanish, and 2.2 reduces to the standard case (i.e., $U_{it}/U_{jt} = P_{it}/P_{jt}$).

Equations 2.15-2.19 imply another standard result. The optimal allocation of inputs into the production process is such that the expected value of the marginal product of the input equals its price. Moreover, at the optimum the marginal rate of transformation between any pair of outputs or inputs will be equal to the ratio of their prices.

It is also noteworthy that none of the demand-side control variables appear in 2.15-2.19, a result indicating that the model is recursive. The model's recursiveness is formally demonstrated in Appendix 2.2 through derivation of the second order conditions (equation A1). By inspection, the Hessian matrix of second derivatives is block diagonal, with the upper left block giving the solution for commodity and inventory demands and the lower block giving the solution for output supplies and factor demands.

Examination of equation A1 reveals that consumption and inventory demands depend on all price variables (including expected prices for the stored commodity), while output decisions depend only on factor and expected output prices (and not on preferences, current prices of commodities consumed, or income due to sales of stored food). In other words, decisions made concerning production activities are separable from the other elements of the household's decision-making process (i.e., consumption and inventory management).

This result is one of the trademark features of existing static models of semi-subsistence household, here generalized to a dynamic case. First demonstrated by Jorgensen and Lau (1969), this separability result is directly related to the assumption that the household is a price-taker in all product and factor markets. This, combined with the fact that income from agricultural production contributes positively to household utility, indicates that the household seeking to maximize utility can do no better than maximize the profits resulting from its agricultural activities. Hence, the independent determination of the household's allocation of the resources at its command to crop production.

The practical advantage of this separability result is that it greatly simplifies the empirical estimation of this class of models. If the assumptions necessary to sustain the result hold, then estimating the production and consumption sides of the model separately will yield consistent estimates of the structural parameters necessary to derive elasticities and test hypotheses.

2.4 Comparative Statics

Existing household-firm models have implicitly assumed that households costlessly store exactly the amount allocated to home consumption over the period between harvests. By explicitly considering inventory holding as an element of the household's overall allocation problem, the model developed above represents a significant departure from previous analyses of semi-subsistence households. Inventories add an inter-temporal dimension to the problem, calling attention to the effect of price expectations on both inventory demand and consumption demand.

The current model also treats the timing of the household's economic activities more carefully than previous work. Existing static models take consumption, output, and sales as occurring simultaneously. Thus, a change in the price of a commodity that is both produced and consumed by the household affects marketed surplus through its impact on both contemporaneous consumption and production. This is not normally the case; rather, the output from which marketed surplus is drawn is generally predetermined and exists in the form of currently held inventories and/or recent harvests. Stocks on hand and expected <u>future</u> output will influence marketing decisions, but only through wealth effects on consumption. As will be demonstrated below, highly restrictive assumption on the ability of households to hold inventories and on the way in which price expectations are formed are required in order to justify the analytical approach that has been used to date.

2.4.1 Commodity Demand Response

The first order conditions imply that the Marshallian demand for the storable commodity may be written as $X_{1t} = X_1(P_{1t}, P_{2t}, P_{3t}, P_{Lt}, \hat{P}_{1t+1}, W_t)$ where $W_t = Y_t + \Pi_t + P_{Lt}T^* + P_{1t}S_t$.[11] W_t is an expression for the household's period t wealth which includes exogenous income, expected net revenue from production (Π_t) over the planning horizon,[12] the value of household time, and the value of stocks of the storable commodity on hand ($P_{1t}S_t$)[13] at the beginning of period t.

The own-price response of current consumption of the storable commodity may be written as

$$(2.24) \quad \frac{dX_{1t}}{dP_{1t}} = \left.\frac{\partial X_{1t}}{\partial P_{1t}}\right|_{d\Pi=0} + \frac{\partial X_{1t}}{\partial W_t} \cdot \frac{\partial W_t}{\partial \Pi_t} \cdot \frac{\partial \Pi_t}{\partial P_{1t}}$$

$$= \left.\frac{\partial X_{1t}}{\partial P_{1t}}\right|_{d\Pi=0} - X_{1t} \cdot \frac{\partial X_{1t}}{\partial W_t} + \left(S_t + \hat{Q}_{1T} \cdot \frac{\partial \hat{P}_{1T}}{\partial P_{1t}} + \hat{P}_{1T} \cdot \frac{\partial \hat{Q}_{1T}}{\partial \hat{P}_{1T}} \cdot \frac{\partial \hat{P}_{1T}}{\partial P_{1t}}\right) \cdot \frac{\partial X_{1t}}{\partial W_t}$$

The first two terms of the second equality represent the substitution and income effects found in a conventional Slutsky equation holding Π_t constant. But consumption also

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[11] For notational simplicity, "^" will be used throughout the remainder of this chapter to denote the appropriately discounted conditional expectation formed in period t.

[12] $\Pi_t = E_t \sum_{s=t}^{T} b^{s-t}(P_{1s}Q_{1s} + P_{2s}Q_{2s} + P_{cs}Q_{cs} - P_{Ls}L_s - P_{vs}V_s)$. In actuality, the discounted expected value of <u>all</u> future net revenue ought to be included here. The truncation of this infinite stream at the end of one planning horizon may be rationalized by arguing that discounting reduces the present value of net revenue accrued in subsequent years to an insignificant magnitude.

[13] That is, $S_t = I_t + Q_{1t}$.

depends on an extra wealth effect (or "profit" effect in Strauss' parlance) due to the impact of a price change on the value of stocks on hand and -- to the extent that a change in the current price implies a change in the price expected to prevail at harvest time -- the value of future output of the commodity under consideration. This extra wealth effect will tend to make own-price demand less elastic (or even positive, if sufficiently large).

The portion of the profit effect having to do with the value of future output is somewhat complicated by the presence of the term $\partial \hat{P}_{iT}/\partial P_{it}$. It is included because the relevant price on which production decisions are based is that price expected to prevail at harvest.[14] Depending on the manner in which price expectations are formed, a change in the current price of the commodity may or may not convey information about the price at harvest. At one extreme, if price expectations are static -- as has often been assumed -- then $\partial \hat{P}_{i,t+1}/\partial P_{it} = 1$ and the additional profit effect becomes $\partial X_{it}/\partial W_t \cdot [S_t + Q_{iT} + \hat{P}_{iT}(\partial Q_{iT}/\partial P_{iT})]$. If, on the other hand, a current price change is perceived to be entirely transitory in the sense that it leaves the expected harvest price unchanged, then the profit effect is simply

[14] In the context of the present model the price on which output decisions are based is a function of the prices expected to prevail in each of the periods of the next planning horizon (i.e. throughout the season in which currently planned output will be disposed of). In essence, the price at harvest is being used here as a proxy for this shadow value of output.

$S_t \cdot \partial X_{it} / \partial W_t$.

Equation 2.24 clarifies the relationship between the model which has been developed here and earlier static models best exemplified by that of Strauss (1986). Ignoring both inventories and price expectations, Strauss' analysis implied that the profit effect is simply $Q_{it} \cdot \partial X_{it} / \partial P_{it}$. For periods in which a harvest occurs, if inventories are ignored (hence $S_t = Q_{it}$) and current price changes have no effect on future production, then the profit effect contained in equation 2.24 is identical to that derived by Strauss. If any of these conditions fails to hold, however, the profit effect of the current model will be larger -- as may be observed by simply subtracting the profit effect derived by Strauss from that contained in 2.24. The implication here is that Strauss' analysis tends to overstate the degree to which demand for stored commodities is price elastic.

For non-harvest periods, if price expectations are static, the future is not discounted (b = 1), inventories are ignored, and output is completely price inelastic then the two results are also equivalent. If these conditions do not hold, then the profit effects implied by the two models are different. In this case, Strauss' profit effect may in fact be larger than that of the current model if inventories are small and future output is heavily discounted. In general, though, it seems probable that here too Strauss' model yields own-price elasticities which are greater (i.e. more negative) than those implied by the current model.

That Strauss' model is nested within the current model suggests a means of gauging whether that model has correctly specified demand response for commodities that are both produced and consumed by the household. The earlier model used annual data in which each "period" represented an entire "planning horizon." The argument for ignoring stocks in models like Strauss' is that if inventories carried over from one year to the next are roughly the same, they are effectively "differenced" out of the problem. Here it has been shown that levels (not differences) of inventory holdings may have important wealth effects on consumption. If inventories of stored commodities are an important component of household wealth, as seems likely within the context of semi-subsistence agriculture, then their omission from the analyses such as Strauss' probably leads to an overstatement of the own-price response for such commodities.

2.4.2 Marketed Surplus Response

A major focus of much of the research on semi-subsistence agriculture has been on the estimation of the response of marketed surplus to prices and other exogenous variables. Typically, analyses have begun with an identity setting marketed surplus equal to the difference between output and consumption. Differentiation of this identity and some algebraic manipulation then allows the elasticity of marketed surplus with respect to a variable of interest to be expressed as a function of the output and demand elasticities with respect to that variable.

Due to a lack of time series data on marketed quantities, early work relied on estimates of output and demand response drawn from existing research in order to estimate marketed surplus elasticities (Krishna (1962); Behrman). Later work used cross-sectional village-level data to estimate marketed surplus response directly. Using ordinary least squares, Bardhan (1970) regressed total marketed surplus of several foodgrains on a composite price index, total output of foodgrains, and other variables using data collected from twenty-seven villages in Northern India. She found significantly negative price elasticities of marketed surplus response. Haessel criticized her empirical work, however, on the grounds that simultaneity bias caused the estimates to be inconsistent. Using two-stage least squares on the same data, he found significantly positive and fairly elastic supply response of marketed surpluses. In the Philippines, Toquero, et al. found that marketed surplus elasticities with respect to price were positive but quite small.

More recently, Strauss (1984) criticized previous work as being flawed either because consumption demand was assumed to be completely inelastic (Behrman, Krishna), or because output was assumed to be fixed (Bardhan, Haessel, Toquero, et al.). Strauss' estimates of marketed surplus elasticities for a cross-section of households in Sierra Leone accounted for the wealth effect attributable to the effect of a price change on farm profits. He found that own-price elasticities were all positive and in some cases quite large.

A conceptual problem common to all existing models is that they take consumption, output, and sales as occurring simultaneously. Thus, a change in the price of a commodity that is produced and consumed by the household affects marketed surplus through its impact on both contemporaneous consumption and production. This is not normally the case, however. Rather, the output from which marketed surplus is drawn is generally predetermined and exists in the form of currently held inventories and/or recent harvests. Stocks on hand and expected <u>future</u> output might influence marketing decisions, but only through wealth effects on consumption. As was just demonstrated, only in special circumstances will these wealth effects be analytically identical to those predicted by earlier models.

Differentiating equation 2.5a with respect to P_{it} (and noting that $dQ_{it}/dP_{it} = dI_t/dP_{it} = 0$)

$$(2.25) \quad \frac{dM_{it}}{dP_{it}} = -\frac{dX_{it}}{dP_{it}} - \frac{dI_{t+1}}{dP_{it}}.$$

From equation 2.20,

$$(2.26)\quad \frac{dI_{t+1}}{dP_{it}} = \frac{\partial I_{t+1}}{\partial \hat{P}_{it+1}} \cdot \frac{d\hat{P}_{it+1}}{dP_{it}} + \frac{\partial I_{t+1}}{\partial P_{it}} + \frac{\partial I_{t+1}}{\partial X_{it}} \cdot \frac{dX_{it}}{dP_{it}}$$

$$= -f(1 - b) \cdot \frac{d\hat{P}_{it+1}}{dP_{it}} + g \cdot \frac{dX_{it}}{dP_{it}}.$$

Thus the response of marketed surplus of the stored commodity to a contemporaneous change in its price is given by

$$(2.27)\quad \frac{dM_{it}}{dP_{it}} = -(1 + g) \cdot \frac{dX_{it}}{dP_{it}} + f(1 - b) \cdot \frac{d\hat{P}_{it+1}}{dP_{it}}.$$

In this derivation, it may be seen that marketed surplus response will be affected by inventories in two distinct ways. First, there will be a direct effect operating via the profit effects on consumption demand contained in dX_{it}/dP_{it}. Second, there will be indirect effects attributable to price effects on inventory demand, as captured in the parameters describing the strength of food security and arbitrage motives (g and f). As with the direct effects of inventories, expected future output modifies marketed surplus response through profit effects on consumption demand.

Assuming f and g to be positive, the sign of dM_{it}/dP_{it} will depend on that of dX_{it}/dP_{it} and $d\hat{P}_{it+1}/dP_{it}$. In general one would expect a positive relationship to exist between current and expected prices and a negative relationship between consumption demand and price. As was shown in the preceding section, only in the case in which the profit effect was strong enough to dominate normal income and substitution effects would dX_{it}/dP_{it} be positive.

Once again, the current model yields distinctly different implications for marketed surplus response than its antecedents. But unlike the case of demand response for home-produced commodities, the earlier results are not nested within the current model. The reason for this is that the current model explicitly accounts for the fact that the output from which marketed surplus is drawn is predetermined and therefore completely unaffected by a price change. Thus, while the earlier models implied that marketed surplus response is simply the difference between output supply response and demand response, the current model implies marketed surplus response is a function of demand response and <u>inventory</u> response. Even if arbitrage motives are absent (i.e. $f = 0$), inventory demand may have an effect on marketed surplus through profit effects on consumption demand and/or the holding of stocks for food security purposes. Moreover, the response of expected <u>future</u> output to non-transitory price changes will affect marketed surplus decisions through profit effects.

2.5 Summary

In this chapter a theoretical model of semi-subsistence agricultural households has been developed which explicitly accounts for the ability of households to store key food staples over the period between harvests. The first order conditions for the model imply a simple inventory demand equation which distinguishes between food security and arbitrage motives for holding inventories. In addition, the first order conditions yield the marginal relationships between prices and quantities found in conventional microeconomic analyses. Given the assumptions of exogeneity of prices and substitutability of factors of production underlying the model, the production side of the model was shown to be separable from the demand side, a result characteristic of this class of models.

Because they are carried over from one period to the next, the presence of inventories add an inter-temporal dimension to the model whereby price expectations assume an important role. The analysis above indicates that the one-step-ahead price forecast for a storable commodity should be included as an argument of the household's Marshallian demand if arbitrage motives for holding inventories exist.

Comparative statics results clarify the differences between the model developed here and previous work. The current model implies that in addition to the substitution and income effects of conventional Slutsky analysis, stocks on hand and expected revenue from future production will have wealth effects on current consumption. It was shown that under certain circumstances, the own-price elasticity of consumption demand predicted here will be identical to that predicted by earlier agricultural household models which ignored inventories. In general, however, the model developed here implies different set of elasticities than its predecessors.

As with consumption demand, the model developed above implies a methodology for computing marketed surplus elasticities which departs from that of earlier models. Unlike the case of consumption demand, though, it is not possible to project the earlier formulae as special cases of the one derived here. The reason for this is a fundamental difference in the way the problem has been formulated: The current analysis accounts for the fact that at the time marketing decisions are made, the output from which marketed surplus is drawn is predetermined and thus immune to changes in price (or,for that matter, any other exogenous variables).

Appendix 2.1

NOTATION FOR THE AGRICULTURAL HOUSEHOLD MODEL

X_{1t} = consumption in period t of a storable commodity that is produced by the household.

X_{2t} = consumption in period t of a non-storable commodity that is produced by the household.

X_{3t} = consumption in period t of a non-storable commodity that is purchased in the market.

X_{Lt} = leisure consumed by the household in period t.

P_{kt} = price in period t of X_{kt}, k = 1,2,3.

P_{Lt} = market wage rate in period t.

I_{t+1} = inventory carried over from period t into period t+1.

M_{1t} = quantity of the produced commodity sold in period t.

F_t = total family labor supply (both on- and off-farm) in period t.

L_t = household demand for labor in period t.

T^* = total time available to the household in a given period.

B_t = household borrowing in period t.

r = market rate of interest.

b = constant discount factor = $(1+r)^{-1}$.

Y_t = exogenous household income in period t.

Q_{1t} = output of a storable food crop in period t.

Q_{2t} = output of a non-storable food crop in period t.

Q_{ct} = output of a cash crop in period t.

P_{ct} = price of the cash crop in period t.

V_t = non-labor variable input use in period t.

P_{vt} = price of the non-labor variable input in period t.

A_o = land allocated to crop production in the "current" cropping season.

λ_1 = Lagrange multiplier associated with the budget constraint for the current period.

λ_2 = Lagrange multiplier associated with the "lifetime" budget constraint for periods t+1 through T.

λ_3 = Lagrange multiplier associated with the production function.

f = parameter describing the strength of arbitrage motives for holding inventories.

g = parameter describing the strength of food security motives for holding inventories.

Appendix 2.2

SECOND ORDER CONDITIONS

Consider the case in which two goods are consumed -- one home-produced and storable, the other purchased and non-storable. This is a simpler case than that considered in the model presented in Chapter 2, but the results are perfectly generalizable. Totally differentiating the first order conditions yields the following linear system of differential equations:

(A1)

$$
\begin{bmatrix}
U_{11}-\lambda_1 C_{xx} & U_{1s} & U_{1L} & \lambda_1 C_{xI} & -P_{1t}-C_x & 0 & 0 & 0 & 0 \\
U_{s1} & U_{ss} & U_{sL} & 0 & -P_{st} & 0 & 0 & 0 & 0 \\
U_{L1} & U_{Ls} & U_{LL} & 0 & -P_{Lt} & 0 & 0 & 0 & 0 \\
-C_{Ix} & 0 & 0 & -C_{II} & 0 & 0 & 0 & 0 & 0 \\
-P_{1t}-C_x & -P_{st} & -P_{Lt} & -P_{1t}-C_I & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \mu H_{LL} & \mu H_{Lv} & \mu H_{L1} & H_L \\
0 & 0 & 0 & 0 & 0 & \mu H_{vL} & \mu H_{vv} & \mu H_{v1} & H_v \\
0 & 0 & 0 & 0 & 0 & -\mu H_{eL} & 0 & -\mu H_{ee} & H_e \\
0 & 0 & 0 & 0 & 0 & H_L & H_v & H_e & 0
\end{bmatrix}
$$

$$
X \begin{bmatrix} dX_{1t} \\ dX_{st} \\ dX_{Lt} \\ dI_{t+1} \\ d\lambda_1 \\ dL_t \\ dV_t \\ dQ_{1T} \\ d\mu \end{bmatrix} = \begin{bmatrix} \lambda_1 dP_{1t} \\ \lambda_1 dP_{st} \\ \lambda_1 dP_{Lt} \\ \Psi_1 \\ \Psi_2 \\ dP_{Lt} \\ dP_{vt} \\ dP_1{}^* \\ 0 \end{bmatrix},
$$

where $\mu = \lambda_3/\lambda_1$

$P_1{}^* = b^{T-t}(E_t P_{1T})$

$$\Psi_1 = dP_{1t} - b[d(E_t P_{1t+1})]$$

$$\Psi_2 = -M_{1t} dP_{1t} + X_{3t} dP_{3t} - (T^* - X_{Lt} - L_t) dP_{Lt}$$

$$- Q_{1T} dP_1^* - dY_t - dB_t + \mu H_A dA_0$$

Note that in differentiating the budget constraint, $\mu(H_L dL_t + H_V dV_t + H_Q dQ_T)$ was substituted for $-P_{Lt} dL_t - P_{Vt} dV_t + P_T dQ_T$. But this is equal to $\mu H_A dA$ since $H(\cdot) = 0$ and $dV_s = dL_s = 0$ for all $s \neq t$].

Extending the model to include other commodities consumed and additional outputs and inputs in production adds more rows and columns to the Hessian matrix, but in no way alters the fundamental analytical result regarding the recursiveness of production.

Chapter 3

EMPIRICAL CONSIDERATIONS

The agricultural household model developed in the previous chapter implies a set of measurable relationships between several observable variables. Specifically, the model predicts that household inventory demand for a storable good is a function of consumption demand for the good and the difference between its current and expected price. The model further suggests a method of computing marketed surplus and demand elasticities that incorporates the response of inventories to changes in exogenous variables. If the model is in fact a reasonable representation of reality, then these relationships will be borne out by careful statistical analysis. In this chapter the framework for conducting such an analysis will be developed.

The two requirements for estimating the model are an empirical strategy -- that is, a method of systematically testing the model's implications -- and the data with which to implement it. The next section outlines the empirical strategy to be employed in exploring the behavioral implications of the model. This discussion touches on the key elements of the empirical work to be conducted in the next chapter and elucidates the data required for testing the model. Section 3.2 provides an overview of panel data from three Indian villages to be used in the analysis, and outlines the process by which it was collected and analyzed.

Section 3.3 presents background information on the three study villages. Section 3.4 contains a statistical overview of the households on which the analysis of the next chapter will be conducted. The graphical and tabular presentation found in this section motivates some informal hypotheses concerning intra- and inter-village differences in the relative strength of food security and profit motives for holding inventories. A detailed description of the procedures used to compute household inventories and construct price and quantity indices is contained in an appendix to this chapter.

3.1 An Empirical Strategy

The empirical analysis to be undertaken in the next two chapters will be directed toward two objectives: measuring the determinants of household inventory demand and estimating marketed surplus and commodity demand elasticities for storable commodities. These two objectives are not independent of one another; as was shown in Chapter 2, marketed surplus and demand elasticities for stored commodities will be affected by inventory response. The procedure to be followed will be to first estimate inventory response and then combine this information with estimates of the parameters of household supply and demand to compute marketed surplus and demand response. Demand parameters will be estimated directly using a systems approach, while estimates of the supply-side parameters will be drawn from outside sources.

Estimating the responsiveness of inventory and commodity demands to prices and other exogenous variables for individual villages is a worthwhile exercise in its own right. The author is unaware of any studies of household inventory demand in India (or in any other developing country for that matter), and existing work on commodity demand in India relies on highly aggregated, regional consumption data (Murty). Of perhaps more interest, though, is the fact that estimation of inventory and commodity demand for three different locations will allow for some comparisons across villages. In particular, it will be possible to examine the relative strength of profit and food security motives for holding inventories in different villages.

The basis for estimating inventory response is found in one of the first order conditions for the household optimization problem (equation 2.20) and is restated here for reference:

$$(3.1) \qquad I_{t+1} = f(bE_t P_{1t+1} - P_{1t}) + g_o + gX_{1t}.$$

This equation along with a set of $(n^2 + n)/2$ marginal rates of substitution between the n commodities consumed make up the demand side of the model. The parameters f and g may be interpreted as indicators of arbitrage and food security motives for holding stocks, respectively, and the estimation will be directed at formally testing the hypotheses that either (or both) of these parameters are significantly greater than zero.

Equation 3.1 can be estimated individually by two stage least squares, using suitable instruments for endogenous right-hand side variables (X_{it} and $E_t P_{i,t+1}$). Alternatively, by specifying a utility function, 3.1 may be jointly estimated with up to n-1 of the marginal rates of substitution. A price forecasting equation may also be estimated jointly with the other equations in the system. Here the simpler (and computationally less expensive) single equation technique will be used. Data requirements for the single equation approach are of course more moderate than if the entire system were to be estimated. Time series data on inventory holdings, prices, and consumption of the stored commodity are required, along with other exogenous variables used as instruments (e.g. other prices).

In order to estimate equation 3.1, it is necessary to assume a mechanism by which households form price expectations. Choices include using the current price in place of the expected price (a static expectations assumption); using a univariate ARMA model to generate price forecasts; and using actual one-step-ahead prices (a perfect foresight model)[15] In the analysis to be conducted, the ARMA approach will be used.

Because negative inventories are not observed a limited dependent variable situation exists. As such, least squares estimates will be biased and inconsistent (Fomby, et al, pg. 359). One remedy for this would be to use maximum likelihood methods to estimate equation 3.1 (i.e. a Tobit analysis). Alternatively, Heckman's (1974) two-step procedure for analyzing censored data may be employed. This latter approach will be adopted below.

The parameters of inventory demand are but one component of marketed surplus elasticities. To measure these fully (as well as commodity demand elasticities) requires estimates of the parameters of demand and supply. Here a Rotterdam model will be used to estimate the system of commodity demands. The Rotterdam model is particularly well-suited to the cross-sectional time-series data to be used here because it alleviates the need to model household-specific socio-economic characteristics explicitly.

The supply-side parameters to be used will be taken from a comprehensive study of output supplies and input

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[15] Still another possibility would be to aggregate individual inventory demand across N households, assume market supply and demand schedules, and then solve for a reduced form expression for $E_t P_{t+1}$. This approach, common to a number of rational expectations models, is inappropriate in this case because individual household data will be used to test the model and the prices faced by those households are determined in regional (or national) markets about which little information is available.

demands in several parts of semi-arid tropical India conducted by Bapna, Binswanger, and Quizon. These were estimated with district level data using a normalized quadratic profit function.

3.2 Data to be Used

Data requirements for estimating the full agricultural household model developed in Chapter 2 are imposing. In the past, lack of detailed household-level data severely restricted analysts' ability to estimate similar household models. Empirical work has generally used cross-sectional data, relying on geographical differences to generate the variation in prices necessary to make inferences regarding price effects on consumption and production [Strauss (1982a, 1982b); Barnum and Squire; Lau, Lin, and Yotopoulos]. The danger in this is that spatial variation in prices may be the result of region-specific variables not otherwise captured in the analysis. If this is the case, parameter estimates will be biased. This issue aside, the dynamic nature of the model of interest here necessitates the use of time-series data, especially for the inventory demand analysis.

The paucity of time-series data suited to exploring economic relationships among semi-subsistence households led researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to initiate an ambitious data collection effort in 1975. Initially covering five villages in three states of south and central India (and later expanded to include five additional villages in two other states), ICRISAT's Village Level Studies (VLS) project was designed to elicit from responding households as complete an accounting of their economic activities as possible. Villages were selected on the basis of their representativeness within their region with respect to certain demographic and socio-economic variables.[16] Enumerators lived in designated villages for up to six years at a stretch, during which time they conducted monthly interviews with 40 households grouped into four land-owning classes (landless, small, medium, and large).

The VLS data set is organized into five "schedules" covering basic demographic variables (e.g., household composition, religion, etc.); agricultural production; family labor allocation; holdings of physical stocks and financial assets; and transactions (both market and intra-household). Labor, production, and transactions activities were sampled approximately once every four weeks, while stock-holding and socio-economic data were collected yearly.

The empirical analysis to be conducted uses data from

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[16] These variables included population density; extent of literacy; population density of cultivators and agricultural laborers; various kinds of livestock; technology used in cultivation; land quality and land use characteristics; rainfall; and the percentage shares of various crops to the gross cropped area for the village. For more information on sampling procedures, see Singh, Binswanger, and Jodha.

three villages in which households were continuously sampled for ten years. These three villages differ widely in terms of rainfall conditions (although all are classified as semi-arid tropical), types of crops grown, importance of irrigation, and ethnic composition. There are, however, some important common denominators. All villages are overwhelmingly dependent on agriculture, with crop production and agricultural labor providing the bulk of household income. Moreover, in each of the villages most farm households satisfy some (if not all) of their demand for their dietary staple through their own production.

At an early stage in the research a decision was made to organize the data on a quarterly basis. Although this decision was made primarily to expedite data handling, aggregating the data in this way also served to smooth the data (in the sense of reducing the number of time periods for which a particular activity was <u>not</u> undertaken) while still preserving degrees of freedom. Another decision made early on was to analyze only data from those households that remained in the sample continuously over the eight year period extending from the 1976 cropyear through the 1983 cropyear.[17] The consensus among ICRISAT economists is that the data collected in the beginning and ending years of the survey were unreliable. For this reason, data from those

[17]For this study, cropyears are defined as beginning on July 1 and ending on June 30. Quarters 1, 2, 3, and 4 begin on July 1, October 1, January 1 and April 1 respectively.

two years were not analyzed.

The procedures used to organize the data into a form compatible with the theoretical model of Chapter 2 are described in the Appendix to this chapter.

3.3 The Study Villages

The three villages in semi-tropical India for which data are analyzed are Aurepalle, located in the southern state of Andhra Pradesh, and Shirapur and Kanzara, located further north in Maharashtra state (see Figure 3.1). Table 3.1 presents some basic demographic information for the villages.

3.3.1 Agronomic Conditions

India's semi-arid tropics (SAT) are characterized by low and erratic rainfall and high rates of evapo-transpiration. Droughts are relatively frequent, and even in years for which the annual total is normal, ill-timed rains may lead to poor growing conditions for farmers without recourse to irrigation facilities.

The three study villages are representative of three distinctly different agro-climatic zones of SAT India (Table 3.2). Aurepalle lies in a region of sandy, red soils with low moisture-holding capacity and low and erratic rainfall (710 millimeters per year). Farmers without access to irrigation usually get only one harvest per year, with most

Figure 3.1 Location of the Study Villages

Table 3.1: Statistical Profiles for the Study Villages

Characteristic	Aure-palle[a]	Shir-apur[b]	Kan-zara[c]
Geographical area (km^2)	16.3	14.7	6.0
Cultivable area (hectares)	1180	1327	540
Population density (per km^2)	167	110	156
Total number of households	476	297	169
Labor households (%)	31	33	32
Farming households (%)	68	62	65
Other households (%)	1	5	3
Average family size	6.0	7.0	6.0
Literacy (%)	25.3	41.4	42.7
Irrigated area to gross cropped area (%)	20.0	10.5	3.7
Cropping intensity (%)	116	110	107

Sources: a. Asokan, Baskar Rao, and Mohan Rao
b. Bhende (1983)
c. Kshirsagar

Table 3.2: Agro-climatic Characteristics of the Study Villages

Village	Mean Annual Rainfall (mm)	Soil Type	Major Crops[a]
Aurepalle	710	Shallow and medium-deep Alfisols	Sorghum Castor Pearl millet Paddy Pigeonpea
Shirapur	690	Medium-deep to deep Vertisols	Sorghum Pigeonpea Chickpea Wheat Minor pulses
Kanzara	820	Medium-deep Vertisols	Cotton Sorghum Mungbean Groundnut Wheat

a. Paddy is the plant which produces rice. Pigeonpea and mungbean are types of lentils. Castor is an oilseed.

Source: Jodha (1979).

allocated to sole-cropped castor (a cash crop). Those farmers having irrigation facilities cultivate paddy almost exclusively on irrigated plots, harvesting up to three paddy crops per year.

Shirapur is the most drought-prone and agriculturally the least prosperous of the three villages. Although the average amount of annual rainfall is about the same as in Aurepalle (690 millimeters), the rains are much more erratic. Complete crop failure is not uncommon, occurring on an average of 11 percent of the total cropped area in any given year (Bhende, 1983a). The village is situated in a region of deep, black, clay soils with very high moisture retention. These soils are very difficult to work when wet. For this reason, cultivation generally takes place in the rabi (post-monsoon) season and relies on residual soil moisture. Sorghum is the dominant crop in the farming system, occupying over 50 percent of the total cropped area on average. Sorghum is generally sole-cropped, although it is sometimes inter-cropped with safflower. Other rabi crops include chickpea and wheat and safflower (a cash crop). Pigeonpea and minor pulses are grown in the kharif.

Kanzara lies in the heart of India's cotton belt. Rainfall is much more dependable than in the other two villages, and the medium-deep black soils are amenable to cultivation during the rainy season. Cotton (both local and hybrid varieties) dominates the farming system, occupying over 50 percent of the total cropped area in the village. Local cotton is usually inter-cropped with sorghum or a pulse, while hybrid cotton is nearly always sole-cropped. Sorghum and sorghum-pigeonpea mixtures occupy over 25 percent of the total cropped area. Wheat and chickpea are the major crops grown in the rabi season, wheat being grown on irrigated plots, and chickpea on residual soil moisture.

3.3.2 Food Consumption

Table 3.3 presents data reported on average diets for the three villages as reported by Walker, et al (1983). These data were collected in four rounds of dietary surveys conducted by Ryan, et al. in 1977. That study found that in all villages there was little seasonal variation in nutrient intake and, somewhat surprisingly, no significant relationship between consumption of any nutrient and income. Differences in nutritional status across villages were attributed primarily to the nutritive value of the dominant food staple consumed in the village.

For religious reasons, many Hindus are vegetarians, and therefore diets of Indian villagers are overwhelmingly cereal-based. Rice is the primary staple food in Aurepalle, although sorghum and pearl millet are also important. Sorghum dominates in Shirapur and Kanzara. Wheat is a major source of calories in Kanzara, but not in the other two villages. Milk and milk products are important nutri-

Table 3.3: Representative Diets by Village (gms/person/day)[a]

Item	Aurepalle	Shirapur	Kanzara
		----Cereal Grains----	
Rice	256.8	-	2.9
Sorghum	54.5	266.1	289.9
Wheat	3.0	4.3	93.5
Millet	27.7	-	-
SUBTOTAL	342.0	270.4	386.3
		----Legumes----	
Pigeonpea dhal	7.3	10.2	16.6
Chickpea dhal	-	3.7	19.5
Blackgram dhal	-	-	1.2
Chickpea	-	4.8	-
Mungbean	-	-	3.2
Groundnut	-	8.1	9.6
SUBTOTAL	7.3	26.8	50.1
		----Vegetables----	
Tomato	10.5	-	5.7
Onion	9.8	5.6	11.6
Eggplant	5.0	4.4	19.9
SUBTOTAL	25.3	10.0	37.2

Table 3.3 (continued)

		----Dairy Products----	
Milk	10.4	23.1	46.5
Buttermilk	75.4	-	2.8
Curd	11.9	-	-
SUBTOTAL	97.7	23.1	49.3
		----Other Foods----	
Chillies	3.8	12.2	3.6
Sugar	2.3	1.0	5.1
Jaggery	-	34.1	44.7
Groundnut oil	2.5	1.9	6.9
Mutton	-	1.9	-
SUBTOTAL	8.6	51.1	60.3
TOTAL	480.9	381.4	583.2

a. Dashes indicate average daily consumption of under one gram.

Source: Walker, et al (1983), Appendix Table 3.

tive sources in all villages, as are pulses (especially pigeonpeas). Pulses are generally consumed in the form of "dhal" (a lentil stew).

3.3.3 Sources of Income

Table 3.4 lists the share of income contributed by various types of activities for farm households in each village. Looking at village-wide totals for all farms, the combined sales of crops and livestock products form the largest single source of income in all cases. Contributions from these activities to total income range from 48 to 58 percent.

Labor income is also important, especially for the small and medium farm-size classes. In all villages the largest share of income earned by small farm households came from this source; this was also true of medium farm households in the two Maharashtra villages. The primary sources of these labor earnings are the daily agricultural labor markets that function relatively smoothly in each village. Labor demand in these markets varies with the season. In both Shirapur and Kanzara, the Maharashtra state government operates a system of public works projects known as the Employment Guarantee Scheme (EGS). Set up in the mid-sixties to provide relief to those rural areas hit by severe drought, the EGS has tended to smooth labor demand signifi-

Table 3.4: Mean Share (%) of Income Contributed from Different Sources by Farm-size Class and Village[a]

	Farm-size Class			
Source of Income	Small	Medium	Large	All
	----Aurepalle----			
Crop	22.8	37.9	76.0	45.6
Livestock	10.4	12.2	16.7	13.1
Labor	42.9	15.9	0.4	19.7
Rental[b]	-2.0	0.8	-0.9	-0.7
Handicraft & Trade	23.0	30.2	9.3	20.8
Transfers[b]	2.9	3.0	-1.5	1.5
	-----Shirapur----			
Crop	20.1	27.2	39.8	29.0
Livestock	25.3	22.3	20.3	22.6
Labor	46.7	49.7	46.2	47.5
Rental	4.3	-2.0	-3.0	-0.2
Handicraft & Trade	0.3	-0.7	-0.5	-0.3
Transfers	3.3	3.5	-2.8	1.3
	-----Kanzara-----			
Crop	17.4	32.9	63.3	37.9
Livestock	4.0	10.9	17.7	10.9
Labor	61.8	45.7	17.4	41.6
Rental	2.0	2.4	-2.4	0.6
Handicraft & Trade	12.6	2.3	0.3	5.1
Transfers	2.2	5.8	3.7	3.9

a. Based on VLS data from 1975 through 1979 for farming households only.

b. Figures for rental and transfer income are net values.

Source: Walker, et al. (1983).

in these two villages.[18]

With the exception of Aurepalle, other sources of income are relatively unimportant. In Aurepalle, the high share of income generated by the "handicrafts & trade" category is primarily due to an extensive trade in palm wine (or "toddy").

3.3.4 Storage

Farm households in all three villages store significant amounts of important foodstuffs for some periods of the year. Most often the commodities stored are ones that the household grew itself, but in some instances large quantities of a commodity will be purchased or received in kind, and will be stored for a quarter or two. Generally, grains are stored in unprocessed form, and converted into an edible form (i.e., flour in the case of coarse grains and wheat, milled rice in the case of paddy) shortly before consumption. Pulses, on the other hand, are usually ground into dhal before being stored.

The two primary methods for storing grains are dung-lined storage bins (holding anywhere from 100 to 1000 kg) and ordinary gunny sacks. The bins are usually made of pigeonpea stalks or palm leaves bonded together with mud and

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[18] For example, Walker, et al. note that between 1979 and 1981 the EGS accounted for 32 and 50 percent of male and female wage employment in Shirapur, and 17 and 8 percent of male and female employment in Kanzara.

dung. In Aurepalle some of the largest farm households have underground storage facilities holding up to four tons of grain. Still others in all the villages have special rooms in their dwellings in which grains are stored. These cases are unusual, however; most dwellings are rather small, and stored goods are kept in a corner of the general living area.

Storage losses due to pests and spoilage vary between villages. Common sources of storage losses are insect damage, rat infestation, and mold. Villagers have adopted a number of different methods for minimizing storage losses. Often the crop is left to dry in the sun for several days prior to storage in order to make the grain more difficult for insects to penetrate. Another common anti-insect measure adopted in all villages is the placing of leaves from neem trees (Azodirachter indica) inside storage bins. These leaves apparently contain a natural insecticide. Against rats, the most common tactic adopted is to raise the storage bins off the floor, or to surround them with thorny sticks.

For the most important commodities stored, storage losses appear to be the worst in Aurepalle. The consensus among farmers during informal interviews was that losses range between 15 and 20 percent per year for paddy and are about 10 percent for coarse grains. In Kanzara, 10 percent losses on stored sorghum and wheat was the most commonly cited figure. In Shirapur storage losses are not commonly regarded as a major problem.[19]

3.3.5 Product and Factor Markets

One of the key assumptions underlying the recursiveness of the model developed in Chapter 2 is that the various product and factor markets in which households interact are classical in a Walrasian sense. Here, village markets will be briefly described with an eye toward ascertaining the degree to which they conform to this assumption.

Each village has several shops in which everyday items may be purchased. Especially for small transactions, a considerable amount of barter trade exists. Larger purchases of both food and non-food items are usually made in a nearby town or, in the case of agricultural goods, from a farmer within the village. There is also a substantial trade in some agricultural commodities with nearby villages.[20]

Sales of food crops are usually made to traders in a nearby town. In some cases, traders will come to the village to procure commodities, but it is more common for villagers to haul their produce to a nearby market in a bullock cart. This is also true of cash crops (castor in

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[19] A likely reason for this is that the particular local variety of sorghum grown in Shirapur has a very hard kernel which is naturally much more difficult for insects to penetrate.

[20] A notable example is the toddy trade in Aurepalle. Aurepalle has a reputation as producing the best palm wine in the area, and attracts buyers from as far as 40 miles away.

Aurepalle and cotton in Kanzara). Overall, it appears that product markets are relatively free of imperfections that would nullify recursiveness.

In all three villages, debt is important both as a means of financing production activities and in smoothing consumption flows. Most households will take out loans from either institutional or informal sources in any given year. One interesting feature of credit markets in these villages is that nearly all informal credit comes from within the village (Ryan and Walker). This contrasts with the prominent role of traders and commission agents in the financial markets in other parts of India.

There are substantial differences in the sources and uses of credit across villages. In Aurepalle, professional moneylenders dominate the credit market, providing about two-thirds of all loans. These loans are for both consumption and production. Long-standing patron-client relationships appear to exist between households and moneylenders. Rates of interest are high -- up to 50 percent on an annual basis -- but such loans tend to be preferred because no collateral is usually required and loans can be obtained quickly. In contrast, obtaining a loan from a credit institution is time-consuming and often involves bribing officials (Asokan, et al). In the two Maharashtra villages, agricultural cooperative credit societies are the main lenders. These loans are officially for production only, often tied to input purchases, but it is not uncommon for borrowers to use these loans for consumption purposes. Default rates on institutional loans are exceptionally high -- in excess of 40 percent (Walker and Ryan).

Bhende (1983b) and Binswanger, et al. (1985) provide evidence of differential access to institutional credit within villages. Tobit analyses of the determinants of institutional credit reveal a strong positive relationship between access to institutional loans and landholdings, asset holdings, years of schooling and caste rank, indicating that, in general, richer, better educated, and upper caste farmers receive are more likely to receive institutional loans. At the same time, a significant amount of short-term interest-free loans among friends and relations have been observed in all the villages (Walker and Ryan). In many cases these are kind transactions -- especially in drought-prone Shirapur -- whose purpose is to see the borrower through a lean period. In short, it appears that some imperfections exist in village credit markets, but that in nearly all instances households are able to borrow from some source.

The primary inputs into agricultural production in the villages to be considered are labor and animal traction. As was discussed in Section 3.3.3, active agricultural labor markets exist in all three villages and the contribution of labor income to total household income is very important, especially for the small and medium farm-size classes. The early literature on economic development tended to view these rural labor markets as uncompetitive, assuming that rural wages were determined by institutional (rather than market) forces thereby leading to significant under- and unemployment. More recent work using Indian data -- especially that of Rosenzweig (1978; 1980) and Bardhan (1979) -- provides strong evidence that rural labor markets do indeed function efficiently.

The other important agricultural input used in the study villages is animal traction. While some hiring of bullocks occurs in all villages, the market for such services operates imperfectly for two primary reasons. First, given the seasonality of bullock demand (peak demand occurs immediately prior to sowing) and the fact that nearly all owners of bullocks are farmers themselves, prospective renters of bullock services will often find it difficult to locate an available animal. Second, in many instances the bullock's owner will want to supervise the use of the hired animal to make sure that it is not mistreated. Such supervision may be unfeasible if the owner is busy on his own farm. Also, social customs may well prohibit supervision if the supervisor is of a lower caste than the renter (Pant). Nevertheless, bullock rentals are observed in all villages.

3.4 Consumption, Carryout and Marketed Surplus

This section provides a description of the various categories of disappearance of stored commodities for the three study villages. The discussion culminates in a set of informal hypotheses regarding intra- and inter-village differences in the determinants of inventory demand.

Throughout the discussion that follows, farms in Shirapur and Kanzara will be categorized as large, medium, and small based on a classification scheme developed at ICRISAT (see Table A3.5). For the most part, the size of the landholdings of a given household are correlated with the household's wealth status (Jodha). As such, points made concerning differences in the behavior of households from the various farm-size classes will be generally construed to imply differences based on household wealth.[21]

The basic information concerning net production, marketed surplus, consumption, and inventories of stored commodities computed from the VLS data set is stored on a data tape and is available from the author upon request. Table 3.5 presents some summary statistics of this data by village and farm type.

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[21] In Aurepalle, the more natural breakdown from the standpoint of wealth status is in terms of rice-producing and non-rice producing households. This is because households which cultivate paddy are those that have access to irrigation facilities (and hence, relatively greater productive capacity). Based on analysis to be conducted in Chapter 4, non-rice producing households were further broken into two groups -- those that do not store appreciable quantities of rice (Group A) and those that do store rice (Group B).

Table 3.5 Consumption, Inventories, and Marketed Surplus of Stored Commodities by Village and Farm Type

Farm Type	Consumption		Inventory		Mkt'd Surplus	
	Mean[a]	C.V.[a]	Mean[a]	C.V.[a]	Mean[a]	C.V.[a]
			-----Shirapur Grains------			
Small	210.0	29.0	247.2	51.9	62.3	248.2
Medium	297.8	23.0	413.9	38.6	133.3	82.0
Large	386.7	28.3	631.5	36.8	84.3	227.3
			-----Kanzara Sorghum------			
Small	164.6	33.3	114.1	44.2	-34.5	414.1
Medium	165.8	7.1	169.8	108.3	-48.0	220.5
Large	302.6	40.2	917.1	64.1	303.9	146.2
			-----Kanzara Wheat/pigeonpea------			
Small	58.1	10.7	62.4	37.1	-12.2	199.1
Medium	50.3	26.2	58.4	46.9	7.0	448.7
Large	195.0	32.2	687.1	70.1	179.7	82.1
			-----Aurepalle Coarse Grains-----			
Group A	90.6	18.7	117.9	49.7	-14.0	139.8
Group B	99.6	32.2	133.6	50.7	-1.7	2641.9
Rice growers	2.3	10.4	200.6	60.3	46.5	157.6
			-----Aurepalle Rice-----			
Group A	130.8	26.9	7.6	51.5	-131.1	26.8
Group B	138.3	27.4	27.2	75.1	-126.5	24.7
Rice growers	173.8	25.3	402.8	70.3	409.7	68.7

a. These are household means (in kilograms) and coefficients of variation across individual household means expressed in percentage terms.

3.4.1 Inventories

Mean quarterly inventory holdings of stored commodities for each village-farm type combination are shown in Figure 3.2. As would be expected, carryout stocks are at a maximum in the quarter in which harvest takes place and decline steadily throughout the year for annually harvested crops -- i.e. for all cases except rice in Aurepalle. With regard to rice in Aurepalle, the picture is somewhat obscured by the fact that paddy is harvested in two to three quarters of each year. Thus, no discernible quarterly pattern emerges from the data.

Within villages, the levels of inventory holdings are in most cases associated with farm size, with larger, generally wealthier farms harvesting greater amounts and hence storing more. This is confirmed by t-tests comparing mean inventory holdings of different types of farm households (Table 3.6). In Aurepalle, rice growing households held significantly greater stocks of both rice and coarse grains than did non-rice growing households. Likewise in Kanzara, large farm households held significantly greater inventories than small and medium farm households. In Shirapur, small farm households held significantly smaller stocks on average than large and medium farm households.

Quarterly Inventory Demand

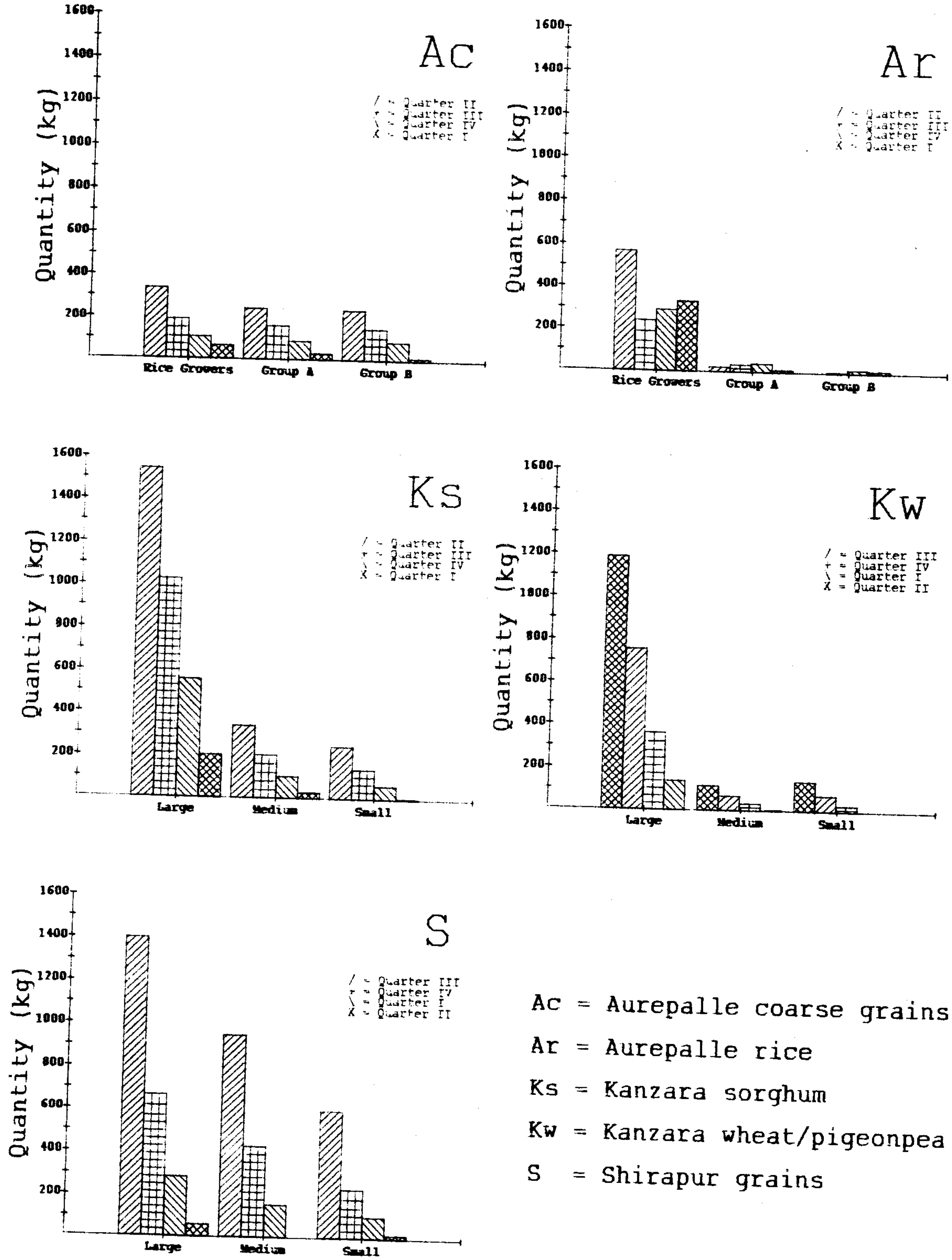

FIGURE 3.2 Mean Quarterly Carryout in Three Villages

Table 3.6 Comparisons of Mean Inventory Holdings

Village	Commodity	T-test Results[a]
Aurepalle	Rice	Rice Growers > Group B > Group A
Aurepalle	Coarse grains	Rice Growers > Group A, Group B
Shirapur	Grains	Large, Medium > Small
Kanzara	Sorghum	Large > Small, Medium
Kanzara	Wheat/p'pea	Large > Small, Medium

a. Significant differences at the 5% level.

3.4.2 Consumption of Stored Commodities

Table 3.7 presents means and coefficients of variation (C.V.) of per capita consumption of stored commodities by village and farm type. The C.V.'s -- expressed in percentage terms -- are somewhat higher than those presented by Walker, et al. (1983) in their analysis of consumption variability. They found that the C.V.'s of total food consumption ranged between 20 and 42 percent. Their analysis was more highly aggregated than the present one, however, in that they looked at annual consumption of all foods. With the exception of wheat and pigeonpea in Kanzara, the estimated C.V.'s of consumption found in Table 3.7 range from 20 to 52 percent.

Significant differences in per capita consumption between farm types exist in all villages (Table 3.8). Interestingly, small farm households havea higher level of average per capita consumption of staple grains than medium

Table 3.7 Means and Coefficients of Variation for Quarterly Per Capita Consumption of Stored Commodities[a]

Village/Commodity	Farm Type[b]					
	I		II		III	
	Mean	C.V.	Mean	C.V.	Mean	C.V.
Shirapur Grains	51.0	38.1	40.7	41.3	53.6	50.8
Kanzara Sorghum	36.0	41.6	31.8	44.7	32.1	48.1
Kanzara Wheat/p'pea	15.3	78.2	9.5	51.2	22.3	63.7
Aurepalle Coarse grains	16.7	48.3	24.6	59.8	17.2	20.0
Aurepalle Rice	23.0	38.9	32.6	44.4	28.1	49.7

a. These are household means (in kilograms) and coefficients of variation across individual household means (expressed in percentage terms).

b. For Kanzara and Shirapur, I = Small farms; II = Medium farms, and III = Large farms. For Aurepalle, I = Group A farms; II = Group B farms; and III = Rice growing farms.

Table 3.8 Comparison of Mean Per Capita Consumption of Stored Commodities Across Farm Types

Village	Commodity	T-test Results[a]
Aurepalle	Rice	Group B > Rice growers > Group A
Aurepalle	Coarse grains	Group B > Rice growers, Group A
Shirapur	Grains	Large, Small > Medium
Kanzara	Sorghum	Small > Large, Medium
Kanzara	Wheat/pig'pea	Large > Small > Medium

a. Significant differences at the 5% level.

farm households in Shirapur, and a higher level of consumption of the dominant staple (sorghum) than both medium and large farm households in Kanzara. Another somewhat surprising result is that rice growing farm households in Aurepalle consume significantly smaller amounts of rice and coarse grains per capita than one of the classes of non-rice growing farm households.

In an attempt to determine whether significant seasonal variation in the consumption of stored commodities existed, t-tests comparing the means of the quarters of maximum and minimum consumption were conducted. The results of this exercise (found in Table 3.9) indicate that in nearly all instances there is little quarterly variation. Only in the cases of sorghum consumption by large farm households in Kanzara and rice consumption by rice growing farm households in Aurepalle were significant quarterly differences detected. This finding, in conjunction with the finding of the previous section that households tended to draw down stocks of stored commodities throughout the year, is consistent with the notion that farm households in the three study villages use inventories as a means of stabilizing consumption between harvests.

Table 3.9 T-statistics for Tests of Significant Differences in Mean Quarterly Consumption[a]

		Type of Farm[b]		
Village	Commodity	I	II	III
Shirapur	Grains	0.21	0.49	0.59
Kanzara	Sorghum	0.94	0.52	2.41**
Kanzara	Wheat, pig'npea	0.39	1.51	1.47
Aurepalle	Coarse grains	0.54	1.61	1.51
Aurepalle	Rice	0.24	0.58	1.80*

a. Figures presented are the results of t-tests between the quarters of maximum and minimum mean consumption of the commodity in question. Significance levels of 5% and 10% are denoted by ** and *, respectively.

b. For Shirapur and Kanzara, I = small, II = medium, III = large farms. For Aurepalle, I = group A, II = group B, and III = rice growing farms.

3.4.3 Marketed Surplus

Table 3.5 indicated that in each of the villages considered certain types of farm households are on average net sellers or net purchasers of storable commodities. In all villages, the better-endowed farms -- i.e. large farms in Shirapur and Kanzara and rice growing farms in Aurepalle -- were net sellers of the crops considered here. By the same token, small farms in Kanzara and non-rice growing farms in Aurepalle were on average net purchasers of staple foods. This is hardly surprising given that average per capita consumption of these commodities is roughly the same across all farm types while productive capacity is different.

While a significant proportion of the households considered here are net purchasers of staple foods, positive marketed surpluses (i.e. net sales) are periodically observed for these households.[22] Likewise, negative marketed surpluses are observed in many quarters for households that are on average net sellers. There is, in fact, an apparent seasonal pattern to the quarterly sale and purchase of storable commodities that appears to be related to the quarter's position in the cropping cycle.

Table 3.10 presents mean quarterly marketed surpluses by village, commodity, and farm type. Here it can be observed that the bulk of sales of stored commodities take place in the quarter in which harvest occurs or the quarter immediately thereafter. An exception is found in the case of wheat and pigeonpea sales by large farms in Kanzara. On average, small and medium farm households in Shirapur and Kanzara are net purchasers of storable commodities in the latter half of the cropping cycle. The same is true of large farm households in Shirapur and non-rice growing households in Aurepalle. Moreover, in most cases marketed surpluses tend to decline (or become more negative) over the cropping cycle.

These results are consistent with information gained through informal discussions with farmers in the villages

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[22] For obvious reasons, positive marketed surpluses are never observed for non-rice growing households in Aurepalle.

Table 3.10 Mean Quarterly Marketed Surpluses of Stored Commodities[a]

Village	Commodity	Quarter	Farm Type I	Farm Type II	Farm Type III
Shirapur	Grains	3*	249.6	344.5	118.8
		4	147.3	229.0	330.4
		1	-69.3	-5.7	-3.9
		2	-117.4	-128.9	-148.3
Kanzara	Sorghum	2*	110.4	2.4	522.4
		3	-59.3	-39.4	230.1
		4	-86.8	-57.6	181.6
		1	-102.3	-97.4	128.3
Kanzara	Wheat/pig'pea	3*	-1.7	44.4	101.1
		4	-4.7	16.0	362.7
		1	-20.6	-15.6	77.2
		2	-21.9	-17.0	362.7
Aurepalle	Coarse grains	2*	-2.7	39.7	48.3
		3	-4.9	-12.3	88.6
		4	-14.6	-15.1	-1.2
		1	-30.0	-21.8	10.2
Aurepalle	Rice	2*	-126.5	-112.0	496.1
		3*	-129.2	-132.5	249.8
		4*	-145.4	-146.5	554.7
		1	-124.0	-112.9	282.7

a. Marketed surplus computed as the sum of sales and in-kind payments less purchases and in-kind receipts. Positive values imply net sales while negative values imply net purchases. Asterisks denote quarters in which harvests occur.

considered here. It is commonly suggested that for most households the timing of food crop sales is associated with the need to meet pressing financial obligations (such as loan repayments), rather than a studied assessment of when market prices will be at their highest.

In summary, the data on marketed surpluses indicate that sales of food crops tend to be seasonal in nature. Small and medium farm households in Kanzara, all households in Shirapur, and non-rice growing households in Aurepalle tend to sell in the two quarters immediately following harvest and buy in the two quarters immediately preceding the next harvest. These findings lend loose support to the idea that only most well-endowed households are able to take advantage of inter-temporal arbitrage opportunities that might exist.

3.4.4 Summary

Figures 3.3 - 3.7 provide a graphical depiction of the discussion of consumption, inventories, and marketed surplus found in the preceding three sections. In essence, the statistical analysis to be conducted in the next chapter seeks to explain the pictures presented in these figures in terms of the theoretical model developed in Chapter 2. Specifically, the goal is to relate these observed movements of consumption, inventories, and marketed surplus to movements in exogenous prices, controlling for differences among

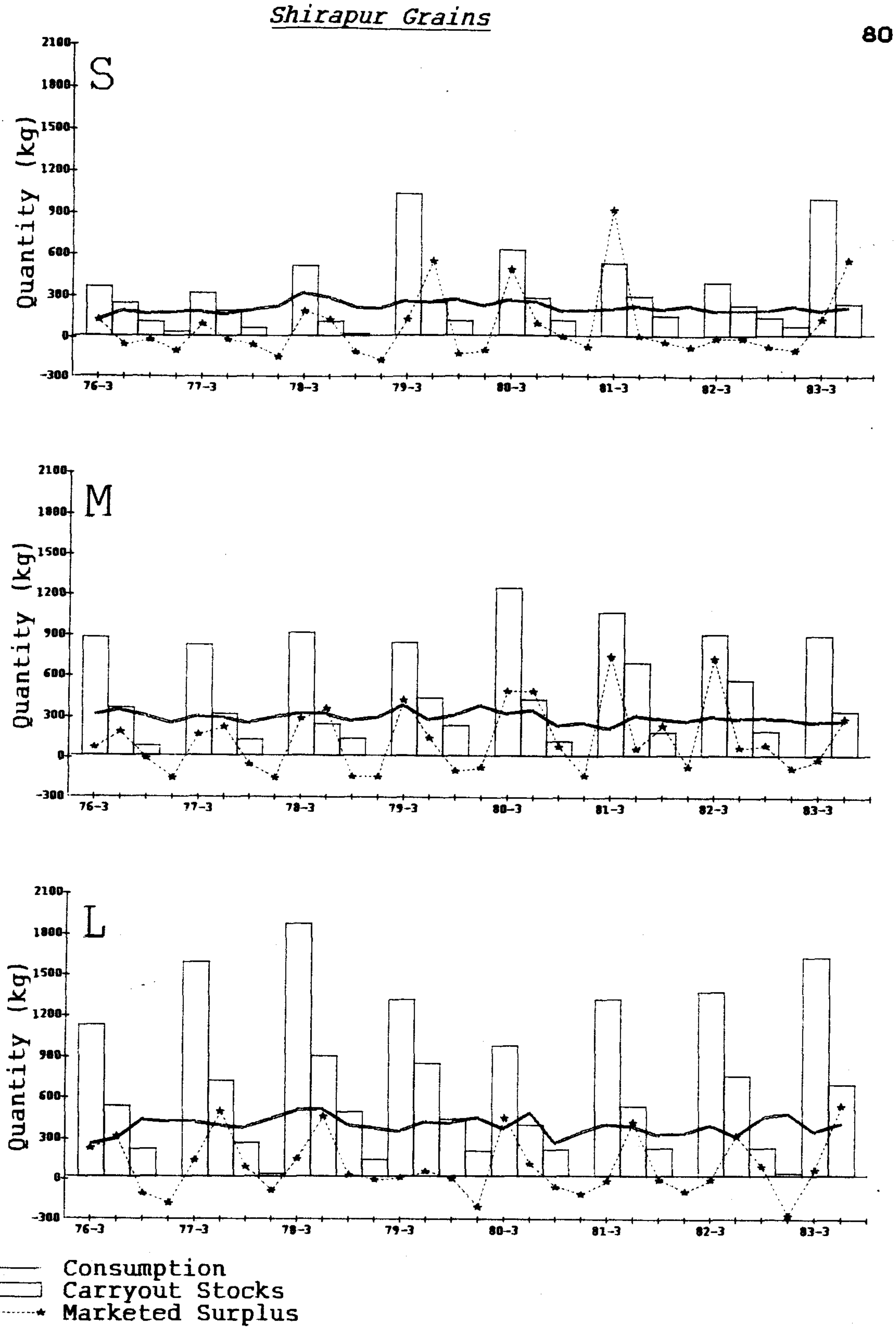


Figure 3.3 Consumption, Carryout, and Marketed Surplus of Grains for Small (S), Medium (M), and Large (L) Farms in Shirapur

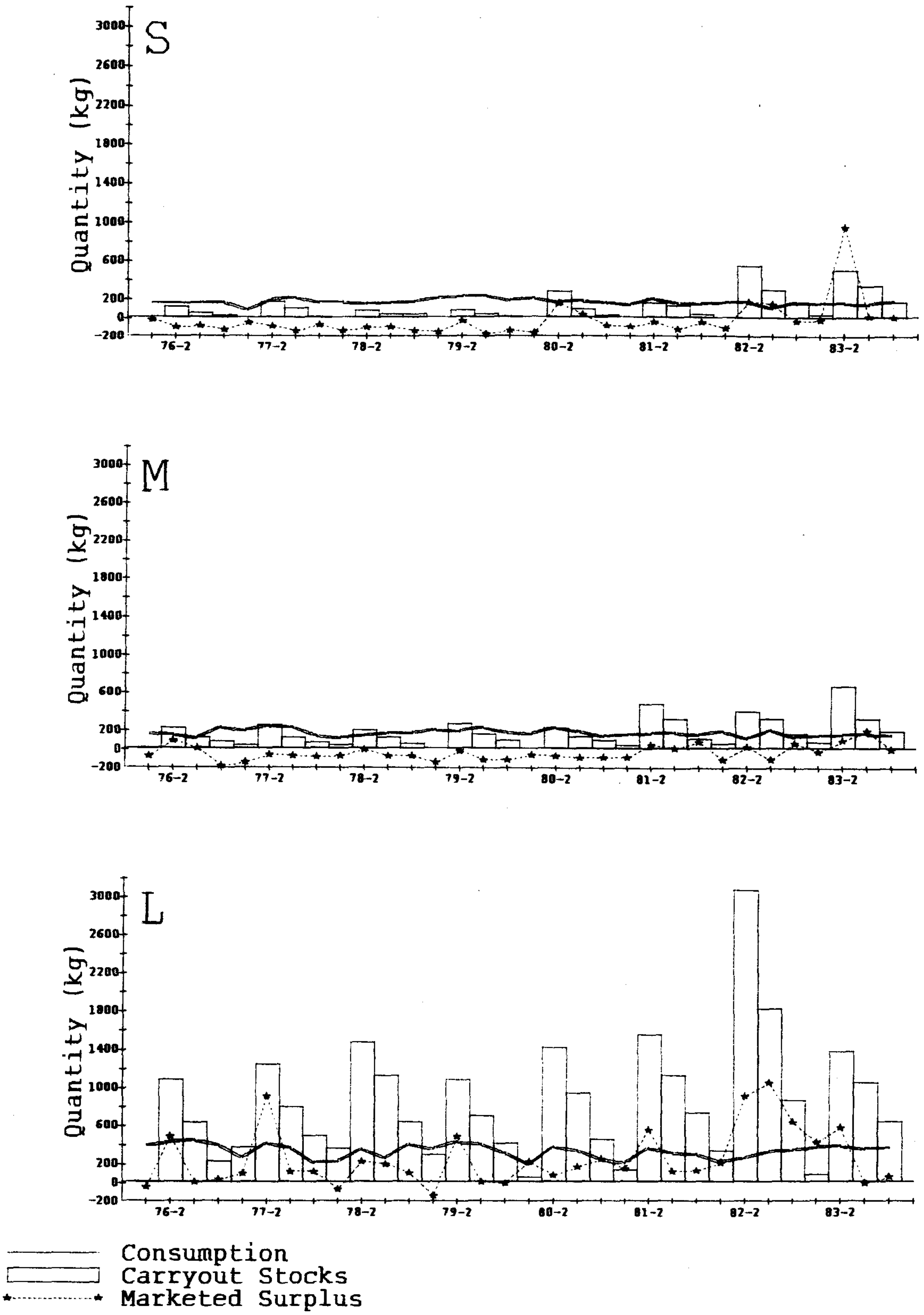


Figure 3.4 Consumption, Carryout, and Marketed Surplus of Sorghum for Small (S), Medium (M), and Large (L) Farms in Kanzara

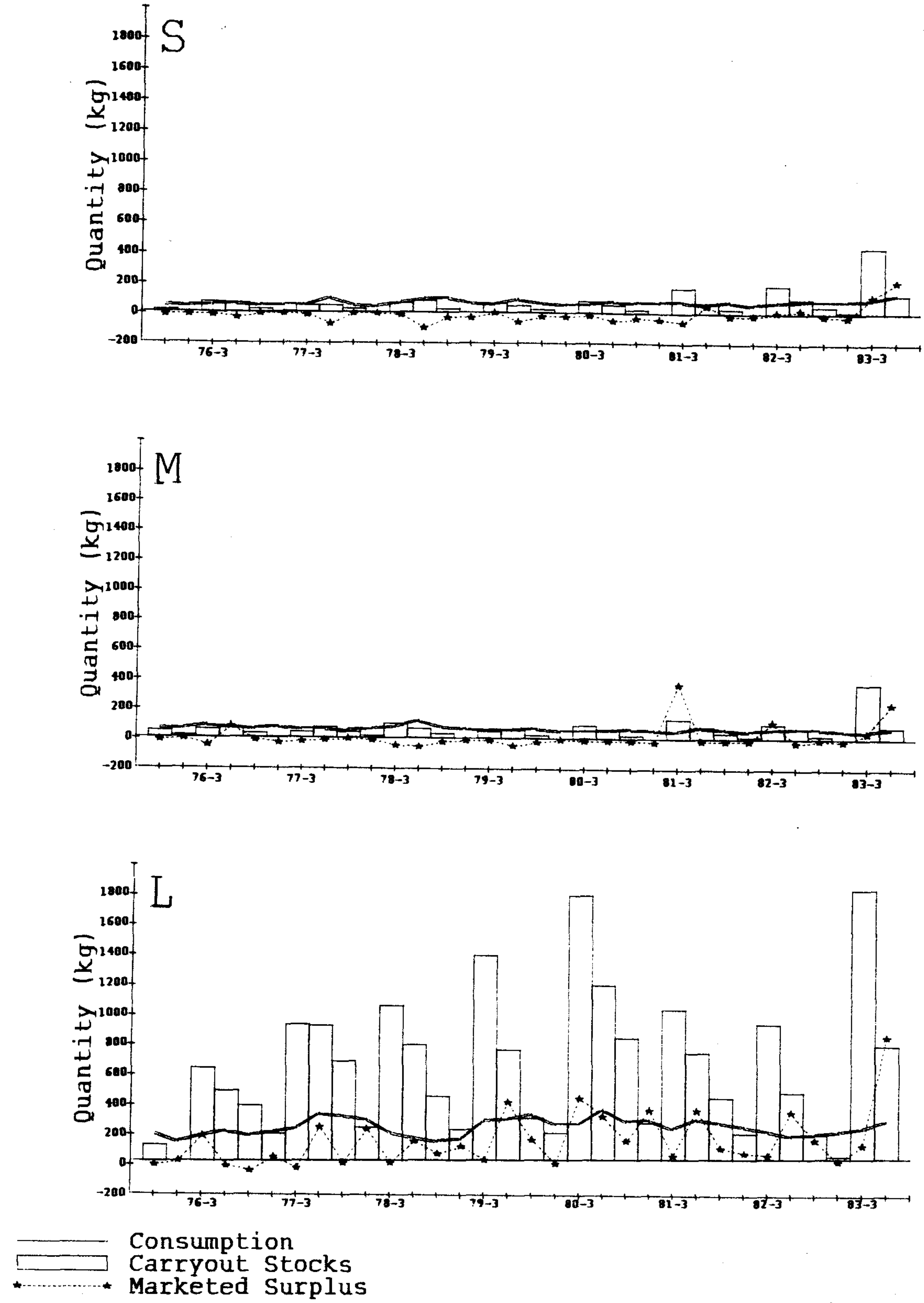


Figure 3.5 Consumption, Carryout, and Marketed Surplus of Wheat and Pigeonpea by Small (S), Medium (M), and Large (L) Farms in Kanzara

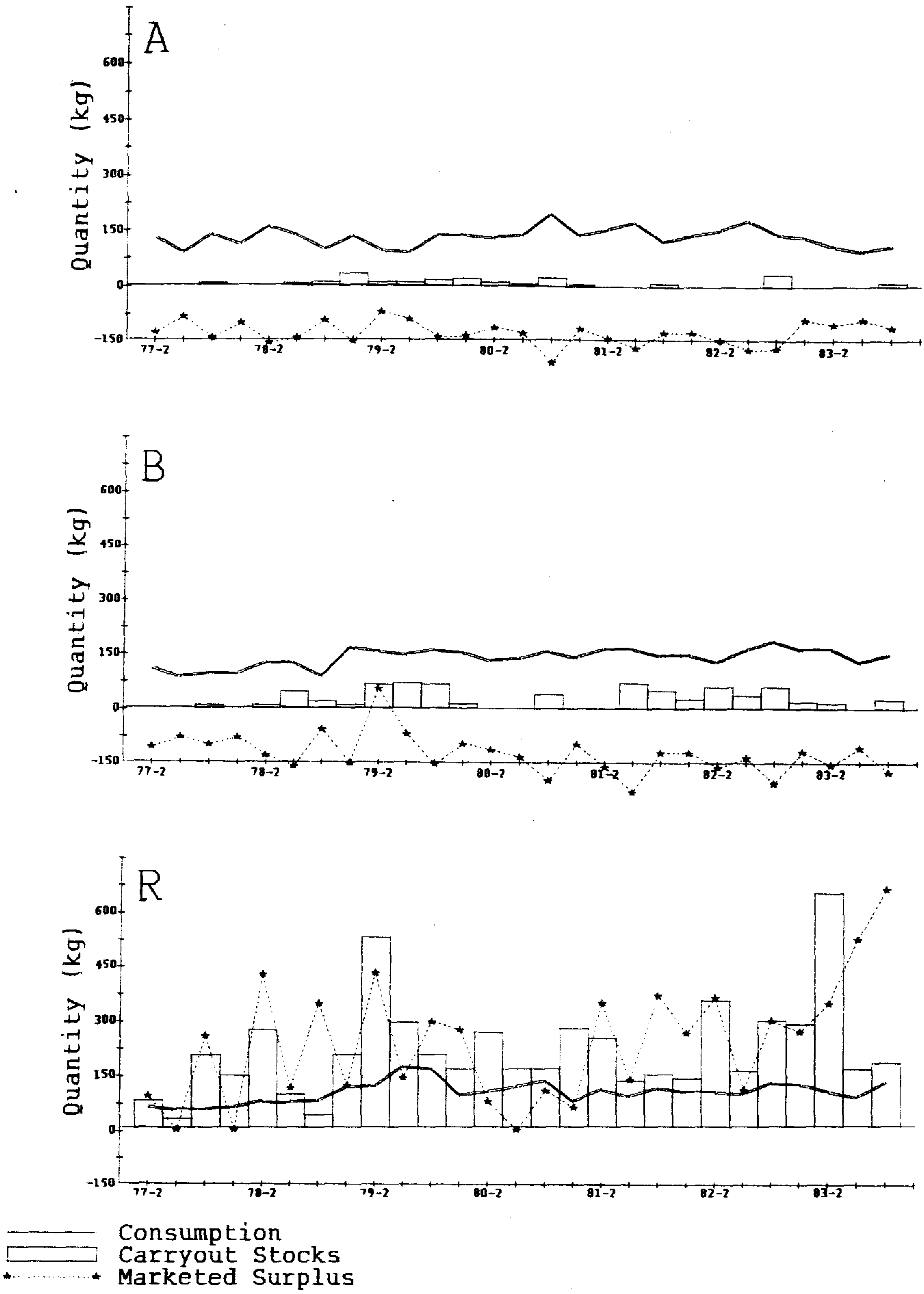
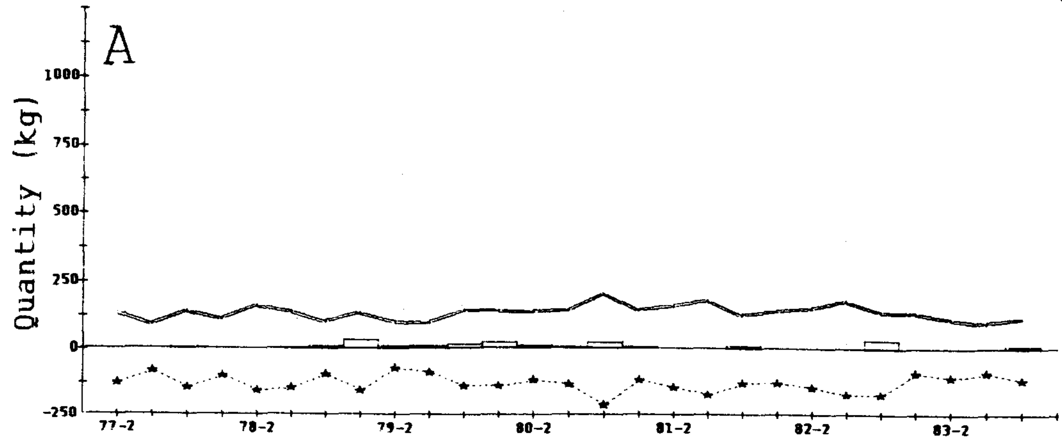
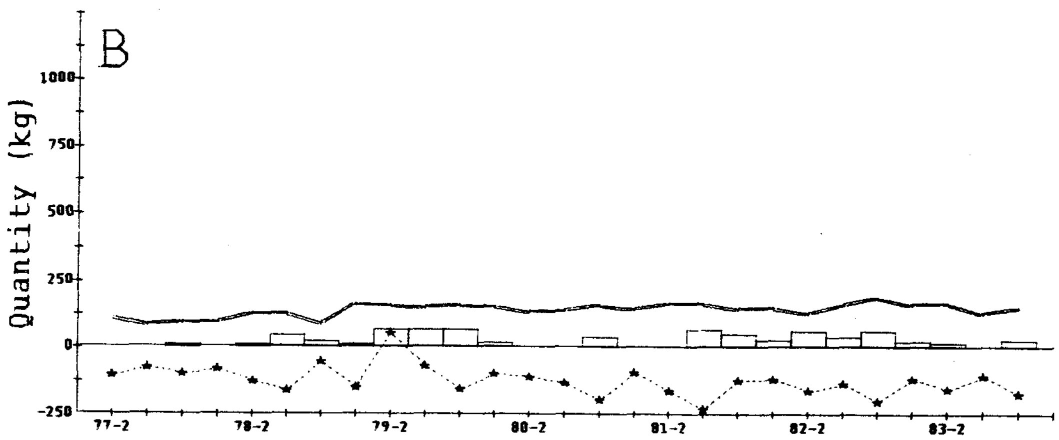


Figure 3.6 Consumption, Carryout, and Marketed Surplus of Coarse Grains for Non-rice Growing (A, B) and Rice Growing (R) Farms in Aurepalle





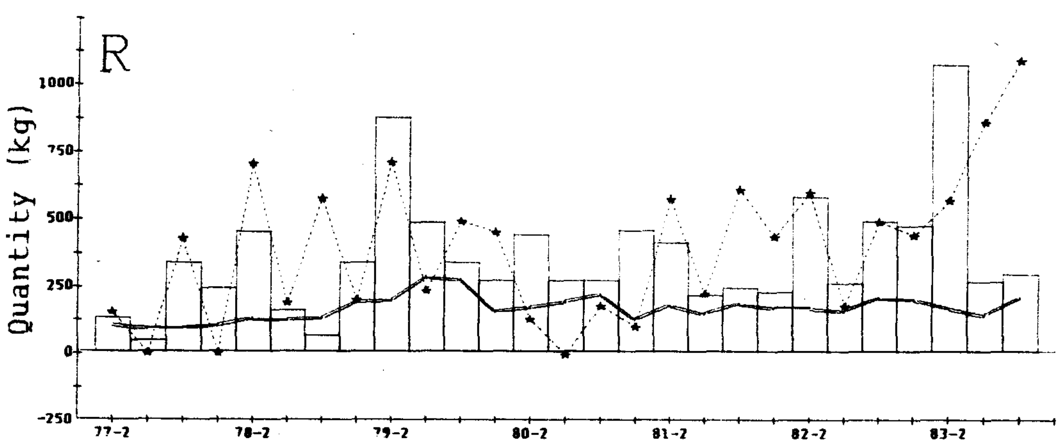


Figure 3.7 Consumption, Carryout, and Marketed Surplus of Rice for Non-rice Growing (A, B) and Rice Growing (R) Farms in Aurepalle

household characteristics and time trends.

Perhaps the most striking feature of the graphs presented in Figures 3.3 - 3.7 is the stability of consumption relative to both carryout stocks and marketed surplus. The analysis in section 3.4.2 indicated that no significant seasonal pattern of per capita consumption of stored commodities was evident in thirteen out of fifteen village-farm type-commodity combinations.

Another prominent feature found in Figures 3.3 - 3.7 is the pattern of steady decline of inventories throughout the period between harvests. Additionally, most households tend to be net purchasers of the stored commodities in the latter half of the inter-harvest period. It thus appears that in the quarters immediately following harvest most households consume the most important staple foods largely out of their own stocks, while in the latter part of the growing season these households rely more heavily on market sources. Those households for which this description doesn't pertain -- large farm households in Kanzara and rice growers in Aurepalle -- are those which are better endowed with land and other productive resources (e.g. irrigation facilities) associated with a higher wealth status.

Pursuant to the discussion of the descriptive statistics that has been presented in this section, several hypotheses may now be advanced regarding intra- and inter-village differences in household inventory demand. The empirical analysis to be conducted in the next chapter will in part be directed at addressing these hypotheses.

Hypothesis I: The inventory demand of larger and better endowed farms will tend to be more price responsive than smaller and less well-endowed farms

A commonly stated opinion among those familiar with Indian villages is that market sales of harvested food grains is typically motivated by the need to meet pressing financial obligations (the so-called "distress sales"). To the extent that this is true, only the most well-endowed farms would be able to hold onto stocks of food in anticipation of perceived future increases in the prices of those foods.

Hypothesis II: Food security motives dominate profit motives in affecting the inventory demand of less well-endowed farm households

Due to liquidity constraints and presumed risk aversion, poor agricultural households in developing countries are often viewed as being relatively limited in their ability to take advantage of market opportunities. Rather, they are often thought of as attempting to be as self-reliant as possible, especially regarding food consumption. If this is the case, then inventory demand should prove to be price inelastic for poorer households with smaller landholdings, while elasticities of inventory demand with respect to consumption ought to be inversely related to the wealth status.

Hypothesis III: Inventory demand in villages for which there exist fewer cash cropping alternative for generating income will be more price responsive

Among the villages considered here, Shirapur is the one with the most limited opportunities for farmers to generate income via the production of cash crops. In Kanzara, a large proportion of the agricultural resources of all farms is devoted to the cultivation of cotton, while in Aurepalle castor is grown by nearly all farmers. If this hypothesis is true then the price elasticities of inventory demand for Shirapur should be higher than for the other villages.

Hypothesis IV: Food security motives figure more prominently in determining inventory demand in villages that are more drought prone

Shirapur stands out as the most drought-prone of the three villages considered, while Kanzara enjoys the most assured rainfall. Assuming that markets are equally efficient in all three villages, elasticities of inventory demand with respect to consumption ought to be larger in Shirapur and smaller in Kanzara for similarly endowed farm households if this hypothesis is true.

Appendix 3

DATA CONSTRUCTION

As mentioned above, the VLS data is organized into five schedules covering demographic variables, agricultural production, holdings of physical stocks and financial assets, family labor, and transactions. This section describes the procedures used to compute carryout stocks and to construct price and quantity indices.

A3.1 Computing Disappearance of Stored Commodities

Commodities for which inventory series were constructed are rice and coarse grains (sorghum and millet) in Aurepalle, sorghum and wheat in Shirapur, and sorghum, wheat, and pigeonpeas in Kanzara. In order to compute levels of carryout stocks for a storable commodity it was necessary to use the VLS production, transactions, and (in a few instances) stock schedules. In principle, the procedure was straightforward. For a given level of carryin stocks, carryout levels may be computed as carryin plus output net of seed use plus net in-kind transactions less consumption plus purchases less sales. However, some difficulties arose that greatly complicated efforts to construct inventory and consumption series.

The first difficulty encountered was that in nearly all cases, a sizable discrepancy existed between the output given in the production schedule and the disappearance of that output over the period extending until the next harvest. For the most part, reported net output[23] exceeded reported disappearance. Two likely reasons for this were thought to be storage losses due to pests and weight loss as harvested grain was dried. Based on information obtained in informal interviews with respondents, it was assumed that these losses were 20 percent for rice and 10 percent for coarse grains in Aurepalle; 10 percent for sorghum, wheat, and pigeonpea in Kanzara; and 5 percent for sorghum and wheat in Shirapur. Even after doing this, discrepancies existed between reported production and disappearance. This discrepancy was removed by scaling all reported transactions for the cropping season up or down by a common proportion such that disappearance for the season exactly equalled net output less year-to-year stock changes.[24,25]

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[23] Throughout this discussion, net output refers to total output (in kilograms) less seed use during the period between harvests.

[24] In nearly all cases, households exhaust their stocks of staple foods by the end of the cropping year (i.e. before the next harvest). This is largely due to the fact that in semi-arid settings with unimodal rainfall and one harvest annually, most households are unable to harvest more than a year's worth of food in most seasons. Also, few of the households considered here felt that they could store grain for over one year without tremendous losses. In a few instances -- primarily among paddy growers in Aurepalle -- some grain was carried over beyond the next harvest. Such behavior was manifested in the data as sales of huge quantities (in excess of the amount most recently harvested).

[25] It would have been simpler to rescale net output to remove the discrepancy; however, it was generally felt by the enumerators that the values reported in the production schedule were far more reliable than those reported in the

A second difficulty encountered had to do with large quantities of a storable commodity purchased or received in kind. In-kind receipts of paddy in excess of 100 kilos as payment for harvesting or threshing work were common for households active in the daily labor market in Aurepalle. Similarly, large amounts of sorghum were sometimes received in-kind for such households in Shirapur and Kanzara. Generally, it was assumed that in-flows of less than 100 kilos were consumed in the quarter in which they took place. In-flows in excess of this amount were handled in one of two ways. If the data showed consumption out of own-production in all quarters, then the large in-flow was added to net output prior to rescaling (i.e., it was proportionately distributed among all reported transactions). If, on the other hand, such a large in-flow occurred in a period in which little or no consumption out of own-production was reported, then the inflow was split evenly among the quarters for which no consumption was reported. This latter case was by far more common.

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transactions schedule. This is hardly surprising. Harvests occur over a fairly short period of time and are likely to be accurately measured by farmers wishing to know "how well they've done" for the season. In constrast, transactions involving the allocation of that harvest occur more or less continuously over the year. Errors in recalling some of these many transactions seems highly likely among even the best-intentioned respondents. Another likely explanation is that most respondents were the male heads-of-household who, while certainly more knowledgable about production and large market transactions of agricultural commodities, may not have been as knowledgeable as their wives about consumption and petty transactions.

Very little use was made of the VLS stock schedule. Eliciting accurate information concerning assets and inventories held by respondents is perhaps the most difficult task in a household survey of this type, and data contained in this schedule was felt to be unreliable -- especially for the early years of the sample. As has already been observed, it was assumed in most cases that inter-year storage did not take place (see footnote 12), so the re-scaling of reported transactions could be calibrated to the end-of-season inventory levels (i.e., to zero).[24] No harvests occurred in the last quarter considered (1983-4), however, so carryout stocks reported in the stock schedule for that quarter were used to calibrate inventories held in the final few quarters (i.e., between the final recorded harvest and 1983-IV).

The only pulse for which significant inventories are held in any of the villages is pigeonpea in Kanzara. Whereas consumption of grains out of own-production could be inferred from the data as the quantity ground into flour or milled into rice in a particular quarter, such an inferrence could not be made for pigeonpea: Unlike grains, which are stored in raw form and converted into an edible form shortly before being consumed, pigeonea is usually converted into

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[24] In the few instances in which stocks were held beyond the end of the growing season, calibration was based on the "zero carryout cropping seasons" bracketing the period in which inventory levels were always positive.

edible form immediately upon acquisition. It was assumed, therefore, that pigeonpea not sold or paid out in kind was consumed in equal amounts in each of the four quarters of the year.

A3.2 Price Indices

Price data were derived from the VLS transaction schedule. This schedule reports both value and quantity for all transactions undertaken by a household. For each recorded transaction, a price was imputed by dividing the value of consumption by the quantity consumed. For each quarter, the mean of all imputed prices for a particular commodity was used as an average quarterly price. These average prices were then deflated by a village-specific consumer price index (see Table 3.5).

Fixed-weight price indices for particular commodity groups were then constructed as weighted averages of these quarterly prices. Commodities were first grouped into aggregates (see Section A3.3 below). For each aggregate, two to four of the most important commodities in the group were used. The weights used in constructing the indices were the ratio of the total value of consumption (over the entire sample) of the specific commodity to the summed total value of consumption of all commodities used in forming the index.

The choice of which commodity prices to use in forming each price index was based on the its importance relative to the other goods in the group and the number of quarters in which transactions were recorded. In all cases the commodities used in forming the group price index accounted for over 70 percent of the total value of consumption of the aggregate over the entire sample period. In a few instances, transactions were not recorded for a particular commodity in a few quarters. In these cases, missing values were "filled in" by linear interpolation based on the observations bracketing the missing values.

A3.3 Quantities Indices

In each village, six to eight commodity aggregates were formed. The choice of commodities to include in an aggregate was guided by two factors: the degree to which the prices of the various commodities moved together and a desire to make the groupings for the different villages as nearly the same as possible (to facilitate cross-village comparisons).

Given the focus on inventories, storable commodities were grouped together in all villages. In Aurepalle, rice, sorghum and pearl millet were stored by all households. Since there was a strong positive correlation between the prices of millet and sorghum (Pearson correlation coefficient greater than .90), these were combined into a "coarse grains" aggregate. There was not a significantly positive correlation between the prices of the coarse grains and rice, however, and so these were kept separate. A similar procedure led to the formation of two groupings of storable commodities in Kanzara, one composed of sorghum, the other of wheat and pigeonpea. In Shirapur, the only commodities stored in large quantities are sorghum and wheat. Since the prices of these commodities are strongly correlated, these were combined.[27]

Aggregation of non-storable commodities was guided by the same considerations as those described above for storable goods. To a large extent, roughly the same commodities are consumed in each of the three villages (in different proportions, of course). The primary differences between villages lies in the dominant staple food -- rice in Aurepalle, sorghum in Shirapur and Kanzara. Tables A3.1 - A3.3 describe the various commodity groupings for the three villages.

For all non-storable commodities the value of consump-

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[27]A problem occurred in those instances where two storable commodities were combined. It was not appropriate to use value measures as quantity indices because changes in prices from one quarter to the next would have implied a spurious appreciation or depreciation of the quantity stored. On the other hand, it was undesirable to simply add the quantities of two different goods together. The procedure adopted was to weight the quantity of one of the two goods by the ratio of its mean price (over the entire sample period) to the mean price of the other stored good in the aggregate and then sum the two together. To the extent that the market's valuation of the individual commodities (on a per calorie or even per "util" basis) is reflected by market prices, this procedure appears to be an appropriate way of handling the problem.

tion of each of the commodities within the aggregate were summed for each quarter. After deflating by the village-specific Consumer Price Index (Table A3.4), these were divided by the associated price index to form a value-based quantity index. For storable grains this was not feasible because of the carryover of inventories -- i.e., changes in prices from one quarter to the next would have implied appreciation or depreciation of the stored quantity. The procedure that was adopted for computing quantity indices for groups of stored commodities was that described in footnote 15.

In the analysis to be conducted in Chapter 4, the level of aggregation of non-stored commodities is greater than that found in Tables A3.1 - A3.3.[28] All home-produced foods -- including non-stored grains, pulses, vegetables, and animal products -- were collected together into an aggregate along the lines of X_{2t} in the theoretical model. Likewise, all commodities obtained exclusively through market purchases -- including non-food, oils, and sugars -- were grouped together. Identical procedures to those described above were used to form the price and quantity indices for the broader aggregates.

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[28] The data set containing the expanded set of commodity groupings is a potentially fruitful source for a more highly disaggregated analysis of commodity demands among semi-subsistence households in SAT India. Such an analysis is deferred to a later date.

Table A3.1 Commodity Groupings for Shirapur

Group	Commodities Included
Storable Grains*	Sorghum, wheat
Oils and oilseeds	Groundnuts, cooking oils
Animal Products	Milk, meats, eggs, ghee, fish
Pulses	Pigeonpea, chickpea and other dhals
Sugars	Granulated sugar, jaggery, sweets,
Vegetables	Onions, chillies, eggplant,tomato, other spices, other vegetables
Other Cereals	Millets, maize, rice
Non-food	

* Asterisk denotes that the commodity is stored.

Table A3.2 Commodity Groupings for Kanzara

Group	Commodities Included
Sorghum*	Sorghum
Other Stored Food*	Wheat, pigeonpea
Vegetables	Onions, chillies, eggplant,tomato, other spices, other vegetables
Oils, Sugars	Cooking oil, granulated sugar, jaggery, sweets,
Animal/Other Products	Milk, meats, eggs, ghee, fish chickpea and other dhals,
Non-food	

* Asterisk denotes that the commodity is stored.

Table A3.3 Commodity Groupings for Aurepalle

Group	Commodities Included
Rice*	Local and hybrid varieties
Coarse Grains*	Sorghum, millets
Sugars, Oils	Granulated sugar, jaggery, sweets, cooking oil,
Vegetables, Milk	Milk, onions, chillies, eggplant, tomato, other spices, other vegetables
Pulses, Meats, Others	Pigeonpea, blackgram, and chickpea dhals, meats, eggs, ghee, fish, wheat, other pulses
Non-food	

* Asterisk denotes that the commodity is stored.

Table A3.4 Consumer Price Indices for the Study Villages[a]

Cropyear	Aurepalle	Shirapur	Kanzara
1976	100	100	100
1977	102	99	100
1978	91	117	105
1979	108	108	114
1980	121	127	134
1981	141	139	141
1982	146	146	138
1983	155	155	140

a. Simple arithmetic average of CPI's for small, medium, and large farm-size classes.

Source: ICRISAT.

Table A3.5 Farm-size Classification for the Study Villages

Village	Farm-size Groups (in hectares)[a]		
	Small	Medium	Large
Aurepalle	0.21-2.50	2.51-5.25	>5.25
Shirapur	0.21-2.50	2.51-6.00	>6.00
Kanzara	0.21-2.25	2.26-5.60	>5.60

a. On the basis of operational landholding.

Source: Jodha, in Binswanger and Rosenzweig (1984)

Chapter 4

THE DETERMINANTS OF INVENTORY DEMAND

In Chapter 2 a model of semi-subsistence agricultural households was developed. The solution of this model implied a set of testable hypotheses concerning the motives for holding inventories of staple foods as well as a new methodology for computing the price responsiveness of commodity demands and marketed surplus. Chapter 3 provided an overview of the three study villages from which data suitable for implementing and testing the model was collected. A two-part stategy for empirically analyzing the theoretical model was developed, which will be carried out in the next two chapters. The first part -- estimation of the structural parameters of inventory demand -- is undertaken in the current chapter. The second part -- combining the results for inventory demand with estimates of the parameters of commodity demands and output supplies in order to compute marketed surplus elasticities -- will be carried out in the next chapter.

This chapter is composed of three sections. Section 4.1 contains a discussion of econometric issues related to the estimation of inventory demand equations. These include the censored nature of the inventory data; appropriate means of modelling price expectations; and the efficient use of cross-sectional time-series data. In Section 4.2, the empirical results of the estimated inventory demand equations for each of fourteen village-commodity-farm type combinations are presented. Statistical tests of the validity of the structural model are conducted, and inferences are drawn regarding hypothesized intra- and inter-village differences in inventory demand behavior postulated at the end of the previous chapter. Section 4.3 summarizes the findings of the empirical analysis.

4.1 Some Econometric Issues

The inventory demand equation to be estimated is a stochastic version of one of the first order conditions of the theoretical model:

$$(4.1) \qquad I_{t+1} = g_0 + f \cdot \Delta P_t + g \cdot X_{1t} + e_t ,$$

where ΔP_t is the difference between the discounted expected value of the price of the storable commodity in the next period and the current price and e_t is an independent, normally distributed error term with zero mean and constant variance σ^2. In order to estimate equation 4.1 it is necessary to first address three econometric issues relating to (i) the censored nature of the dependent variable; (ii) an appropriate proxy for the expectational variable $E_t P_{t+1}$; and (iii) aggregation of the data across households. These are taken up in order below.

4.1.1 Censored Data

As was described in Chapter 3, most households considered in all three villages exhaust their stocks of home-produced food by harvest time. This is reflected in the large number of zero entries for carryout levels in Tables A4.6 -A4.8. While households may well hold negative inventories (in the form of, say, informal borrowing from friends) these are unobservable. Hence, I_{t+1} is a limited dependent variable of the kind analyzed in Tobin's (1958) much-cited paper.

Letting I^*_{t+1} stand for a latent variable describing household demand for inventories (and I_{t+1} for observed carryout),

$$(4.2)\qquad I^*_{t+1} = g_0 + f\cdot\Delta P_t + g\cdot X_{1t} + e_t$$

$$I_{t+1} = \max(0, I^*_{t+1})$$

Define a T x 3 matrix $X = (1, \Delta P_t, X_{1t})$ and the vector $\tilde{\beta} = (g_0, f, g)'$. Letting s equal the number of observations for which $I_{t+1} = 0$ and arranging the data so that for the last s of the T observations $I_{t+1} = 0$, the regression equation becomes

$$(4.3)\qquad E(I_{t+1} | X\tilde{\beta}, I^*_{t+1} > 0) = X\tilde{\beta} + E(e_j | I^*_{t+1} > 0),$$

$$j = 1,\ldots,T-s.$$

The conditional expectation of the error term in 4.3 is non-zero and is given by

(4.4) $$E(e_j \mid I_{t+1} > 0) = \frac{\sigma^2}{(\sigma^2)^{1/2}} \cdot \lambda_j ,$$

where
$$\lambda_j = \frac{f(\psi_j)}{1 - F(\psi_j)},$$

$$\psi_j = -X\tilde{\beta}/(\sigma^2)^{1/2} ,$$

and $f(\cdot)$ and $F(\cdot)$ are the density and distribution functions of a standard normal random variable (Fomby, et al). Estimating equation 4.1 by ordinary least squares using the (T-s) observations in which I^*_{t+1} will
yield biased estimates of the parameters in $\tilde{\beta}$ due to the omission of the conditional expectation of the error term.

Heckman (1974) pioneered the use of a two-step procedure for dealing with censored data of this form. In the first step, a probit model is used to estimate the probability that a positive value of the dependent variable is observed. This produces a consistent estimate of $\tilde{\beta}/(\sigma^2)^{1/2}$ that can be used to compute consistent estimates of ψ_t and λ_t. The second step of Heckman's procedure is to then include the estimated λ_t as a regressor in equation 4.3 and apply least squares to the resulting equation.

The Heckman procedure was applied to the inventory data for each of the three villages. In the first step a variable S^* was created which took the value 1 if positive carryout was observed and 0 otherwise. For each village-commodity group combination, S^* was regressed on the amount of the commodity carried into the quarter (I_t), the price of the commodity, and a set of household and quarterly dummy variables. In order to avoid perfect collinearity between the regressors, one of the household dummies and one of the quarterly dummies was omitted. In all cases, the dummy corresponding to the median household (in terms of average inventory holdings) was omitted. Likewise, in all cases the quarter chosen for exclusion was one of the two not immediately adjacent to the quarter in which harvest occurred. Maximum likelihood probit estimates are presented in Tables 4.1a - 4.1c.

The probit estimates were used to compute estimates of λ_{jt} as given in equation 4.4 above. The computed λ's were used as right hand side regressors in the inventory demand equations to be estimated in section 4.2. For a given household, λ_t is inversely related to the probability that positive carryout will be observed for the household. Lee (pg. 422) has shown that the asymptotic covariance matrix of the parameters estimated using the Heckman procedure is in general heteroskedastic. In order to insure that the correct inferences are made from the parameter estimates, the covariance matrix were estimated using White's heteroskedasticity-consisten estimator.[29]

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[29] Letting v be the n-vector of OLS residuals, X the nxk information matrix, and defining $V = n^{-1}\Sigma_i v_i^2 X_i' X_i$ for i = 1,...,n, the White estimator is $(X'X/n)^{-1}V(X'X/n)^{-1}$.

Table 4.1a: Probit Estimates of Demand for Grain Inventories in Shirapur

Variable	Estimate	S.E.	Asymptotic t-value
Constant	0.892	0.937	0.95
Carryin	0.002	.0005	3.63
Price	0.136	0.697	0.20
HH #1	0.008	0.622	0.01
HH #2	-1.401	0.564	2.48
HH #3	-0.465	0.577	0.81
HH #4	0.053	0.619	0.09
HH #5	-0.146	0.601	0.24
HH #6	-0.417	0.600	0.70
HH #7	-0.365	0.594	0.61
HH #8	-1.109	0.594	1.87
HH #9	-1.045	0.69	1.51
HH #10	0.186	0.679	0.27
HH #11	0.482	0.663	0.73
HH #12	-0.800	0.566	1.41
HH #13	-0.064	0.693	0.09
Qtr. I	-0.306	0.311	0.98
Qtr. II	-2.584	0.376	6.87
Qtr. III	1.668	0.451	3.70
Log likelihood		-107.17	

Table 4.1b: Probit Estimates of Inventory Demand in Kanzara

	Sorghum			Wheat/pigeonpea		
Variable	Estimate	S.E.	t	Estimate	S.E.	t
Constant	-1.387	1.160	1.20	1.226	0.931	1.32
Carryin	0.002	.0005	4.12	0.006	0.002	2.74
Price	-0.537	1.066	0.50	0.070	0.367	0.19
HH #1	0.185	0.438	0.42	-0.029	0.610	0.05
HH #2	-0.156	0.410	0.38	-0.260	0.585	0.44
HH #3	-0.057	0.397	0.14	-0.528	0.540	0.98
HH #4	1.592	0.595	2.68	-0.071	0.569	0.12
HH #5	-1.053	0.407	2.59	-0.214	0.562	0.38
HH #6	-0.206	0.394	0.52	-0.045	0.608	0.07
HH #7	-0.206	0.410	0.50	0.283	0.613	0.46
HH #8	-0.016	0.440	0.04	-0.437	0.636	0.69
HH #9	3.748	2.145	1.75	0.371	0.717	0.52
HH #10	-0.146	0.734	0.20	1.126	1.983	0.57
HH#11	0.973	0.822	1.18	-0.880	0.790	1.11
HH #12	0.967	0.570	1.70	0.350	0.699	0.50
Qtr. II	3.310	0.382	8.66	-2.820	0.343	8.22
Qtr. III	2.258	0.351	6.43	0.151	0.380	0.40
Qtr. IV	2.043	0.335	6.10	1.655	1.492	1.11
Log likelihood		-127.53			-134.94	

Table 4.1c: Probit Estimates of Inventory Demand in Aurepalle

	Rice			Coarse Grains		
Variable	Estimate	S.E.	t	Estimate	S.E.	t
Constant	-0.204	0.740	0.28	-5.780	2.080	2.78
Carryin	.0003	.0005	0.57	0.007	0.002	3.25
Price	-0.684	0.456	1.50	5.548	2.515	2.21
HH #1	1.920	0.435	4.41	0.264	0.587	0.45
HH #2	2.080	0.447	4.65	0.639	0.621	1.03
HH #3	-0.083	0.448	0.19	-0.104	0.531	0.20
HH #4	0.109	0.435	0.25	0.692	0.586	1.18
HH #5	0.741	0.405	1.83	0.075	0.562	0.13
HH #6	0.293	0.422	0.69	0.710	0.574	1.24
HH #7	-0.163	0.504	0.32	0.403	0.635	0.63
HH #8	3.901	1.752	2.23	0.921	0.636	1.45
HH #9	-0.079	0.448	0.18	0.122	0.566	0.22
HH #10	2.063	0.513	4.02	2.312	2.923	0.79
HH #11	0.651	0.417	1.56	0.204	0.547	0.37
HH #12	2.448	0.479	5.11	0.523	0.551	0.95
HH #13	1.045	0.410	2.55	0.118	0.599	0.20
HH #14	2.572	0.570	4.51	0.373	0.590	0.63
Qtr. II	-0.011	0.234	0.05	3.120	0.374	8.34
Qtr. III	-0.442	0.242	1.83	2.697	0.507	5.32
Qtr. IV	2.072	0.276	7.51	1.634	0.264	6.19
Log likelihood		-137.07			-87.70	

4.1.2 Price Expectations

In order to empirically analyze the determinants of inventory demand it is necessary to come up with suitable measures of one-step-ahead price forecasts for stored commodities. As noted earlier, possible candidates include using current prices, ARMA forecasts, or actual realized prices in computing ΔP_t. Use of ARMA forecasts seems preferable on a number of grounds. First, the assumption of static expectations implicit in the use of a current price as a proxy for expected price is simply a special case of a general AR1 model -- one in which the coefficient on the lagged price equal to one (i.e. a random walk). Second, ARMA models are easily specified and the forecasts can be easily computed using any number of software packages. Finally, the assumption of perfect foresight implied by using realized prices in place of some kind of price forecast seems implausible.

For these reasons, the measures of expected prices to be used here are based on the ARMA forecasts determined by applying standard Box-Jenkins techniques. Since the only price data available is for the same period over which the estimation takes place, it is assumed that the time series of prices are ergodic -- i.e. the time series behavior of a given price over any two finite time frames will be identical. This is a strong assumption, but also one which is unavoidable (and untestable) given the data available.

The best fitting ARMA models describing the time series behavior of the prices of the stored commodities considered are given in Table 4.2. For grains in Shirapur, rice in Aurepalle, and wheat in Kanzara, the data is best fit as an AR1 process. In these cases, Dickey-Fuller tests cannot reject the null hypothesis of unit root non-stationarity -- that is, prices seem to follow a random walk. Sorghum prices in Kanzara are best approximated by an MA2 process, while coarse grain prices in Aurepalle follow an AR2 process. Unit root non-stationarity is rejected in both these cases.[30]

Figures 4.1 - 4.5 depict the time series of prices and the ARMA price forecasts for the stored commodities of interest. It will be observed that the ARMA forecasts track the actual price movements rather well. Over the sample period, the prices exhibited a fair degree of quarterly variation. Interestingly, none of the series seem to fit the sawtoothed seasonal pattern that might have been expected a priori. This may be seen by examining the average prices for each quarter over the sample period (Figure 4.6). Only in the cases of sorghum in Kanzara and coarse grains in Aurepalle do prices rise (on average) over the cropping cycle, and even in these instances the price increases are

[30] The Dickey-Fuller test statistics are as follows. Shirapur grains: -1.69; Kanzara sorghum: -4.26; Kanzara wheat and pigeonpea: -2.38; Aurepalle rice: -1.67; Aurepalle coarse grains: -5.54. The 95% critical value of the test statistic is -2.99.

Table 4.2 ARMA Forecast Models for Prices of Stored Commodities in the Study Villages

<u>Shirapur Grains (AR1)</u>

$$P_t = 0.183 + \underset{(0.103)}{0.844}\, P_{t-1} + \epsilon_t, \qquad Q^a = 2.92$$

<u>Kanzara Sorghum (MA2)</u>

$$P_t = 0.994 + \epsilon_t + \underset{(0.122)}{1.230}\, \epsilon_{t-1} + \underset{(0.122)}{0.764}\, \epsilon_{t-2} + v_t \qquad Q = 2.77$$

<u>Kanzara Wheat/pigeonpea (AR1)</u>

$$P_t = 0.208 + \underset{(0.074)}{0.907}\, P_{t-1} + \epsilon_t, \qquad Q = 2.11$$

<u>Aurepalle Coarse Grains (AR2)</u>

$$P_t = 0.870 + \underset{(0.171)}{0.411}\, P_{t-1} - \underset{(0.172)}{0.550}\, P_{t-2} + \epsilon_t, \qquad Q = 0.75$$

<u>Aurepalle Rice (AR1)</u>

$$P_t = 0.223 + \underset{(0.099)}{0.855}\, P_{t-1} + \epsilon_t, \qquad Q = 5.31$$

a. The Box-Jenkins Q statistic is distributed as a chi-square and tests the null hypothesis that the error term is white noise. In all cases, the p-values of the Q statistics are in excess of .25.

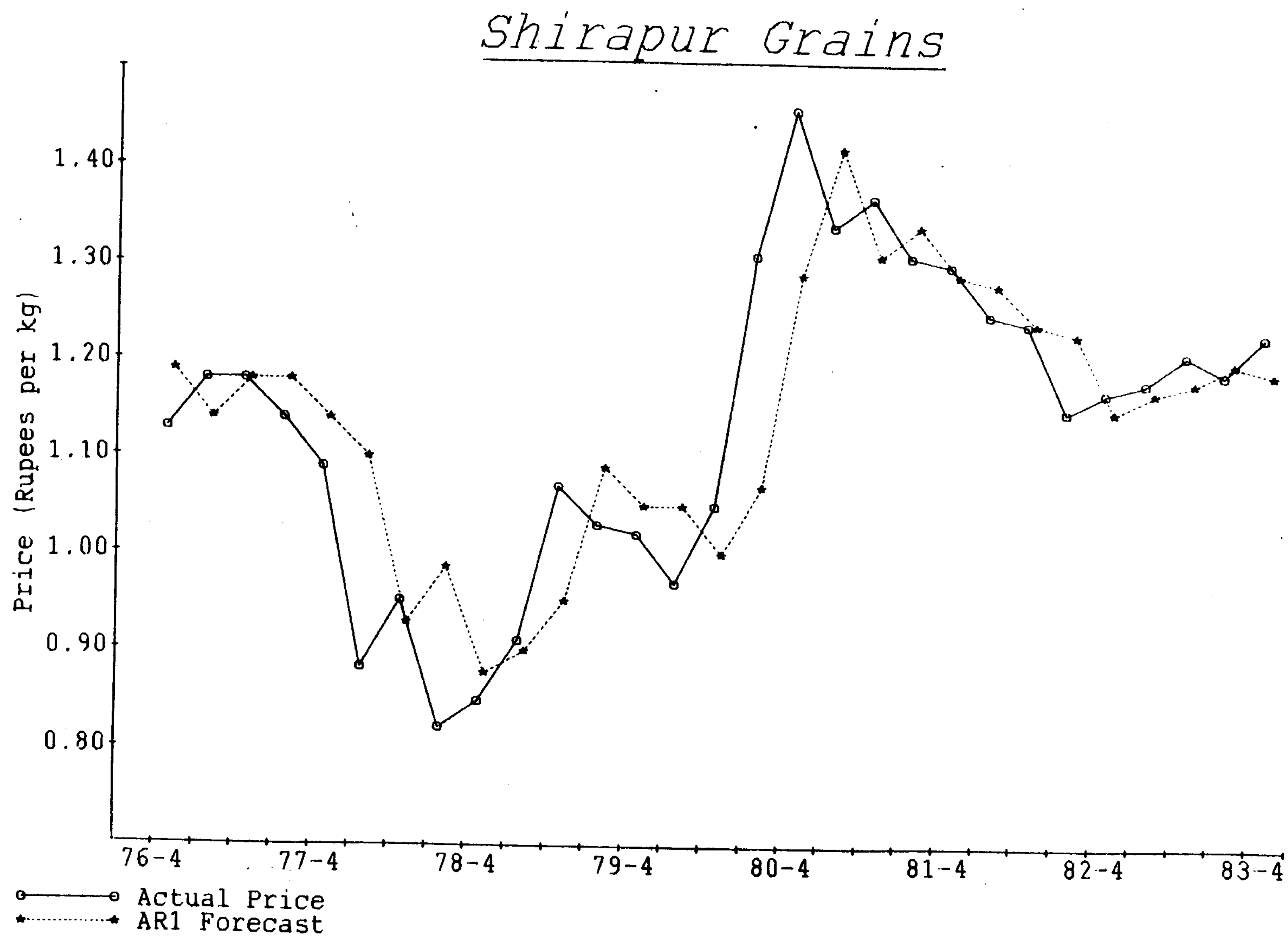

FIGURE 4.1 Comparison of Actual and Forecast Prices of Shirapur Grains

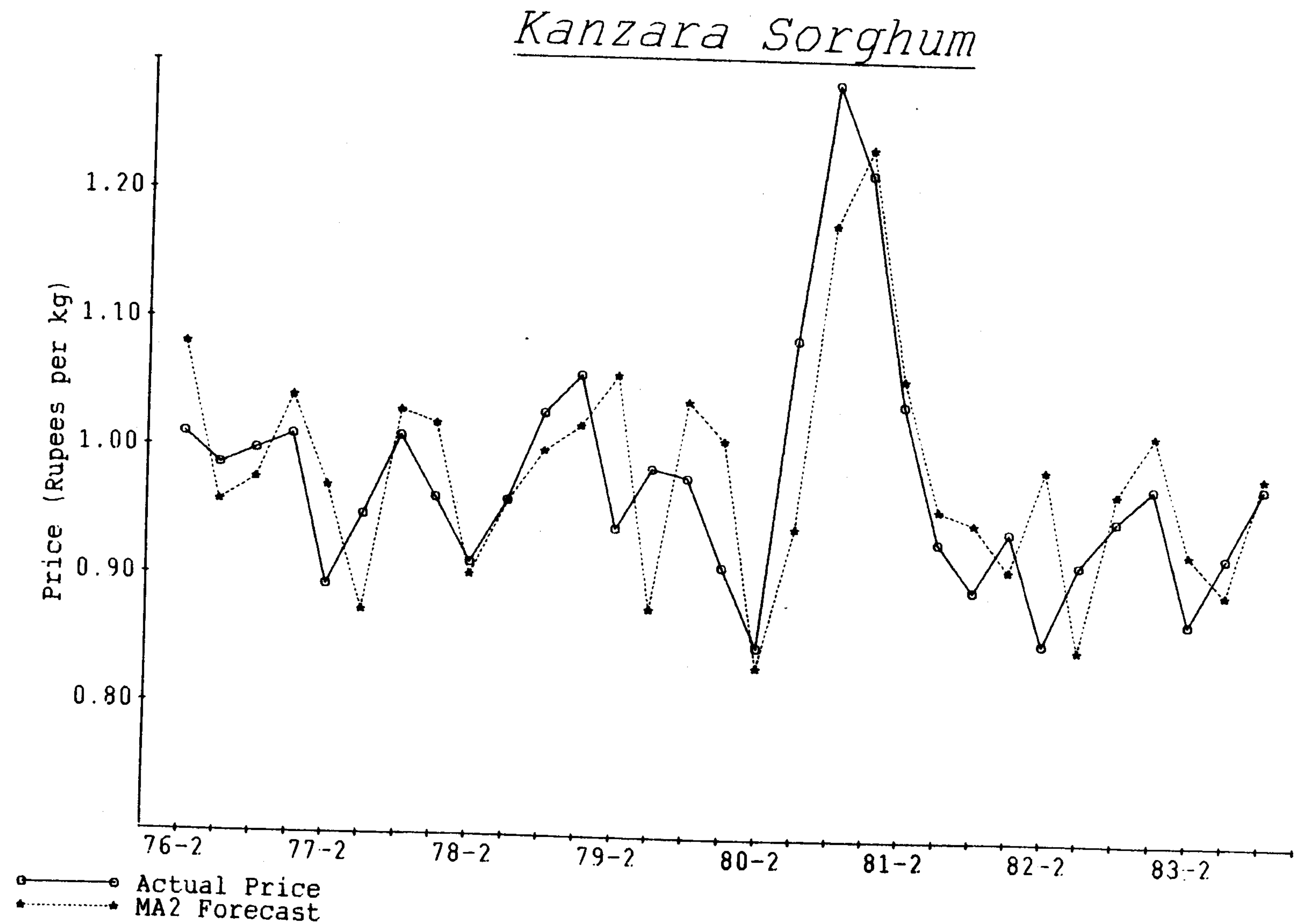

FIGURE 4.2 Comparison of Actual and Forecast Prices of Kanzara Sorghum

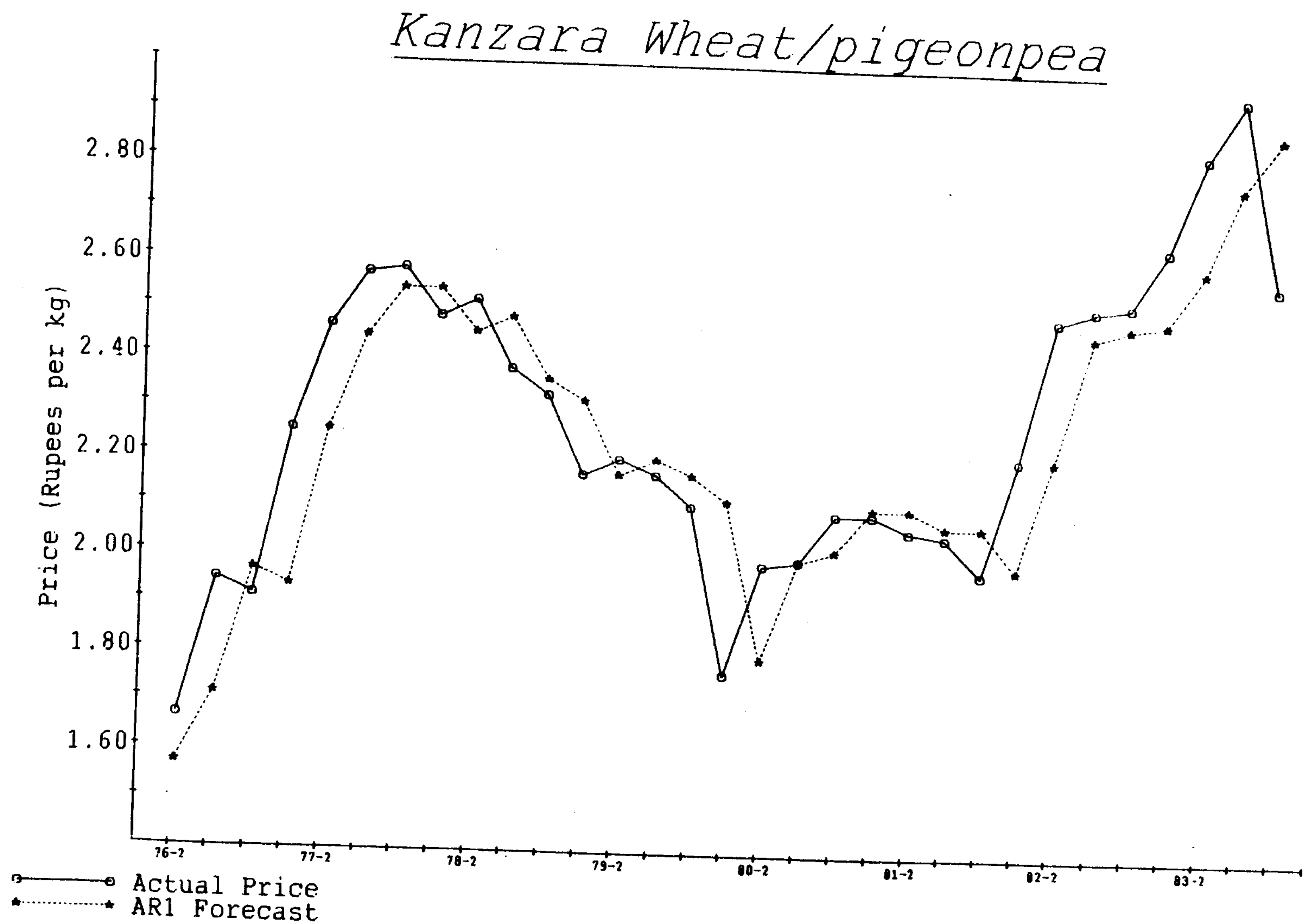

FIGURE 4.3 Comparison of Actual and Forecast Prices of Kanzara Wheat/pigeonpea

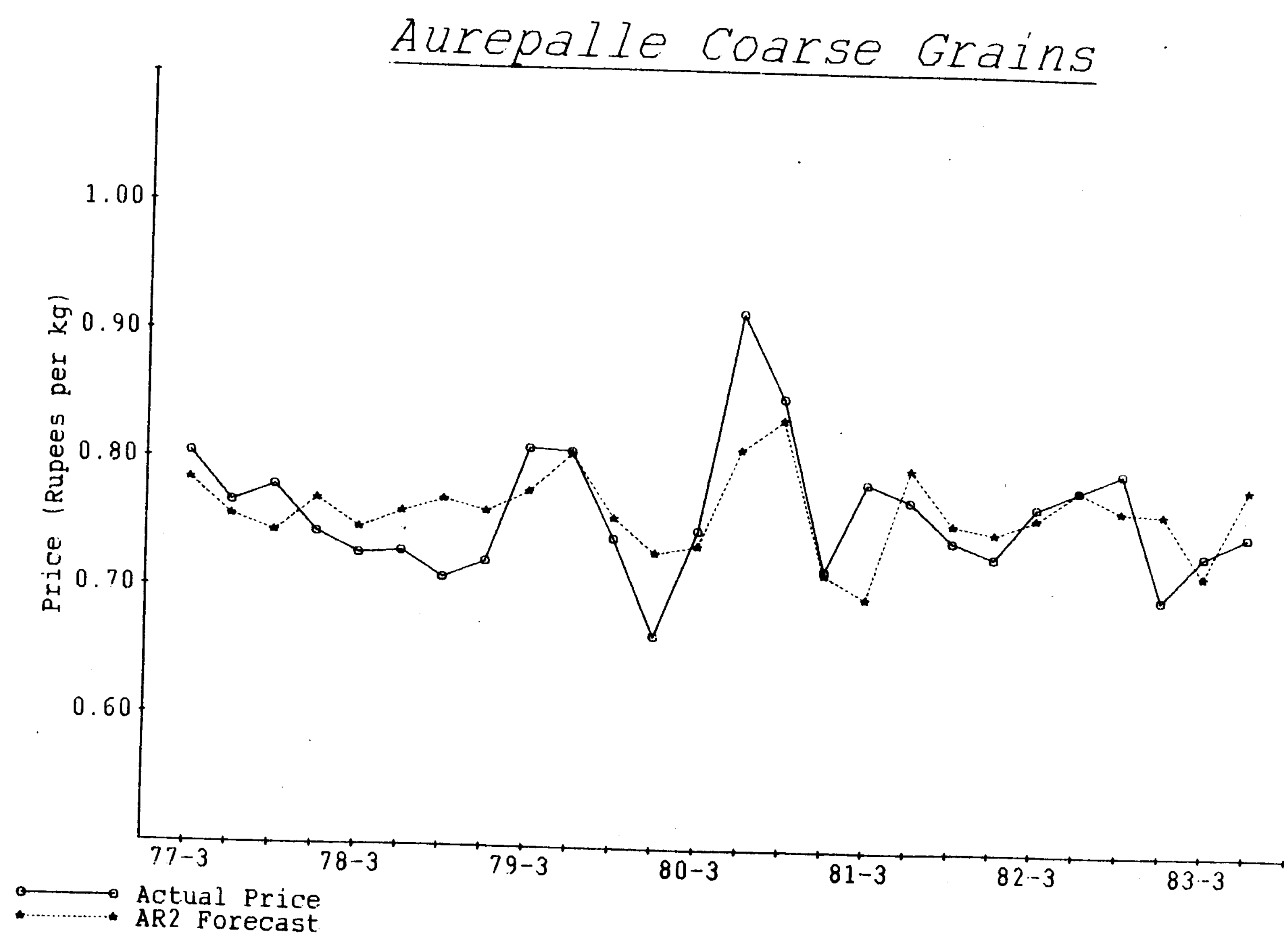

FIGURE 4.4 Comparison of Actual and Forecast Prices of Aurepalle Coarse Grains

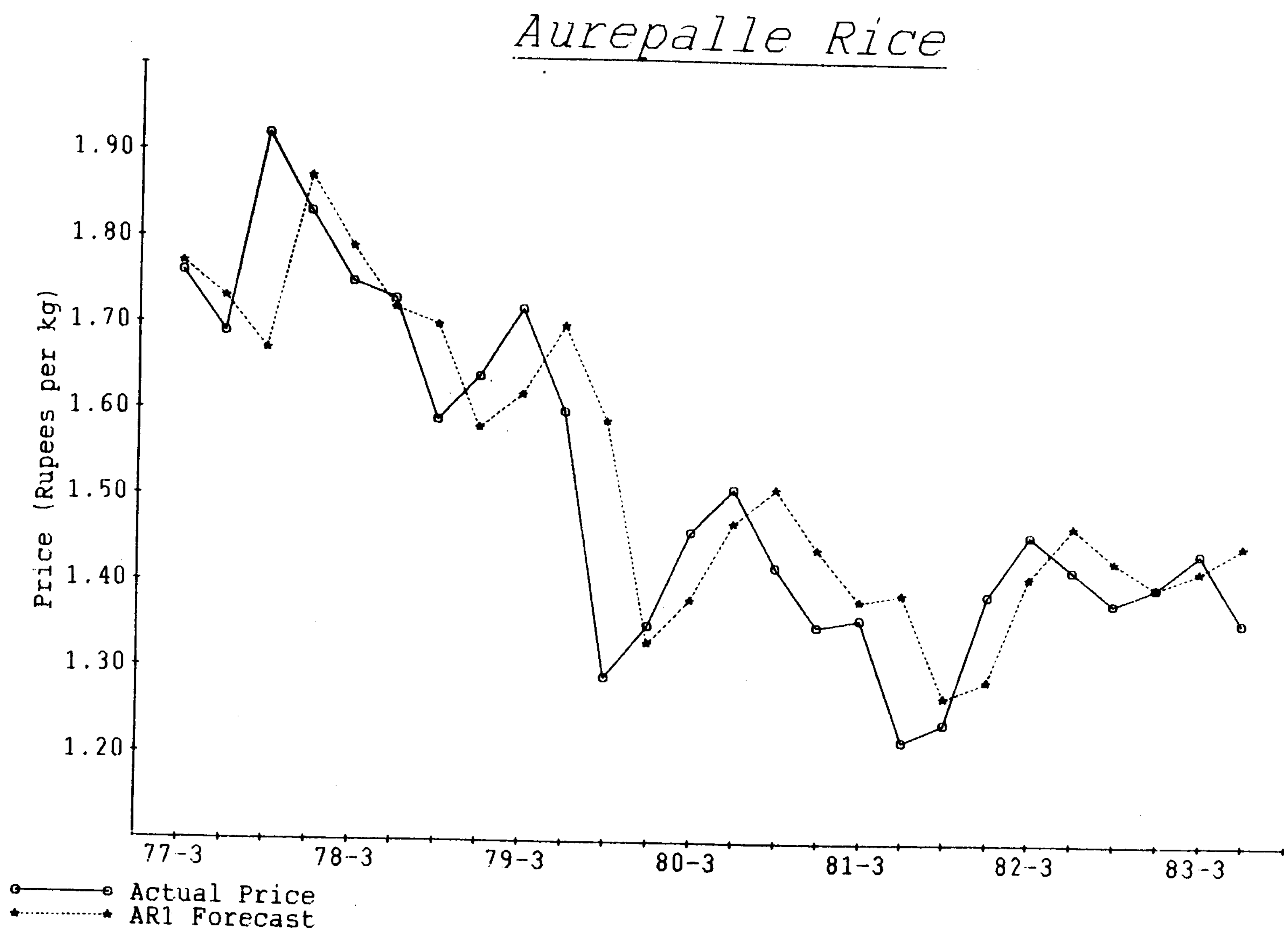

FIGURE 4.5 Comparison of Actual and Forecast Prices of Aurepalle Rice

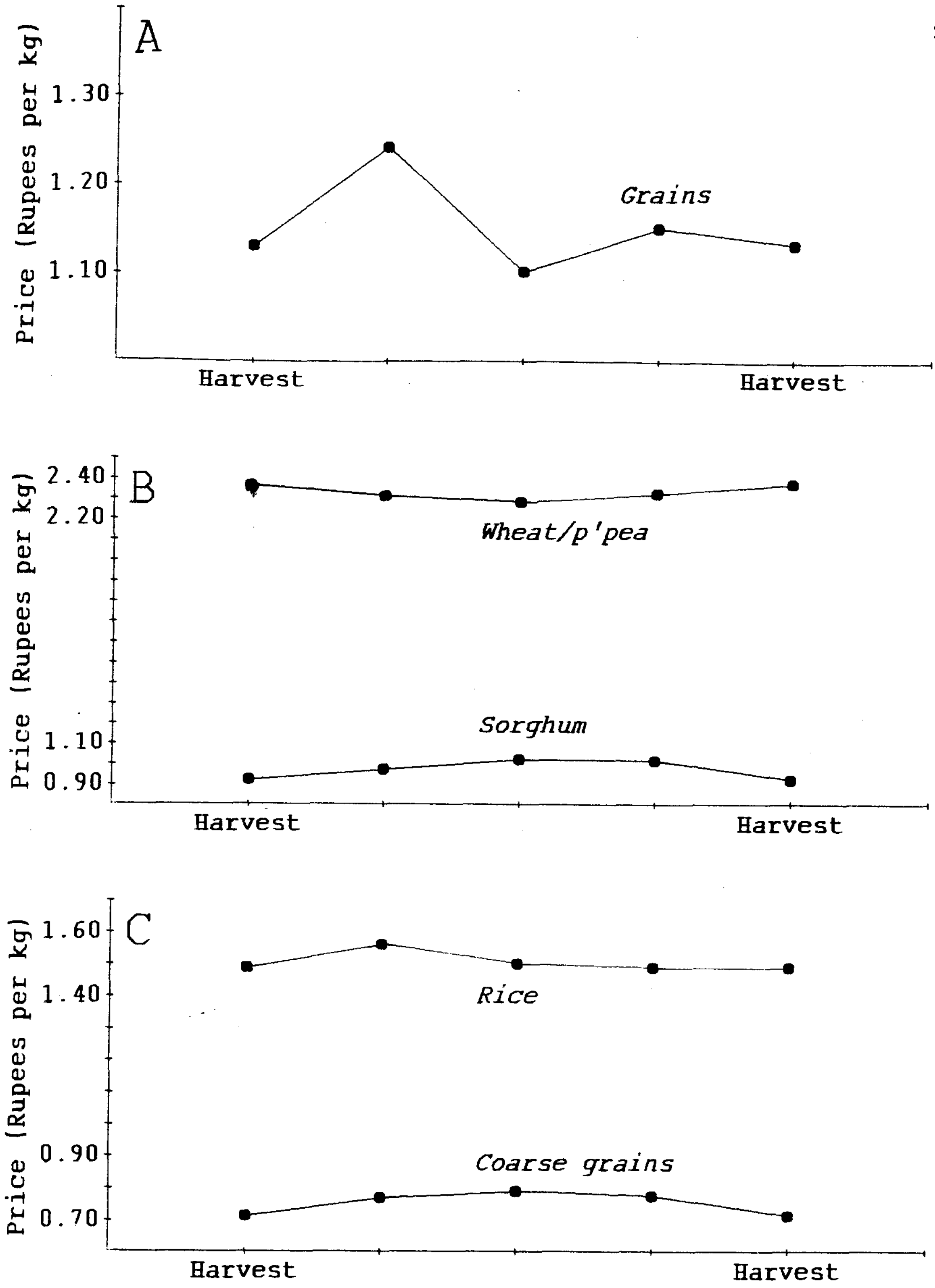

Figure 4.6 Average Quarterly Prices for Stored Commodities in Shirapur (A), Kanzara (B), and Aurepalle (C)

quite mild.

Two reasons may be advanced for this. First, markets throughout India are well integrated with goods flowing relatively freely both within and between regions throughout the year. Moreover, given the size of the country, harvests of agricultural products occur at various times during the year. This may well explain the apparent absence of a distinct quarterly pattern of price movement in a given locale whereby prices rise steadily throughout the growing season and then fall at harvest.

A second possible explanation for the stability of prices has to do with the actions of the government of India in some key grain markets. Over the period considered here, the government was especially active in the markets for wheat and rice in the major producing areas (the northwest for wheat and the south for rice) through a system of price supports. This intervention served to stabilize the prices of these commodities considerably, and -- given substitutability among grains and the degree to which markets are integrated nationally -- had a stabilizing influence on other grain markets as well.

The expected price contained in ΔP_t in equation 4.1 is the conditional expectation of an individual household. While the true mechanism by which this conditional expectation is formed cannot be known for certain, it is important to ask whether an ARMA forecast of the next period's price is a reasonably good approximation of the household's true (but unknown) forecast? This is necessarily a statistical question whose answer depends on standard statistical criteria of consistency, unbiasedness, and efficiency to which estimators are generally subjected.

It is assumed that some kind of model is used by a given household to forecast prices. The household's model may well be different from the one derived from the data available here if, for example, the household is privy to information about future prices other than that contained in previously observed prices. If the ARMA model specified in Table 4.2 is different from the true model by which price expectations are formed, then an errors-in-variables problem exists and ΔP_t will be biased and inconsistent due to this misspecification.

It is possible to test for misspecification by means of a Wu-Hausman test. The Wu-Hausman test compares an estimator that is efficient under the null hypothesis but inconsistent under the alternative with one that is consistent under both the null and alternate hypotheses. Typically, an OLS estimator is compared with an IV estimator, the null hypothesis being that the OLS estimator is consistent and asymptotically efficient (Thurman, 1986). If the null is not rejected, then the OLS estimates are efficient; if, on the other hand, the null is rejected, then use of the IV estimator is indicated. Letting β^{o} and β^{*} denote OLS and IV estimates of a K x 1 vector of coefficients, and defining V = Var(β^{o}) - Var(β^{*}) to be the difference between the covariance matrices of the two estimators, the test statistic (T) is computed as

$$T = (\beta^{o} - \beta^{*})' V^{-1} (\beta^{o} - \beta^{*}).$$

and is distributed as a chi-square random variable with K degrees of freedom (Hausman).

The Wu-Hausman test is easy to perform and has been widely used. For the problem being considered here, it was necessary to find an alternate estimator for inventory demand that was consistent. To this end, a two-stage least squares (2SLS) estimator was constructed using the realized future price in the construction of ΔP_t. Because the realized price (P_{t+1}) contains forecast errors,[31] it was necessary to purge these errors with an appropriate instrument. A logical choice of instruments was the ARMA price forecast, since each forecast relied solely on information contained in agents' information sets and hence was uncorrelated with forecast errors.

In the analysis below, Wu-Hausman tests were conducted to compare an OLS estimator of inventory demand with the 2SLS estimator described above. If the consistency of the OLS estimator was rejected, then the 2SLS estimator was used.

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[31] That is, $P_{t+1} = E_t P_{t+1} + u_t$, where u_t is forecast error.

4.1.3 Cross-sectional Time Series Data

The data to be used is drawn from 13 to 15 households sampled over a period of 27 to 32 quarters in each of the three villages considered. For several reasons, it will be desirable to combine the observations on different households. First, combining the data in this way will boost the number of degrees of freedom available, thereby increasing the efficiency of the econometric estimates. Second, it is of more interest to make inferences regarding the behavior of certain kinds of households -- say, "rich" and "poor" farmers, or those specializing in particular types of crops -- than to chart the behavior of individual households. Third, aggregating the data average out some of the household-specific variability that might tend to obscure the fundamental behavioral relationships of interest.

Following the procedure recommended by Hsiao (1986), aggregation of the households into groups was based on tests of the hypothesis that the slope coefficients f and g are identical for all households. A separate regression may be postulated for each of N households in a given village:

$$(4.5) \quad I_{j,t+1} = g_{j0} + f_j \Delta P_{jt} + g_j X_{j,1t} + h_j \lambda_{jt} + v_t,$$

$$j = 1,\ldots,N,$$

$$t = 1,\ldots,T.$$

Here λ_{jt} is the value of the conditional expectation of the error term from equation 4.2 ("Heckman's lambda") as computed earlier, and v_t is an independent, normally distributed error with mean zero and constant variance. For a given grouping of households, the T-vectors of individual household inventory demands were stacked and jointly estimated as a system of seemingly unrelated regressions.[32] Two regressions were run, one in which all f and g coefficients were constrained to be identical and the other unrestricted. F-tests then compared the sums of squared residuals of the two regressions to determine whether the null hypothesis of homogeneous slope coefficients could be rejected.

The aggregation of households within villages was designed to form groups reflective of differences in wealth status. For Shirapur and Kanzara, the households were divided into three groups corresponding to small, medium, and large farm-size classes. For Aurepalle, it seemed more appropriate to divide the households into two groups: those who grew rice and those who didn't. Preliminary results strongly rejected homogeneity among the nine non-rice growing households, so these were further divided into two groups. This latter split was based on the average carryout stocks of rice held over the entire sample period: "Group A" corresponds to the four households with the lowest average

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[32] Since consumption and inventory demands are simultaneously determined, it was necessary to account for the endogeneity of X_{it} in the estimation. To do this, X_{it} was regressed on its own price, income, and the price of one other commodity. The predicted values of X_{it} resulting from this equation were used as regressors in the inventory demand equations.

quarterly stocks of rice while the other five non-rice growing households comprise "Group B."

The results of the homogeneity tests for the slope coefficients are presented in Table 4.3. For eleven out of fifteen groups, homogeneity of the slope coefficients cannot be rejected at the one percent significance level by the Mean Square Error Test (Wallace, 1976).[33] These results indicate that the proposed household groupings are reasonably consistent with the data. In contrast, the hypothesis that the slope coefficients are the same for <u>all</u> households in each village is strongly rejected for all village-commodity combinations. Hence, there appear to be significant differences in the determinants of inventory demand between groups in all villages.

4.2 The Determinants of Inventory Demand

Inventory demand equations were estimated for each village-commodity-farm type combination using both OLS and 2SLS. The commodities included in the analysis were: Grains (sorghum and wheat) in Shirapur; sorghum and a wheat/pigeonpea aggregate in Kanzara; and coarse grains (sorghum and

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[33] Since the same data used for estimating the structural parameters of the inventory demand equations are being used to provide guidance for pooling the data, use of simple F-tests in making inferences regarding the homogeneity tests is inapproprate. As discussed by Wallace, the preferred (and probably overly conservative) procedure for data-pooling tests is to reject the null hypothesis if the calculated F-statistics are greater than 2.00.

Table 4.3: Test Results for Homogeneity of Slope Coefficients

Farm Type	F-value	d.f.	Test Result[a]
	----Shirapur grains----		
Small farms	1.77	8,130	Do not reject
Medium farms	2.02	6,104	Do not reject
Large farms	3.40	6,104	Do not reject
All farms	4.33	24,338	Reject
	----Kanzara sorghum----		
Small farms	1.16	6,112	Do not reject
Medium farms	0.69	6,112	Do not reject
Large farms	2.51	8,60	Reject
All farms	27.40	24,156	Reject
	----Kanzara wheat/pigeonpea----		
Small farms	2.23	6,112	Reject
Medium farms	1.37	6,112	Do not reject
Large farms	1.43	8,60	Do not reject
All farms	12.93	24,156	Reject

Table 4.3 (continued)

----Aurepalle Coarse grains----			
Group A	1.80	6,72	Do not reject
Group B	1.88	8,115	Do not reject
Rice growers	6.44	10,96	Reject
All farms	15.40	26,236	Reject
----Aurepalle Rice----			
Group A	1.55	6,72	Do not reject
Group B	1.38	8,115	Do not reject
Rice growers	1.76	10,96	Do not reject
All farms	14.10	26,236	Reject

a. Using Wallace's Mean Square Error test (critical value = is approximately equal to 2.00).

millet) and rice in Aurepalle. The farm type groupings used were those discussed in Section 4.1.3: Small, medium, and large farms in both Shirapur and Kanzara; and rice growing and two groups of non-rice growing farms in Aurepalle. No rice inventory demand equations were estimated for the group of households in Aurepalle that did not store appreciable quantities of rice (Group A).

Throughout the analysis a quarterly discount factor of .95 was used. The discussion of credit markets in Chapter 3 indicated that market interest rates in all villages are high, approaching 50 percent (on an annual basis) in many instances. At the same time, it was also pointed out that some institutional credit is available at much lower nominal interest rates (especially in the Maharashtra villages), and that in all villages short-term interest-free loans among friends and relations are often observed. The discount factor used -- which corresponds to an annual interest rate of about 23 percent -- was chosen as a rough and ready median value.[34]

4.2.1 Estimation

The complete set of parameter estimates are contained in Tables A4.1 - A4.5 of the Appendix to this chapter. The computed residuals were used to estimate a heteroskedasticity-consistent parameter covariance matrix as proposed by White. Standard error estimates found in the tables are the diagonal elements of that matrix.

The explanatory power of the equations was variable, with R^2's ranging from .37 to .78. In those instances where Durbin-Watson statistics indicated the presence of serial correlation in the residuals, a first order autocorrelation correction was imposed using the AUTOREG procedure of SAS.

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[34] In an attempt to determine how sensitive the econometric estimates were to the choice of discount factor, several regressions were run with values of b ranging from .90 to 1.00. The results of this exercise indicated that the only parameter estimates affected to any appreciable degree were the constant term (g_0) and the parameter describing arbitrage motives (f). The significance level of these parameters remained the same throughout, and the implied elasticities of inventory demand with respect to (discounted) expected price were generally close for all values of b. It was therefore concluded that the chosen of discount factor, while somewhat arbitrary, did not significantly modify the implications of the econometric results to be presented.

Wu-Hausman test statistics were calculated for each pair of village-commodity-farm type estimates. A question arose whether to calculate these statistics using all the estimated parameters and the full covariance matrix (as described in section 4.1.2 above) or to simply use the parameter estimates and standard errors of the coefficient on ΔP_t ("f"). In the latter case, the test statistic is computed as the difference between parameter estimates divided by the difference in standard errors and follows a t distribution.

It was decided to compute the test statistics using the simple t-tests for the following reason. Examination of the estimates in tables A4.1 - A4.5 reveals that the OLS and 2SLS estimates of the other parameters are generally quite close. As such, computing the Wu-Hausman statistics using all the parameter estimates would tend decrease the test statistic relative to its critical value, making it more difficult to reject the null hypothesis. In other words, the t-test is the more conservative of the two tests. In 10 of 14 cases, the null hypothesis that the OLS estimates were consistent was rejected.[35]

In addition to the structural parameters of the theoretical model, sets of household, quarterly, and yearly dummies were included as independent variables in each

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[35] By comparison, consistency could not be rejected in 12 of 14 cases using the X^2 test.

equation to account for cross-sectional and inter-temporal differences. The household dummies were meant to account for household-specific characteristics such as household size and composition. The yearly dummies captured the effects of harvest size on the overall level of inventory holdings throughout the year, while the quarterly dummies were included to account for the distinct seasonal pattern of inventory holdings discussed in the previous chapter. In most cases, a large proportion of the quarterly and household dummies were significant, indicating marked inter-household and seasonal effects. The yearly dummies were in general less significant in explaining inventory demand variation in all villages.

For easier reference, the estimated structural parameters are presented in Tables 4.4 - 4.6. These results are mixed in terms of validating the theoretical model. In only 5 of 14 cases is the sign of the estimated coefficient on expected price differentials positive (as expected a priori), and only in the case of medium and large farms in Shirapur are these significantly different from zero. At the same time, a significant negative relationship between expected price differentials and inventory demand was found in the cases of demand for stocks of wheat/pigeonpea by medium and large farm households in Kanzara and for stocks of rice by non-rice growing households in Aurepalle.

These negative coefficients are puzzling. That these

Table 4.4 Estimated Structural Parameters of Demand for Grain Inventories in Shirapur[a]

Parameter	Small Farms[b]	Medium Farms[b]	Large Farms[c]
g_0	-135.8 (154.8)	439.4 (305.5)	480.6 (357.6)
f	-1433.1 (1150.0)	489.7* (268.9)	5806.2** (2087.4)
g	0.61 (0.75)	1.77** (0.73)	1.43*** (0.45)
λ	435.6** (174.7)	119.1*** (29.6)	109.9 (167.0)

a. "f" is the coefficient on the expected price differential (ΔP_t); "g" is the coefficient on current consumption; and "g_0" is an intercept. Standard errors are in parentheses and significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

b. OLS estimates using ARMA forecast in ΔP_t.

c. 2SLS estimates using the realized price as an instrument for the ARMA forecast price contained in ΔP_t.

Table 4.5 Estimated Structural Parameters of Demand for Inventories of Stored Commodities in Kanzara[a]

	Sorghum			Wheat and Pigeonpea		
	Small Farms[c]	Medium Farms[b]	Large Farms[c]	Small Farms[b]	Medium Farms[c]	Large Farms[c]
g_o	-184.3	-188.5	347.7	-159.2	123.1**	-60.1
	(159.1)	(127.7)	(315.6)	(155.1)	(46.9)	(232.6)
f	368.8	241.9	201.1	-839.4	-587.1*	-4148.6**
	(580.5)	(337.9)	(1037.8)	(688.9)	(316.9)	(1885.5)
g	1.34**	0.12	-1.67	2.05	-0.83	0.12
	(0.51)	(0.39)	(1.24)	(1.33)	(0.55)	(1.14)
λ	-4.1	452.3***	-350.9	258.1	101.8	718.2**
	(158.9)	(115.7)	(214.4)	(192.0)	(79.1)	(271.7)

a. "f" is the coefficient on the expected price differential (ΔP_t); "g" is the coefficient on current consumption; and "g_o" is an intercept. Standard errors are in parentheses and significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

b. OLS estimates using ARMA forecast in ΔP_t.

c. 2SLS estimates using the realized price as an instrument for the ARMA forecast price contained in ΔP_t.

Table 4.6 Estimated Structural Parameters of Demand for Inventories of Stored Commodities in Aurepalle[a]

	Coarse Grains			Rice		
	Group A Farms	Group B Farms	Rice Growers	Group A Farms	Group B Farms	Rice Growers
g_0	-32.2	-356.8***	253.3	-	-2.5	137.8
	(157.3)	(76.7)	(148.0)		(38.1)	(191.9)
f	-126.1	-287.7	-29.8	-	-1849.3**	-3865.5
	(283.0)	(195.2)	(432.7)		(690.0)	(1613.5)
g	0.04	0.70**	0.41	-	-0.08	-0.25
	(0.67)	(0.35)	(0.82)		(0.25)	(0.83)
λ	83.6	233.3***	57.9	-	9.7	-201.5
	(89.5)	(42.9)	(109.8)		(68.8)	(426.5)

a. Group A includes non-rice growing households that store negligible amounts of rice. Group B includes those non-rice growing households that do store rice. "f" is the coefficient on the expected price differential (ΔP_t); "g" is the coefficient on current consumption; and "g_0" is an intercept. All estimates use the realized price of the commodity involved as an instrument for the ARMA forecast price contained in ΔP_t. Standard errors are in parentheses and significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

farmers are systematically holding inventories when prices are expected to fall is an implausible result, suggesting that one or more important explanatory variables might not have been included in the estimation. It was thought that one such omitted variable might have been household credit status. If households are "forced" to sell or otherwise dispose of their stocks of staple grains due to a need to repay a debt, inventories will be reduced. For the most part, such disposal of staple foods is probably not related to current market conditions in the sense that it is unrelated to prices; rather it has more to do with non-market constraints such as loan repayment schedules.

In an attempt to discover whether omission of credit variables from the estimation accounted for this perverse result, two different credit variables -- the quarterly value of loans repaid and quarterly loan activity -- were added to the estimating equations. The latter included both loans received (and paid back) and loans made by households. Neither of these variables was significant, and had a minimal effect on the other parameter estimates.

The estimated coefficients on current consumption (also expected to be positive) conformed more to a priori expectations. In four of fourteen cases the estimates were positive and significant, while in the four cases in which the sign was negative, the estimates were not significantly different from zero.

Significant estimates of the coefficient on λ indicate that self-selection bias exists in inventory demand. In the present context, λ is inversely related to the probability that a household will hold inventories in a given quarter, and the sign of the coefficient on λ was expected to be positive. In roughly five of fourteen cases, the parameter estimates were significantly greater than zero.

4.2.2 Inference

The results of the estimation discussed above indicate that in some cases the model developed here adequately describes the behavior of the households under consideration, while in other cases the model fails rather miserably. One simple test of the validity of the model is to examine the null hypothesis that both of the important structural parameters -- i.e. those associated with expected price differentials and current consumption -- are zero. The results of these tests are found in Table 4.7.[36] There it will be observed that the null hypothesis cannot be rejected in exactly half of the fourteen cases. Furthermore, four of the rejections --two for wheat/pigeonpea in Kanzara and two for

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[36] As discussed in White, the appropriate means of testing this and other linear hypotheses is to compute a test statistic of the form $(R\beta - r)'[R(X'X)^{-1}V(X'X)^{-1}R']^{-1}(R\beta - r)$, where V is the heteroskedasticity-consistent covariance matrix estimator, and $(R\beta - r)$ is a matrix of linear restrictions. The test statistic is distributed as a chi-square random variable with degrees of freedom equal to the number of linear restrictions.

Table 4.7 Chi-square Tests[a] of $H_0: f = g = 0$

		Type of Farm[b]		
Village	Commodity	I	II	III
Shirapur	Grain	1.92	11.40***	23.80***
Kanzara	Sorghum	7.40**	0.52	1.86
	Wheat, pig'npea	2.69	4.91*	4.89*
Aurepalle	Coarse grains	0.30	4.53	0.26
	Rice	-	7.45***	5.84*

a. Critical values of X^2 with two degrees of freedom at the .10, .05, and .01 significance levels are 4.61, 5.99, and 7.38, respectively.

b. For Shirapur and Kanzara, I = small, II = medium, III = large farms. For Aurepalle, I = group A, II = group B, and III = rice growing farms.

rice in Aurepalle -- arise due to the significance of the price variable. Since the estimated coefficient in these cases is of the wrong sign, it is concluded that the model fails here too -- that is, neither profit or food security motives explain household demand from carryout inventories.

The absence of empirically important food security motives implies that in most of the cases examined households rely on means other than inventories to smooth consumption flows. This finding is in line with assertions made by Walker and Ryan that households in the study villages tend to maintain their consumption levels in the face of income variability via consumption credit (especially in Aurepalle), labor earnings (primarily in the case of small farm households), and sales of assets other than stored foods.

We are left with three instances in which at least one of the estimated structural coefficients is significant and of the correct sign. The three cases include demand for inventories of grains by medium and large farm households in Shirapur; and of sorghum by small farm households in Kanzara. What, if anything, can be inferred from these results in the context of the four hypotheses formulated at the end of Chapter 3?

Only in the cases of medium and large households in Shirapur were expected price differentials found to motivate inventory demand. The implied elasticities of inventory demand with respect to expected price (evaluated at the sample means) are 1.25 for medium farm households and 10.00 for large farm households. In all other instances, significant arbitrage motives were found to be absent. This result tends to substantiate Hypothesis III, that price incentives for the holding of inventories are greatest where market sales of staple foods are a relatively more important means by which households generate cash income. Cash crops (cotton in Kanzara and castor in Aurepalle) are cultivated by all households in the other two villages, whereas no important cash cropping alternatives exist for most farmers in Shirapur.

In general, food security motives for holding inventories of staple foods appear to dominate arbitrage motives. In order to facilitate comparisons, elasticities of inventory demand with respect to consumption (evaluated at sample means) were calculated for each village-commodity-farm type combination (Table 4.8). For grains in Shirapur, sorghum in Kanzara, and coarse grains in Aurepalle estimated elasticities are positive for at least two of the three farm types. Interestingly, the elasticities for small farm households in Shirapur are strikingly smaller than those for the larger (better endowed) farm-size classes, in contrast to the relationship postulated in Hypothesis II. In contrast, demand for inventories of the dominant staple (sorghum) by small farm households in Kanzara was found to be highly elastic with respect to consumption, while those for the larger farm-size classes were not significantly different from zero. A similar relationship appears to exist in the case of wheat and pigeonpea in Kanzara (although none of the estimates are significant). In the case of coarse grains in Aurepalle, the elasticity for one of the groups of non-rice growing household was significant and greater than that for rice growing households. Finally, food security motives in the determination of demand for inventories of rice in Aurepalle appear to be absent.

These results offer only fragmentary and contradictory evidence concerning the hypotheses on within- and between-village differences in the importance of food security

Table 4.8 Elasticities of Inventory Demand With Respect to Consumption[a]

		Type of Farm[b]		
Village	Commodity	I	II	III
Shirapur	Grain	0.52	1.27**	0.88***
Kanzara	Sorghum	1.89**	0.12	-0.51
	Wheat, p'pea	1.91	-0.71	0.05
Aurepalle	Coarse grains	0.03	0.52**	0.21
	Rice	-	-0.47	-0.06

a. Evaluated at sample means for each village-commodity-farm type combination. Significance levels of .05 and .01 are denoted by ** and ***, respectively.

b. For Shirapur and Kanzara, I = small farms, II = medium farms and III = large farms. For Aurepalle, I = Group A farms, II = Group B farms, and III = rice-growing farms.

motives in determining inventory demand. The overall level of significance and magnitudes of the calculated elasticities suggest that food security motives are more important in drought-prone Shirapur than in the other two villages, a finding in support of Hypothesis IV. At the same time, the evidence is mixed regarding within-village differences.

One final point that merits attention here is that the model seems to "work" best for Shirapur. Shirapur stands out among the three villages considered as having the most marginal environment for agricultural production and is the least diverse in terms of cropping activities engaged in by its inhabitants. Relative to the other villages considered, cultivation of staple foods is much more important as a source of cash income. Moreover, given the harsher environmental conditions, the risk of crop failure and attendant nutritional stress is much higher than in either Aurepalle or Kanzara. In this light, it is not surprising that the empirical results indicate that the storage of the staple foods in Shirapur is affected more strongly by both arbitrage and food security motives than in the other villages.[37]

4.3 Summary

In this chapter, inventory demand equations were estimated for the important groups of stored staple foods in the three study villages. The model was found to perform relatively well for four of the fourteen village-commodity-farm type combinations considered. In half of the cases the null hypothesis that both of the structural parameters of interest (those associated with current consumption and expected

[37] Another consideration here is that in Shirapur a much higher proportion of the total annual harvest occurs in one quarter of the year than in the two other villages. In Aurepalle, there are two to three harvests of paddy per year while in Kanzara sorghum is generally harvested in a different quarter than wheat. The occurrence of multiple yearly harvests of important food staples in these two villages may well be important in explaining the absence of empirically significant food security and arbitrage motives, the argument being that multiple harvests provide an alternative to inventories as a means of stabilizing consumption over the annual cropping cycle.

price differentials) could not be rejected, while in three others the coefficient on the price variable was of the wrong sign.

The results indicated that in all villages food security motives generally dominate arbitrage motives in determining the level of inventory demand. Arbitrage motives were found to exist only for the two larger farm-size classes in Shirapur.

Finally, the statistical results of the inventory analysis were used to make inferences on the four hypotheses postulated at the end of the previous chapter regarding between- and within-village differences in the motives for holding stocks of staple foods. The results seem to corroborate the hypothesis that arbitrage motives are greatest in the village in which the fewest cash cropping alternatives exist. The empirical evidence was mixed concerning the relative importance of food security motives within villages. Between villages, food security motives appear to be the greatest in the village with the most marginal agricultural environment.

Table A4.1 OLS and 2SLS Estimates of Demand for Carryout Stocks of Grains in Shirapur[a]

	Small Farms		Medium Farms		Large Farms	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
g_0	-135.8	-139.7	439.4	338.4	464.9	480.6
	(154.8)	(157.0)	(305.5)	(363.2)	(353.8)	(357.6)
f	-1433.1	-1419.1	489.7*	27.5	5863.6***	5806.2***
	(1150.0)	(1138.8)	(268.9)	(1625.1)	(2108.0)	(2087.4)
g	0.61	0.61	1.77**	1.81***	1.43***	1.43***
	(0.75)	(0.75)	(0.73)	(0.73)	(0.45)	(0.45)
λ	435.6**	435.6**	119.1***	56.1	109.9	109.9
	(174.7)	(174.7)	(29.6)	(231.1)	(167.0)	(167.0)
Q_1	-173.3***	-173.3***	-271.8***	-247.5***	-482.2***	-482.1***
	(52.1)	(52.1)	(80.4)	(83.0)	(77.2)	(77.2)
Q_2	-993.3***	-993.3***	-798.0	-642.0	-650.8**	-650.8**
	(341.1)	(341.1)	(431.6)	(432.3)	(245.4)	(245.4)
Q_3	426.9***	426.9***	540.1***	536.8***	770.3***	770.3***
	(85.9)	(85.9)	(86.3)	(88.6)	(101.6)	(101.6)
Y_{76}	-56.2	-56.2	-307.1***	-238.3**	-271.3	-271.3
	(84.0)	(84.0)	(111.3)	(122.1)	(192.5)	(192.5)
Y_{77}	-87.4	-87.4**	-334.4***	-268.2**	-112.3	-112.3
	(75.2)	(75.2)	(121.4)	(127.1)	(177.8)	(177.8)
Y_{78}	1.9	1.9	-392.3**	-276.5	-393.8*	-393.8*
	(117.5)	(117.5)	(174.6)	(190.5)	(222.8)	(222.8)
Y_{79}	238.6	238.6	-320.8**	-222.4	-130.0	-130.0
	(217.7)	(217.4)	(156.7)	(192.5)	(192.9)	(192.9)
Y_{80}	16.4	16.4	-53.7	-30.3	-258.5*	-258.5
	(54.8)	(54.8)	(125.1)	(128.6)	(149.3)	(149.3)
Y_{82}	-68.8	-68.8	-38.3	-3.9	-121.6	-121.6
	(71.8)	(71.8)	(109.6)	(112.6)	(140.8)	(140.8)
Y_{83}	163.1	163.1	-154.9	-91.8	-61.6	-61.6
	(127.2)	(127.2)	(132.9)	(127.3)	(131.6)	(131.6)
D_{81}	232.0	232.0**	-	-	-	-
	(105.0)	(105.0)				

Table A4.1 (continued)

D_{34}	-395.5***	-395.5***	-	-	-	-
	(114.8)	(114.8)				
D_{36}	240.5*	240.5*	-	-	-	-
	(132.3)	(132.3)				
D_{38}	213.4	213.4	-	-	-	-
	(137.1)	(137.1)				
D_{40}	-	-	-400.8**	-397.8**	-	-
			(159.6)	(158.7)		
D_{41}	-	-	-491.2***	-475.5***	-	-
			(146.3)	(144.5)		
D_{43}	-	-	-243.1	-230.2	-	-
			(174.8)	(175.5)		
D_{49}	-	-	-312.8**	-302.3**	-	-
			(149.4)	(148.9)		
D_{51}	-	-	-	-	570.7***	570.7***
					(144.8)	(144.8)
D_{53}	-	-	-	-	194.3	194.3
					(153.2)	(153.2)
D_{54}	-	-	-	-	-244.8**	-244.8**
					(121.2)	(121.2)
R^2	.51	.51	.61	.61	.72	.72
D-W	2.33	2.33	2.21	2.20	1.94	1.99
Wu-Hausman Statistic[b]	1.25		0.34		2.79***	

a. D_{30} - D_{55} are household dummies; Q_1 - Q_3 are quarterly dummies; and Y_{76} - Y_{83} are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. The Wu-Hausman statistic tests the the null hypothesis that the OLS estimates are consistent against alternative estimates that are known to be consistent (in this case, 2SLS using the ARMA forecast price as an instrument for the realized future price). The test statistic computed here follows a t distribution as it compares only the estimates and standard errors of the parameter f.

Table A4.2 OLS and 2SLS Estimates of Demand for Carryout Stocks of Sorghum in Kanzara[a]

	Small Farms		Medium Farms		Large Farms	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
g_0	-188.1	-184.3	-188.5	-190.1	297.1	347.7
	(161.2)	(159.1)	(127.7)	(128.0)	(321.4)	(315.6)
f	302.6	368.8	241.9	212.9	-204.3	201.1
	(592.9)	(580.5)	(337.9)	(317.8)	(785.6)	(1037.8)
g	1.33**	1.34***	0.12	0.11	-1.62	-1.67
	(0.51)	(0.51)	(0.39)	(0.39)	(1.28)	(1.24)
λ	-6.9	-4.1	452.3***	455.3***	-354.4	-350.9
	(158.0)	(158.9)	(115.7)	(117.3)	(214.0)	(214.4)
Q_1	-127.9	-131.8	-503.4***	-508.3***	-424.5**	-400.3**
	(211.7)	(209.7)	(99.7)	(101.5)	(180.9)	(171.8)
Q_2	193.5**	187.2**	454.9***	450.1***	1057.1***	1058.3***
	(80.9)	(76.8)	(89.9)	(87.9)	(170.4)	(178.2)
Q_3	73.9*	71.5	202.0***	202.5***	553.0***	537.5***
	(43.8)	(43.7)	(52.5)	(52.6)	(134.0)	(130.5)
Y_6	-65.3	-62.8	-240.2***	-237.8***	-28.1	-47.5
	(64.7)	(62.7)	(64.2)	(63.5)	(172.9)	(166.4)
Y_7	-25.0	-26.1	-229.6***	-227.9***	-236.3	-261.7
	(71.5)	(69.3)	(64.0)	(63.5)	(186.6)	(183.0)
Y_8	-39.2	-38.9	-280.8***	-277.5***	-11.0	-38.8
	(84.7)	(83.0)	(62.7)	(60.8)	(200.6)	(196.4)
Y_9	-94.9	-94.4	-170.0***	-168.6***	-113.7	-132.7
	(63.4)	(62.4)	(60.2)	(60.0)	(182.0)	(175.7)
Y_0	-2.3	3.6	-306.4***	-298.6***	-160.3	-189.1
	(80.6)	(83.1)	(72.9)	(67.1)	(168.8)	(157.6)
Y_2	201.4**	197.9**	-80.0	-78.7	770.7**	730.5**
	(98.2)	(96.5)	(73.3)	(72.4)	(302.4)	(285.9)
Y_3	202.2**	200.1**	151.1	153.2	48.9	-19.5
	(80.8)	(78.9)	(118.4)	(118.9)	(202.6)	(194.7)

Table A4.2 (continued)

D_{30}	243.3*** (85.5)	245.3*** (85.3)	-	-	-	-
D_{35}	-11.6 (48.0)	-11.8 (48.2)	-	-	-	-
D_{37}	-100.5* (52.0)	-100.6* (52.1)	-	-	-	-
D_{41}	-	-	714.3*** (106.2)	715.6*** (107.0)	-	-
D_{45}	-	-	-102.9* (60.8)	-103.6* (60.7)	-	-
D_{46}	-	-	-74.3 (47.7)	-74.2 (47.8)	-	-
D_{50}	-	-	-	-	426.1 (448.9)	449.8 (456.7)
D_{51}	-	-	-	-	534.5*** (177.6)	540.2*** (177.6)
D_{54}	-	-	-	-	1633.0*** (232.7)	1637.7*** (234.0)
D_{55}	-	-	-	-	1198.2*** (256.9)	1206.3*** (257.0)
R^2	.53	.53	.76	.76	.71	.71
D-W	1.72	1.71	1.52	1.53	1.59	1.60
Wu-Hausman Statistic[b]	5.34***		1.44		2.71***	

a. D_{30} - D_{55} are household dummies; Q_1 - Q_3 are quarterly dummies; and Y_6 - Y_9 are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. See notes to Table A4.1.

Table A4.3 OLS and 2SLS Estimates of Demand for Carryout Stocks of Wheat/pigeonpea in Kanzara[a]

	Small Farms		Medium Farms		Large Farms	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
go	-159.2	-99.4	51.2	123.1**	-567.9	-60.1
	(155.1)	(120.9)	(67.7)	(46.9)	(401.8)	(232.6)
f	-839.4	-488.7	-1008.5*	-587.1*	-7126.1**	-4148.6**
	(688.9)	(401.1)	(544.4)	(316.9)	(3238.7)	(1885.5)
g	2.05	2.05	-0.83	-0.83	0.12	0.12
	(1.33)	(1.33)	(0.55)	(0.55)	(1.14)	(1.14)
λ	258.1	258.1	101.8	101.8	718.2***	718.2**
	(192.0)	(192.0)	(79.1)	(79.1)	(271.7)	(271.7)
Q_1	-62.6*	-62.6*	-23.6	-23.6	-257.2***	-257.2***
	(27.0)	(27.0)	(15.8)	(15.8)	(94.2)	(94.2)
Q_2	-521.5	-521.5	-187.8***	-187.8**	-921.4***	-921.4***
	(359.7)	(359.7)	(118.5)	(118.5)	(161.1)	(161.1)
Q_3	32.1	32.1	39.4***	39.4***	378.9***	378.9***
	(34.9)	(34.9)	(14.7)	(14.7)	(119.3)	(119.3)
Y_{76}	19.5	19.5	32.6	32.6	62.8	62.8
	(48.9)	(48.9)	(26.6)	(26.6)	(200.6)	(200.6)
Y_{77}	-61.9	-61.9	-71.5**	-71.5**	-422.6	-422.6
	(42.1)	(42.1)	(34.2)	(34.2)	(243.7)	(243.7)
Y_{78}	-52.1	-52.1	-50.7*	-50.7*	-378.1**	-378.1**
	(42.6)	(42.6)	(30.2)	(30.2)	(192.3)	(192.3)
Y_{79}	-49.7	-49.7	-41.2*	-41.2*	30.2	30.2
	(27.9)	(27.9)	(21.2)	(21.2)	(154.6)	(154.6)
Y_{80}	-28.4	-28.4	-4.6	-4.6	225.0	225.0
	(30.2)	(30.2)	(17.7)	(17.7)	(152.2)	(152.2)
Y_{82}	-32.5	-32.5	-45.9	-45.9	-573.5**	-573.5**
	(46.4)	(46.4)	(31.3)	(31.3)	(219.3)	(219.3)
Y_{83}	2.5	2.5	-2.6	-2.6	-643.5**	-643.5**
	(60.9)	(60.9)	(40.0)	(40.0)	(275.9)	(275.9)

Table A4.3 (continued)

D_{30}	38.0 (24.0)	38.0 (24.0)	-	-	-	-
D_{33}	-16.5 (18.6)	-16.5 (18.6)	-	-	-	-
D_{37}	-15.8 (27.3)	-15.8 (27.3)	-	-	-	-
D_{41}	-	-	34.1 (22.4)	34.1 (22.4)	-	-
D_{43}	-	-	-97.7*** (27.2)	-97.7*** (27.2)	-	-
D_{46}	-	-	-51.2*** (17.8)	-51.2*** (17.8)	-	-
D_{50}	-	-	-	-	184.1 (179.7)	184.1 (179.7)
D_{51}	-	-	-	-	546.7*** (131.4)	546.7*** (131.4)
D_{54}	-	-	-	-	1383.8*** (245.8)	1383.8*** (245.8)
D_{55}	-	-	-	-	1270.7*** (354.5)	1270.7*** (354.5)
R^2	.47	.49	.53	.57	.69	.69
D-W	2.40	2.30	2.36	2.19	1.75	1.78
Wu-Hausman Statistic[b]	1.21		1.85*		2.20**	

a. D_{30} - D_{55} are household dummies; Q_1 - Q_3 are quarterly dummies; and Y_{74} - Y_{83} are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. See notes to Table A4.1.

Table A4.4 OLS and 2SLS Estimates of Demand for Carryout Stocks of Coarse Grains in Aurepalle[a]

	Group A Farms[b]		Group B Farms[b]		Rice-growing Farms	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
g_o	163.1 (173.3)	-32.2 (157.3)	-356.5*** (78.6)	-356.8*** (76.7)	253.4** (120.8)	253.3 (148.0)
f	289.7 (314.6)	-126.1 (283.0)	-282.6 (195.2)	-282.7 (195.2)	-29.6 (432.7)	-29.9 (432.7)
g	-2.65*** (0.28)	0.04 (0.67)	0.70** (0.35)	0.70** (0.35)	0.41 (0.82)	0.41 (0.82)
λ	2.6 (109.6)	83.6 (89.5)	233.3*** (42.9)	233.3*** (42.9)	57.9 (109.8)	57.9 (109.8)
Q_2	203.7 (146.0)	249.4** (125.2)	371.2*** (56.9)	371.2*** (56.9)	215.1** (103.3)	215.1** (103.3)
Q_3	107.7 (146.5)	151.4 (120.3)	292.2*** (56.3)	292.2*** (56.3)	61.6 (58.4)	61.6 (58.4)
Q_4	34.3 (120.9)	70.9 (103.0)	197.3*** (46.5)	197.3*** (46.5)	-14.5 (27.8)	-14.5 (27.8)
Y_7	41.0 (32.2)	-20.6 (27.8)	78.6*** (23.6)	78.6*** (23.6)	77.4* (42.9)	77.4* (42.9)
Y_8	41.8 (26.3)	115.2*** (37.4)	151.7*** (32.2)	151.7*** (32.2)	215.5*** (39.7)	215.5*** (39.7)
Y_9	44.8 (27.0)	15.0 (33.1)	-3.8 (21.9)	-3.8 (21.9)	102.3** (45.3)	102.3** (45.3)
Y_0	-27.7 (30.7)	-42.6 (30.7)	38.2 (25.0)	38.2 (25.0)	2.4 (38.5)	2.4 (38.5)
Y_2	30.0 (38.7)	33.6 (48.3)	26.9 (33.3)	26.9 (33.3)	148.2 (96.2)	148.2 (96.2)
Y_3	182.0** (73.1)	164.5** (65.1)	96.4*** (28.0)	96.4*** (28.0)	136.5*** (47.9)	136.5*** (47.9)
D_{33}	32.7 (27.2)	-49.4* (29.9)	-	-	-	-
D_{44}	39.7 (24.1)	-64.0* (33.4)	-	-	-	-

Table A4.4 (continued)

D_{48}	308.7*** (31.2)	119.3*** (32.4)	-	-	-	-
D_{35}	-	-	21.1 (16.4)	21.1 (16.4)	-	-
D_{43}	-	-	126.3*** (25.2)	126.3*** (25.2)	-	-
D_{46}	-	-	46.8** (22.1)	46.8** (22.1)	-	-
D_{55}	-	-	201.9*** (34.0)	201.9*** (34.0)	-	-
D_{30}	-	-	-	-	-350.8*** (66.5)	-350.8*** (66.5)
D_{31}	-	-	-	-	-311.5*** (59.8)	-311.5*** (59.8)
D_{45}	-	-	-	-	-176.0 (121.7)	-176.0 (121.7)
D_{54}	-	-	-	-	-354.7*** (67.4)	-354.7*** (67.4)
D_{58}	-	-	-	-	-300.2*** (64.8)	-300.2*** (64.8)
$\hat{\rho}$	0.44	0.45	0.33	0.33	-	-
R^2	.69	.64	.72	.73	.37	.36
D-W	1.09	1.06	1.32	1.29	2.15	2.15
Wu-Hausman Statistic[c]	13.16***		78.08**		45.70***	

a. D_{30} - D_{58} are household dummies; Q_2 - Q_4 are quarterly dummies; and Y_7 - Y_8 are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. Group A is composed of non-rice growing households that hold negligible stocks of rice. Group B is composed of non-rice growing households that do store rice.

c. See notes to Table A4.1.

Table A4.5 OLS and 2SLS Estimates of Demand for Carryout Stocks of Rice in Aurepalle[a]

	Group B Farms[b]		Rice-growing Farms	
	OLS	2SLS	OLS	2SLS
g_o	5.1 (36.6)	-2.5 (38.1)	153.6 (199.3)	137.8 (191.9)
f	-2186.1*** (815.7)	-1849.3** (690.0)	-4569.3** (1907.3)	-3865.5 (1613.5)
g	-0.08 (0.25)	-0.08 (0.25)	-0.25 (0.83)	-0.25 (0.83)
λ	9.7 (68.8)	9.7 (68.8)	-201.5 (426.5)	-201.5 (426.5)
Q_2	55.1 (79.3)	55.1 (79.3)	99.9 (133.1)	99.9 (133.1)
Q_3	50.1 (83.3)	50.1 (83.3)	322.7** (160.5)	322.7** (160.5)
Q_4	127.0 (96.0)	127.0 (96.0)	18.9 (195.3)	18.9 (195.3)
Y_{77}	-263.8*** (69.2)	-263.8*** (69.2)	-304.6 (219.1)	-304.6 (219.1)
Y_{78}	-281.4*** (74.3)	-281.4** (74.3)	-375.6** (177.3)	-375.6** (177.3)
Y_{79}	-163.1*** (54.7)	-163.1*** (54.7)	-82.8 (147.0)	-82.8 (147.0)
Y_{80}	-147.3*** (40.8)	-147.3*** (40.8)	-97.3 (76.7)	-97.3 (76.7)
Y_{82}	-94.2** (35.8)	-94.2 (35.8)	40.1 (71.4)	40.1 (71.4)
Y_{83}	-107.5*** (30.0)	-107.5*** (30.0)	205.0 (146.3)	205.0 (146.3)

Table A4.5 (continued)

D_{35}	42.2 (35.3)	42.2 (35.3)	-	-
D_{45}	46.1** (17.8)	46.1** (17.8)	-	-
D_{46}	53.1 (33.8)	53.1 (33.8)	-	-
D_{55}	81.8*** (24.5)	81.8*** (24.5)	-	-
D_{30}	-	-	-190.5* (104.0)	-190.5 (104.0)
D_{31}	-	-	-148.2.* (74.0)	-148.2.* (74.0)
D_{45}	-	-	501.0*** (177.6)	501.0*** (177.6)
D_{54}	-	-	-204.2* (107.3)	-204.2 (107.3)
D_{58}	-	-	36.8 (134.9)	36.8 (134.9)
R^2	.78	.77	.48	.47
D-W	2.25	2.25	1.56	1.53
Wu-Hausman Statistic[c]	2.68***		2.40***	

a. D30 - D58 are household dummies; Q2 - Q4 are quarterly dummies; and Y77 - Y83 are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. These are non-rice growing households that hold stocks of rice.

c. See notes to Table A4.1.

Table A4.5 (continued)

D_{35}	42.2 (35.3)	42.2 (35.3)	-	-
D_{45}	46.1** (17.8)	46.1** (17.8)	-	-
D_{46}	53.1 (33.8)	53.1 (33.8)	-	-
D_{55}	81.8*** (24.5)	81.8*** (24.5)	-	-
D_{30}	-	-	-190.5* (104.0)	-190.5 (104.0)
D_{31}	-	-	-148.2** (74.0)	-148.2** (74.0)
D_{45}	-	-	501.0*** (177.6)	501.0*** (177.6)
D_{54}	-	-	-204.2* (107.3)	-204.2 (107.3)
D_{58}	-	-	36.8 (134.9)	36.8 (134.9)
R^2	.78	.77	.48	.47
D-W	2.25	2.25	1.56	1.53
Wu-Hausman Statistic[c]	2.68***		2.40***	

a. D30 - D58 are household dummies; Q2 - Q4 are quarterly dummies; and Y77 - Y83 are yearly dummies. All other parameters are as defined in the text. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively. Standard errors are in parentheses.

b. These are non-rice growing households that hold stocks of rice.

c. See notes to Table A4.1.

Chapter 5

MARKETED SURPLUS RESPONSE

The comparative statics results found in Chapter 2 implied methods for computing the price response of commodity demands and marketed surplus that differ from those of existing models. These differences arise because: (a) household inventories are incorporated into the model; (b) more careful attention is paid to the timing of economic activities undertaken by households; and (c) price expectations are explicitly treated. The analysis suggested that possibly large empirical differences might exist between marketed surplus elasticities calculated using the formulae derived in Chapter 2 and those derived using the earlier methods.

The goal of this chapter is to explore this issue. To do so requires estimates of the parameters of commodity demand and output supply. These may then be combined with the empirical results from the analysis of inventory demand. Demand systems will be estimated for each of the three study villages in section 5.1. The parameters of output supply will be drawn from a detailed study of agricultural supply in semi-arid tropical India. These are presented and discussed in section 5.2. In section 5.3, own-price elasticities of commodity demand and marketed surplus for stored commodities in each of the three study villages are calculated using the formula derived in Chapter 2. In order to determine whether differences in demand and marketed surplus response exist at different points in the cropping cycle, two sets of elasticities will be calculated, one for the "lean" season immediately prior to harvest and one for the period following harvest. The computed elasticities are then compared to estimates of marketed surplus response using the methodology employed by earlier authors in section 5.4.

5.1 Commodity Demands

In this section, commodity demand systems[38] for the three study villages are estimated, and income and (compensated) price elasticities are calculated. For each village, commodities were grouped in the manner described in the theoretical model: storable home-grown foods (X_k, k = G, S, W, C, R); non-storable home-grown foods (X_2); and commodities procured exclusively from the market (X_3). As in the inventory demand analysis, storable commodity groups were: sorghum/wheat in Shirapur (X_G); sorghum (X_S) and wheat/pigeonpea (X_W) in Kanzara; coarse grains (X_C) and rice (X_R) in Aurepalle.

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[38] Labor demand is omitted from the analysis. That is, household labor is assumed to be weakly separable from commodity demand.

5.1.1 Choice of Functional Form

The theoretical model of Chapter 2 indicated that commodity demand functions for households in the three study villages are of the following form:

$$\text{Shirapur:} \quad X_j = X(P_{jt}, \hat{P}_{Gt+1}, \hat{P}_{GT}, W_t), \quad j = G,2,3$$

$$\text{Kanzara:} \quad X_j = X(P_{jt}, \hat{P}_{St+1}, \hat{P}_{ST}, \hat{P}_{Wt+1}, \hat{P}_{WT}, W_t), \quad j = S,W,2,3$$

$$\text{Aurepalle:} \quad X_j = X(P_{jt}, \hat{P}_{Ct+1}, \hat{P}_{CT}, \hat{P}_{Rt+1}, \hat{P}_{RT}, W_t), \quad j = C,R,2,3,$$

where once again "^" indicates the appropriately discounted expected value and W_t is household wealth (as developed in Chapter 2).

The functional form chosen to estimate these systems of commodity demands is the Rotterdam model developed by Barten and Theil. The Rotterdam model has a number of desirable properties favoring its use here. It is linear and parsimonious in parameters and therefore easy to estimate. Its parameters are readily related to the restrictions suggested by demand theory. It is no less flexible than other, more heavily parameterized functional forms such as the translog and the generalized Leontieff.[29] Moreover, there is some evidence suggesting that the Rotterdam model generally outperforms the linear expenditure system and the indirect addilog model (Parks).

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[29] In a recent paper, Mountain demonstrates that the order of approximation implied by the Rotterdam model is the same as that of models based on second-order approximations of an underlying indirect utility function.

In the present case, the Rotterdam model has an additional advantage -- not generally discussed in the literature -- that is related to the cross-sectional nature of the data to be used. Because it is estimated using the first differences of logarithms, it eliminates the necessity of modeling household-specific characteristic such as household size and age-structure and other socio-economic variables. As long as these variables remain roughly constant or change slowly over the sample period for a given household, their effect on demand will be effectively differenced out of the analysis.[40]

As derived by Deaton and Muellbauer, the basic Rotterdam model for N commodities may be written as follows:

$$(5.1) \quad \omega_i \Delta\log X_i = \beta_i \Delta\log Y^* + \sum_j \beta_{ij} \Delta\log P_j, \qquad i,j = 1,\ldots,N$$

where $Y = \sum_k P_k X_k$ (total expenditure)

$\omega_i = P_i X_i / Y$ (expenditure shares)

$\Delta\log Y^* = \Delta\log Y - \sum_k \omega_k \Delta\log P_k$

$\beta_i = \omega_i \epsilon_i$

$\epsilon_{ij} = \omega_i \epsilon_{ij}^*$.

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[40]Ashenfelter, et al. discuss the advantages (and potential pitfalls) of using first-difference estimators with panel data. They point out that if there is significant measurement error due to faulty data collection, the ratio of measurement error variance to total variance (and hence the bias induced by such errors) may be greatly increased by differencing the data.

Here, ϵ_i is the income elasticity for good i and ϵ_{ij}^* is the compensated elasticity of demand for good i with respect to the price of good j.

The quantity Y^* represents the proportional change in real total expenditure -- an index of real income. Given the way in which the data were constructed, Y includes the value of stocks on hand (net of market sales and carryout inventories).[41] Thus, Y^* incorporates all real income flows contained in the current-period household budget constraint. It does not account for expected net revenues from future production, however. The second order conditions implied that this element of the inter-temporal budget constraint is captured by current acreage (A_0). Data on acreage was not readily available, however, so an intercept was included in the regressions as a proxy for this variable.[42]

It was necessary to modify the basic Rotterdam model of equation 5.1 in order to include the expected price variables for the stored commodities. Following the procedure recommended by Nerlove, Grether, and Carvalho, the results of the time series analysis of these prices were used in deriving the appropriate lag structure of the reduced form. Specifically, for commodities whose price was found to

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[41] Recall that from equation 2.5a, $X_{it} = Q_{it} + I_t - M_{it} - I_{t+1}$.

[42] Since the intercept will also pick up any trends in consumption, the effect of future net revenue proxied in this way will not be identifiable.

follow an AR1 process, no lags were included in the estimating equations. For commodities found to follow a second-order ARMA process (sorghum in Kanzara and coarse grains in Aurepalle), once-lagged values of these prices were included.[43]

5.1.2 Estimation

Commodity demand systems were estimated for the three farm types in each of the three study villages. The farm types were the same as those in the inventory demand analysis: rice growers and two groups of non-rice growing farms in Aurepalle; and small, medium, and large farms in Shirapur and Kanzara. The time period covered was 1976.3 - 1981.4 for Shirapur; 1976.1 - 1981.4 for Kanzara; and 1977.2 - 1981.4 for Aurepalle. Data for consumption of oils, sugars, and non-food was missing for the 1982 and 1983 cropyears. For this reason, those years were excluded from the analysis. Differencing deleted the initial observation for each household. The number of data points ranged from 83 to 104 for Shirapur; 82 to 84 for Kanzara; and 68 to 92 for Aurepalle.

Given the construction of the real income variable, adding-up was automatically imposed on the system. Moreover,

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[43] Sorghum prices in Kanzara follow a moving average process which, in principle, implies an infinite-order distributed lag. In practice, an AR2 generally provides a reasonable approximation -- hence the truncation at one lag here.

since all prices and the expenditure variable were deflated by a common price index, homogeneity was also imposed. Finally, inspection of equation A1 reveals that the upper left block of the Hessian matrix of second derivatives is not symmetric. Hence, symmetry was neither imposed nor tested in the estimation.

Mean expenditure shares for each farm type were calculated for the entire sample period. These are presented in Table 5.1. Expenditure shares are generally quite similar between different farm types in each village. An exception is found in the case of the two stored commodities in Kanzara. There, large farm households appear to allocate a greater proportion of total expenditure to wheat/pigeonpea and a smaller proportion to sorghum than small and medium farm households. In all cases, "market" goods (X_3) account for the largest share of consumption expenditures, ranging from 40% in Kanzara to over 50% in Aurepalle. Consumption of storable foods accounts for between 25% and 45% of the value of total consumption in the three villages.

The individual commodity demand equations were estimated as a system of seemingly unrelated regressions using the SYSNLIN procedure of SAS. Significant negative serial correlation was evident in most of the individual demand equations. To correct for this, a Cochrane-Orcutt procedure was employed, using Durbin's formula for approximating the autocorrelation coefficient.

Table 5.1 Mean Expenditure Shares by Village and Farm Type

Village	Farm Type	Commodity Group[a]						
		X_e	X_s	X_W	X_c	X_R	X_2	X_3
Shirapur	Small	.32	-	-	-	-	.23	.45
	Medium	.34	-	-	-	-	.21	.45
	Large	.35	-	-	-	-	.20	.45
Kanzara	Small	-	.23	.20	-	-	.17	.40
	Medium	-	.25	.20	-	-	.15	.40
	Large	-	.17	.28	-	-	.14	.41
Aurepalle	Group A	-	-	-	.06	.19	.25	.50
	Group B	-	-	-	.07	.19	.24	.50
	Rice growers	-	-	-	.07	.20	.17	.57

a. Commodity groups are as follows: X_e = sorghum and wheat; X_s = sorghum; X_W = wheat and pigeonpea; X_c = coarse grains (sorghum and millet); X_R = rice; X_2 = non-storable home-produced foods (vegetables, pulses, other cereals); and X_3 = market-purchased goods (oils, sugars, non-food).

Tables 5.2 - 5.4 contain the parameter estimates for the demand systems. The results are reasonably satisfactory. In two case -- rice demand by Group A households in Aurepalle and demand for "market goods" by large farm households in Kanzara -- own-price coefficients are positive (although small and insignificant). All other own-price coefficients are negative. With the exception of medium and large farms in Shirapur and small farms in Kanzara, at least one quarter of the price coefficients are significant at the 10% level or better. Nearly all income coefficients attain the 1% significance level. Most constants are insignificant, and those that are significant are quite small,

5.1.3 Demand Elasticities

One of the beauties of the Rotterdam model is the ease with which elasticities may be computed from the parameter estimates -- they are calculated by dividing the coefficients by the relevant expenditure share. Income and compensated price elasticities are presented in Tables 5.5 - 5.7.

Income elasticities are all positive, which is to be expected at this level of aggregation. With the exception of rice growing households in Aurepalle, the income elasticities of the stored commodities are strikingly smaller than the those for other commodity groups in nearly all instances. Again, this is not unexpected, since the stored

Table 5.2 Estimated Demand Parameters for Shirapur[a]

	Farm-size Class				Farm-size Class		
	Small	Medium	Large		Small	Medium	Large
β_{GG}	-.328***	-.006	-.130	β_G	.175***	.161***	.135***
	(.123)	(.151)	(.145)		(.027)	(.034)	(.022)
β_{G2}	.062	.023	-.002	β_2	.184***	.220***	.183***
	(.095)	(.123)	(.114)		(.026)	(.022)	(.020)
β_{G3}	1.040	.422	.024	β_3	.557***	.562***	.605***
	(.740)	(.956)	(.918)		(.030)	(.031)	(.027)
β_{2G}	.120	.059	.131	α_G	-.017	-.007	-.004
	(.118)	(.095)	(.122)		(.015)	(.019)	(.018)
β_{22}	-.252***	-.172**	-.208**	α_2	-.0008	-.005	.0001
	(.092)	(.074)	(.093)		(.014)	(.011)	(.014)
β_{23}	.105	-.094	.074	α_3	.037**	.015	.026
	(.717)	(.566)	(.729)		(.016)	(.016)	(.020)
β_{3G}	.263*	-.022	.216	ρ_G	-.407	-.364	-.434
	(.139)	(.132)	(.171)				
β_{32}	.273**	.191*	.179	ρ_2	-.268	-.463	-.396
	(.106)	(.105)	(.132)				
β_{33}	-1.853**	-.602	-1.374	ρ_3	-.204	-.442	-.339
	(.829)	(.802)	(1.041)				

a. Parameters of a Rotterdam model estimated with homogeneity imposed. Commodity groups indicated by the subscripts are: G = sorghum/wheat; 2 = non-storable home-produced foods; 3 = commodities not produced by households. Significance levels of .1, .05, and .01 are denoted by *, **, and ***, respectively.

Table 5.3 Estimated Demand Parameters for Kanzara[a]

	Farm-size Class				Farm-size Class		
	Small	Medium	Large		Small	Medium	Large
β_{ss}	-.125	-.172	-.211	β_{2s}	-.001	-.034	-.178
	(.176)	(.158)	(.140)		(.087)	(.116)	(.130)
β_{sw}	.040	.270*	.587***	β_{2w}	-.124	.207*	.234
	(.190)	(.162)	(.171)		(.095)	(.123)	(.160)
β_{s2}	-.126	-.220	-.237*	β_{22}	-.190**	-.257**	-.096
	(.182)	(.162)	(.140)		(.086)	(.118)	(.129)
β_{s3}	.080	.608***	.242	β_{23}	-.015	.160	.146
	(.225)	(.190)	(.207)		(.111)	(.143)	(.193)
β_{ws}	.132	.236	.442***	β_{3s}	-.156	.195	-.129
	(.132)	(.154)	(.160)		(.131)	(.211)	(.175)
β_{ww}	-.187	-.230	-.145	β_{3w}	.077	-.031	-.273
	(.149)	(.178)	(.195)		(.145)	(.229)	(.192)
β_{w2}	.154	-.157	-.187	β_{32}	.108	.080	.472**
	(.136)	(.147)	(.158)		(.136)	(.213)	(.178)
β_{w3}	.023	-.047	-.472**	β_{33}	-.168	-.540**	.044
	(.174)	(.199)	(.235)		(.171)	(.265)	(.241)
γ_{ss}	-.036	-.420***	-.191*				
	(.147)	(.125)	(.115)				
γ_{sw}	.144	.054	-.008				
	(.122)	(.128)	(.131)				
γ_{s2}	-.001	.126	-.029				
	(.072)	(.093)	(.108)				
γ_{s3}	-.104	.084	.090				
	(.111)	(.171)	(.136)				

Table 5.3 (Continued)

β_s	.070* (.040)	.058** (.029)	.047** (.023)
β_w	.123*** (.030)	.157*** (.027)	.070*** (.026)
β_2	.142*** (.019)	.123*** (.021)	.112*** (.021)
β_3	.540*** (.030)	.581*** (.038)	.590*** (.028)
α_s	-.001 (.010)	-.005 (.008)	-.004 (.009)
α_w	.002 (.008)	-.001 (.011)	.005 (.010)
α_2	-.000 (.005)	-.002 (.006)	-.001 (.009)
α_3	.000 (.007)	-.002 (.012)	-.001 (.009)
ρ_s	-.359	-.373	-.162
ρ_w	-.263	-	-.148
ρ_2	-.242	-.284	-.123
ρ_3	-.312	-.237	-.431

a. Parameters of a Rotterdam model estimated with homogeneity imposed. Commodity groups indicated by the subscripts are: S = sorghum; W = wheat/pigeonpea; 2 = non-storable home-produced foods; 3 = commodities not produced by households. γ_{ij} are the coefficients on lagged price variables, with i denoting the commodity whose price is lagged and j indexing the equation. α_j are intercepts. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

Table 5.4 Estimated Demand Parameters for Aurepalle[a]

	Farm Type				Farm Type		
	Group A	Group B	Rice Growers		Group A	Group B	Rice Growers
β_{cc}	-.071	-.223***	-.087*	β_{2c}	.027	.218	-.220*
	(.048)	(.049)	(.052)		(.132)	(.154)	(.129)
β_{cR}	.057	.270***	.004	β_{2R}	-.227	-.214	.201
	(.063)	(.068)	(.070)		(.169)	(.210)	(.170)
β_{c2}	-.052	-.260***	-.028	β_{22}	-.412*	-.523**	.741***
	(.074)	(.077)	(.084)		(.213)	(.259)	(.223)
β_{c3}	-.077	.225**	.043	β_{23}	.999***	.722**	.861***
	(.096)	(.098)	(.108)		(.266)	(.317)	(.267)
β_{Rc}	.002	.043	.113	β_{3c}	-.089	-.168	.113
	(.117)	(.103)	(.112)		(.137)	(.127)	(.131)
β_{RR}	.033	-.079	-.028	β_{3R}	.168	.255	.033
	(.146)	(.141)	(.151)		(.175)	(.172)	(.175)
β_{R2}	-.272	-.272	.613***	β_{32}	.708***	.751***	.063
	(.187)	(.172)	(.185)		(.205)	(.213)	(.224)
β_{R3}	.414*	.148	-.442*	β_{33}	-.974***	-.878***	-.541*
	(.231)	(.211)	(.233)		(.262)	(.260)	(.273)
γ_{cc}	-.117**	.075	-.001				
	(.044)	(.046)	(.049)				
γ_{cR}	.180*	.073	-.080				
	(.105)	(.094)	(.104)				
γ_{c2}	.292**	.248*	.111				
	(.120)	(.140)	(.118)				
γ_{c3}	-.195	-.258**	-.076				
	(.126)	(.115)	(.121)				

Table 5.4 (Continued)

β_C	.002 (.113)	.005 (.009)	.041*** (.011)
β_R	.104*** (.030)	.126*** (.021)	.098*** (.025)
β_2	.278*** (.035)	.353*** (.032)	.116*** (.029)
β_3	.591*** (.035)	.527*** (.026)	.685*** (.030)
α_C	.000 (.003	-.006* (.003)	-.002 (.003)
α_R	-.006 (.007)	-.001 (.007)	.017** (.007)
α_2	-.021** (.008)	-.023** (.010)	-.016** (.008)
α_3	.019** (.009)	.025*** (.008)	.005 (.008)
ρ_C	-.228	-.132	-.311
ρ_R	-.434	-.309	-.360
ρ_2	-.371	-.334	-.478
ρ_3	-.258	-.304	-.434

a. Parameters of a Rotterdam model estimated with homogeneity imposed. Commodity groups indicated by the subscripts are: C = coarse grains (sorghum and millet); R = rice; 2 = non-storable home-produced foods; 3 = other commodities not produced by households. γ_{ij} are the coefficients on lagged price variables, with i denoting the commodity whose price is lagged and j indexing the equation. α_j are intercepts. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

Table 5.5 Income and Price Elasticities in Shirapur[a]

Good	With Respect to the Price of:[b] X_G	X_2	X_3	Income
		----Small Farms----		
X_G	-1.021***	0.192	3.234	0.54***
X_2	0.534	-1.125***	0.469***	0.82***
X_3	0.578*	0.600**	-4.077**	1.23***
		----Medium Farms----		
X_G	-0.017	0.070	-1.261	0.48***
X_2	0.278	-0.807**	-0.441	1.03***
X_3	-0.050	0.428*	-1.348	1.26***
		----Large Farms----		
X_G	-0.370	-0.007	-0.069	0.38***
X_2	0.652	-1.038**	0.366	0.91***
X_3	0.485	0.400	-3.078	1.36***

a. Commodity groups indicated by the subscripts are: G = stored grains (sorghum and wheat); 2 = non-storable home-produced foods; and 3 = commodities not produced by households. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

b. Compensated price elasticities

Table 5.6 Income and Price Elasticities in Kanzara[a]

Good	With Respect to the Price of:[b]				Income
	X_S	X_W	X_2	X_3	
		----Small Farms----			
X_S	-0.545	0.174	-0.547	0.347	0.30*
X_W	0.641	-0.907	0.745	0.110	0.60***
X_2	-0.003	0.746	-1.137**	-0.090	0.85***
X_3	-0.393	0.193	0.272	-0.422	1.36***
		----Medium Farms----			
X_S	-0.699	1.097*	-0.893	2.469***	0.23*
X_W	1.175	-1.143	-0.780	-0.235	0.78***
X_2	-0.218	1.342*	-1.667**	1.036	0.80***
X_3	0.489	-0.077	0.200	-1.354**	1.46***
		----Large Farms----			
X_S	-1.253	3.491***	-1.411*	1.442	0.28**
X_W	1.600***	-0.524	-0.676	-1.709**	0.25***
X_2	-1.270	1.669	-0.686	1.045	0.80***
X_3	-0.312	-0.658	1.137***	0.107	1.42***

a. Commodity groups indicated by the subscripts are: S = sorghum; W = wheat/pigeonpea; 2 = non-storable home-produced foods; and 3 = commodities not produced by households. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

b. Compensated price elasticities.

Table 5.7 Income and Price Elasticities in Aurepalle[a]

Good	With Respect to the Price of:[b]				Income
	X_C	X_R	X_2	X_3	
			----Group A Farms----		
X_C	-1.132	0.910	-0.821	-1.217	0.03
X_R	0.008	0.176	-1.465	2.227*	0.56***
X_2	0.108	-0.901	-1.634*	3.967***	1.10***
X_3	-0.178	0.336	1.416***	-1.947***	1.18***
			----Group B Farms----		
X_C	-3.138***	3.801***	-3.661***	-3.169**	0.07
X_R	0.230	-0.420	-1.447	0.789	0.67***
X_2	0.915	-0.900	-2.198**	3.033**	1.48***
X_3	-0.335	0.508	1.494***	-1.747***	1.05***
			----Rice Growing Farms----		
X_C	-1.298*	0.059	-0.411	0.635	0.61***
X_R	0.563	-0.141	3.067***	-2.208*	0.49***
X_2	-1.315*	1.204	-4.438***	5.155***	0.69***
X_3	0.200	0.058	0.111	-0.958**	1.21***

a. Commodity groups indicated by the subscripts are: C = coarse grains (sorghum and millet); R = rice; 2 = non-storable home-produced foods; and 3 = commodities not produced by households. Significance levels of .10, .05, and .01 are denoted by *, **, and ***, respectively.

b. Compensated price elasticities.

commodities are the dominant staple foods consumed. Income elasticities for the "market" goods group (X_3) are all greater than unity and generally larger than those for other commodity groups. This group is dominated by expenditures on non-food items such as clothing and personal services.

With the two exceptions noted earlier, compensated own-price elasticities are all negative and in some cases quite large. Unlike the case of income elasticities, there is no distinct pattern in the magnitude of own-price response of different commodities. In a several instances, cross-price elasticities indicate some complementarity among commodities, primarily between one of the stored commodities and one of the non-stored commodities. In the villages in which two groups of stored commodities were included in the estimation, the results indicate that these are substitutes.

5.2 <u>Supply Response</u>

In section 2.4.1 the following formula for computing the uncompensated own-price response of a stored commodity was derived:

$$(5.2) \quad \frac{dX_{it}}{dP_{it}} = \left.\frac{\partial X_{it}}{\partial P_{it}}\right|_{dU=0} + \frac{\partial X_{it}}{\partial W_t}\cdot\frac{\partial W_t}{\partial \Pi_t}\cdot\frac{\partial \Pi_t}{\partial P_{it}}$$

$$= \left.\frac{\partial X_{it}}{\partial P_{it}}\right|_{dU=0} - X_{it}\cdot\frac{\partial X_{it}}{\partial W_t} + \left(S_t + \hat{Q}_{iT}\cdot\frac{\partial \hat{P}_{iT}}{\partial P_{it}} + \hat{P}_{iT}\cdot\frac{\partial \hat{Q}_{iT}}{\partial \hat{P}_{iT}}\cdot\frac{\partial \hat{P}_{iT}}{\partial P_{it}}\right)\cdot\frac{\partial X_{it}}{\partial W_t}.$$

This may be converted to an expression for the uncompensated elasticity using the notation of the Rotterdam model:

$$(5.3) \quad \epsilon_{ii} = \epsilon_{ii}^{*} + [S + \hat{Q}_i \cdot \frac{\partial \hat{P}_{i\tau}}{\partial P_{i\tau}} + \hat{P}_{i\tau} \cdot \frac{\partial \hat{Q}_{i\tau}}{\partial \hat{P}_{i\tau}} \cdot \frac{\partial \hat{P}_{i\tau}}{\partial P_{i\tau}} - X_i] \cdot \frac{\beta_i}{X_i}.$$

Computation of this elasticity requires an estimate of the supply response of the commodity of interest with respect to change in its expected price ($\partial\hat{Q}_{i\tau}/\partial\hat{P}_{i\tau}$).

An exhaustive analysis of output supply and input demand for semi-arid tropical India has been conducted by Bapna, Binswanger, and Quizon (BBQ). The study used district level data from four states in central and southern India. The districts in which the three study villages of the current analysis are located were either included in the BBQ analysis (Aurepalle), or are immediately adjacent to ones which were.

Output supply systems were estimated by BBQ for three sub-regions, as well as for all areas combined. The sub-regions were termed the "wheat," "rice," and "groundnut-cotton" zones. A detailed appendix giving average rainfall and cropping patterns in the districts incorporated into the sub-regions allows a choice of which of the supply systems is most applicable to individual study villages. Upon examination, it was decided that the results for the wheat zone were most applicable to Shirapur, the groundnut-cotton zone for Kanzara, and the rice zone for Aurepalle.

The BBQ estimates of own-price supply elasticities to be used in the analysis below are presented in Table 5.8.

Table 5.8 Estimated Supply Elasticities[a]

Output	Shirapur	Kanzara	Aurepalle
Sorghum	0.77	0.38	0.47
Wheat	0.33	0.34	-
Rice	-	-	0.46

a. All estimates are own-price elasticities taken from Bapna, Binswanger, and Quizon. Estimates for Shirapur, Kanzara, and Aurepalle are those for the wheat, cotton-groundnut, and rice zones, respectively.

Since wheat is the dominant commodity in the wheat/pigeonpea aggregate for Kanzara, its elasticity will be used for that group. The same holds for sorghum in the coarse grains aggregate for Aurepalle. For Shirapur, an average supply elasticity of .75 was calculated for the sorghum/wheat group, using mean annual output of each crop as weights.[44]

Finally, the data used in the BBQ analysis precluded the estimation of supply elasticities for different farm types. Such disaggregated estimates would be interesting from the point of view of the current analysis. Nonetheless, the orientation here is more of a methodological nature -- i.e., it focuses on how the approach developed in Chapter 2 compares with that of previous analyses. More precise measurement of the commodity demand and marketed surplus response of specific types of farms is therefore left as a subject for future research.

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[44] Averages were calculated for each farm-size class. These turned out to be virtually identical.

5.3 Marketed Surplus Response

Given the estimates of supply response described in the previous section, it is now possible to compute total demand elasticities and marketed surplus elasticities. In this section, these computations will be carried out. In choosing a point at which to evaluate the elasticities, it seemed desirable to obtain estimates for different points during the cropping cycle. Therefore, cropyears were split into two periods -- the two quarters immediately preceding harvest (the "lean" season) and the two quarters immediately following harvest (the "harvest" season), and elasticities were evaluated at the quarterly means for each season.

5.3.1 Uncompensated Demand Elasticities

Uncompensated demand elasticities were computed for four of the five groups of stored commodities that have been considered throughout this study. The results found in Table 5.4 indicate that the estimated own-price coefficient for rice demand among Group A households was positive, thus raising serious doubts concerning the reliability of the estimates for that farm group. For this reason, these households were omitted from this (and subsequent) analyses.

Seasonal elasticities were calculated for each farm type using the quarterly means of the variables contained in equation 5.3. For stocks on hand (S) and consumption (X_4) this was straightforward. The other terms contained within the brackets in 5.3 were somewhat trickier to handle since they contained expectational variables. Observed mean output was used as a proxy for mean expected output. For the harvest season, this is probably a very good approximation, since little information regarding weather and other environmental variables affecting output in the next growing season would be available at that time. For the lean season, the approximation is probably not as good for a particular year, since farmers would in fact be aware of the agroclimatic conditions determining the upcoming harvest. Nonetheless, over the entire sample period this seems to be the best available proxy.[45]

Estimates of the derivatives of expected prices with respect to current prices were based on the ARMA models described in Chapter 4. For the prices following AR1 processes (grains in Shirapur and wheat/pigeonpea in Kanzara), these were easily calculated as $\partial E_t P_{t+k} / \partial P_t = \theta^k$, where θ is the autoregressive parameter. In the case of coarse grains in Aurepalle, whose price follows an AR2 process of the form $P_t = \theta_0 + \theta_1 P_{t-1} + \theta_2 P_{t-2} + \epsilon_t$, the derivative is more complicated, but straightforward to compute.[46] Finally,

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[45] Because rice farmers in Aurepalle harvest more than one crop per year, this procedure was modified somewhat. Mean output for the upcoming season was taken to be mean expected output, using the same definition of seasons as was used for coarse grains.

[46] The k-steps-ahead derivatives for an AR2 process are: θ_1 for k=1; $\theta_1^2 + \theta_2$ for k=2; $\theta_1^3 + 2\theta_1\theta_2$ for k=3; and $\theta_1^4 + 3\theta_1^2\theta_2 + \theta_2^2$ for k=4.

sorghum prices in Kanzara were found to follow an MA2 process of the form $P_t = \theta_0 + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \nu_t$. Calculating the derivative of expected price with respect to the current price involved first inverting the MA process to form an infinite-order AR process. This yielded an expression for P_t as a function of lagged prices, with the coefficients on the lagged prices being nonlinear functions of θ_1 and θ_2. Recursive substitution of the AR representation then yielded expressions for $E_t P_T$ as a function of P_{t-j} ($j = 0,\ldots,\infty$) from which dP_T/dP_t could be calculated for t = 1,...,4.

Since the BBQ supply elasticities are estimates of supply response with respect to expected prices, a proxy for mean expected price was not required.[47] It was necessary to incorporate a discount factor, however. As in the inventory demand analysis, a quarterly discount factor of .95 was assumed. For each quarter, $\widehat{dP}_T/dP_t$ was calculated as $.95^k \cdot dP_T/dP_t$, where k = 4 for the quarter in which harvest occurred, k =3 for the following quarter, etc. These were then averaged over the relevant season.

Uncompensated own-price demand elasticities for the lean and harvest seasons are presented in Table 5.9. In all instances the uncompensated elasticities are greater (less negative) than their compensated counterparts. That is, the

[47] The BBQ elasticities are $\eta_i = (\partial Q_{iT}/\partial EP_{iT}) \cdot (EP_{iT}/Q_{iT})$. Therefore, $E_t P_{iT} \cdot (\partial Q_{iT}/\partial E_t P_{iT}) = \eta_i \cdot Q_{iT}$.

Table 5.9 Uncompensated Own-price Demand Elasticities and Profit Effects by Season[a]

	Lean Season		Harvest Season	
Farm Type	ϵ_{ii}	Profit Effect	ϵ_{ii}	Profit Effect
	----Shirapur grains----			
Small	0.090	1.29	0.159	1.36
Medium	1.104	1.28	1.162	1.34
Large	0.476	0.98	0.590	1.10
	----Kanzara sorghum----			
Small	-0.274	0.34	-0.269	0.35
Medium	-0.473	0.28	-0.477	0.28
Large	-0.666	0.63	-0.754	0.55
	----Kanzara wheat/pigeonpea----			
Small	-0.444	0.59	-0.401	0.63
Medium	-0.330	0.97	-0.243	1.06
Large	0.209	0.80	0.320	0.91
	----Aurepalle coarse grains----			
Group B	-3.134	0.01	-3.136	0.01
Rice growers	-1.233	0.11	-1.256	0.08
	----Aurepalle Rice----			
Group B	-0.512	0.03	-0.508	0.04
Rice growers	1.049	1.29	1.010	1.25

a. Lean season corresponds to the two quarters preceding harvest. Harvest season includes the quarter in which harvest occurs and the following quarter. Profit effects calculated as the difference between the computed demand elasticity and that computed using a conventional Slutsky equation.

profit effects (calculated as the difference between the elasticities presented in Table 5.9 and those computed usinga conventional Slutsky equation) are positive. Thus the positive effects of a price change on perceived household wealth -- the enhancement of the value of currently held stocks and expected future net revenue -- dominate the normal income effects on consumption.

For non-rice growing households in Aurepalle, these profit effects were found to be quite small. For rice growing households in Aurepalle and all households in Shirapur and Kanzara, however, the profit effects were substantial. For all farm-size classes in Shirapur the profit effects were large enough to induce positive own-price elasticities in the demand for storable grains in both the lean and harvest seasons. This was also true of demand for wheat and pigeonpea by large farm households in Kanzara and for rice by rice growing farmers in Aurepalle. This is an interesting result, one that has been recognized as a theoretical possibility for a long time, but has seldom been observed in empirical analyses.[48] In the present case, it is attributable to the inclusion of both stocks and the expected value of output of stored commodities into the analysis.

In order to distinguish the relative importance of

[48] Strauss (1984) found positive own-price demand elasticities to exist for one commodity by poor farmers in his work in Sierra Leone.

these two components of profit effects, the demand elasticities were re-calculated, this time omitting stocks of stored commodities from the computing equation. The results of this exercise are found in Table 5.10. For all annually harvested commodities, "stock effects" are particularly strong in the harvest season. In the harvest season, stocks on hand are greater than in the lean season. Moreover, discounting diminishes the effect of expected net revenue from production on currently perceived wealth. Likewise, in the lean season, "production effects" on perceived household wealth figure are more important, both absolutely and relative to stock effects. For rice growers in Aurepalle, the two components of profit effects are strong in each season. This is attributable to multiple cropping, since twice- or thrice-annual harvests lead to roughly constant seasonal means for both output and inventory holdings.

The first column in Table 5.10 lists the share of stocks of the stored commodities under examination in household wealth. This was computed by dividing the value of stocks on hand by the sum of the value of stocks on hand and the value of non-storable commodities consumed.[49] It is

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[49] A more complete (but computationally much more difficult) measure of wealth would have included the average discounted value of net revenue from agricultural activities. The measure used in Table 5.10 thus overstates the wealth share of stocks on hand. Nonetheless, it is adequate for the purposes of the present discussion -- namely, the linking of the magnitude of stock effects with the importance of stocks in perceived household wealth.

Table 5.10 Comparison of Demand Elasticities With and Without Stock Effects

		Lean Season		Harvest Season	
	Wealth Share of Stocks	With Stock Effect	No Stock Effect	With Stock Effect	No Stock Effect
		----Shirapur grains----			
Small	.38	0.090	-0.054	0.159	-0.511
Medium	.46	1.104	0.938	1.162	0.488
Large	.52	0.476	0.306	0.590	0.016
		----Kanzara sorghum----			
Small	.16	-0.274	-0.317	-0.269	-0.429
Medium	.21	-0.473	-0.508	-0.477	-0.619
Large	.24	-0.666	-0.805	-0.754	-1.033
		----Kanzara wheat/pigeonpea----			
Small	.21	-0.444	-0.551	-0.401	-0.733
Medium	.22	-0.330	-0.507	-0.243	-0.770
Large	.43	0.209	-0.005	0.320	-0.188
		----Aurepalle coarse grains----			
Group B	.16	-3.134	-3.141	-1.778	-1.812
Rice growers	.10	-1.233	-1.322	-1.397	-1.668
		----Aurepalle Rice----			
Group B	.04	-0.512	-0.546	-0.508	-0.546
Rice growers	.43	1.049	0.532	1.010	0.426

a. Wealth share computed as the value of stocks divided by the sum of the value of stocks and the value of other commodities consumed.

interesting to note that the cases in which the computed own-price elasticities were positive correspond to those cases in which the wealth share of stocks is quite large. For two groups of households, ignoring the stock effect reverses the sign of the elasticity in both seasons.

In sum, the analysis above indicates that in most instances profit effects were sizeable, and that both production effects and stock effects were empirically important in the computation of total demand elasticities for the stored commodities. No dramatic differences in the computed elasticities for specific village-farm type combinations were observed across seasons, but seasonal differences in the relative magnitude of stock effects and production effects emerged for annually harvested commodities. The conclusion to be drawn is that analyses of the demand response of important (stored) food staples in the context of semi-subsistence agriculture, ought to include both the value of currently held stocks and the expected value of future output ought to be incorporated into such analyses.

5.3.2 Marketed Surplus Elasticities

The formula for the own-price response of marketed surplus that was derived in Chapter 2 is

$$(5.7) \qquad \frac{dM_{it}}{dP_{it}} = -(1 + g)\cdot\frac{dX_{it}}{dP_{it}} + f(1 - b)\cdot\frac{d\hat{P}_{it+1}}{dP_{it}}.$$

As in the case of the uncompensated own-price response, this may be re-stated in terms of elasticities and the parameters of the empirical model of inventory demand:

$$(5.5) \qquad \mu_i = -(1 + g)\cdot\epsilon_{ii} + f\cdot(1 - b)\cdot\frac{d\hat{P}_{i,t+1}}{dP_{it}}\cdot\frac{P_i}{M_i}.$$

Here μ_i is the own-price elasticity of marketed surplus of good i.

In computing the μ_i's, use was made of the empirical results of the previous chapter. For those village-commodity-farm type combinations for which the null hypothesis that $f = g = 0$ could not be rejected, the marketed surplus elasticity was taken to be identical to the uncompensated demand elasticity in magnitude but of the opposite sign. Similarly, for those cases in which f was not significantly greater than zero, the second term was omitted in the computing equation.

For ease of interpretation, the absolute value of mean marketed surpluses was used. For households that were net sellers, a positive (negative) marketed surplus indicates that a price increase will lead to greater (less) sales. Similarly, for households that were net purchasers, a positive (negative) elasticity indicates that a price increase will lead to less (more) market purchases.

The computed marketed surplus elasticities are found in Table 5.11. Once again, these were evaluated at the means

Table 5.11 Marketed Surplus Elasticities by Season[a]

Farm Type	Lean Season: Average Mkt'd Surplus	Lean Season: μ_i	Harvest Season: Average Mkt'd Surplus	Harvest Season: μ_i
	----Shirapur grains----			
Small	-93	-0.20	198	-0.17
Medium	-67	-12.58	287	-3.32
Large	-76	-2.40	225	-1.28
	----Kanzara sorghum----			
Small	-95	1.07	26	4.12
Medium	-78	0.95	-19	4.36
Large	155	1.23	376	0.71
	----Kanzara wheat/pigeonpea----			
Small	-21	1.12	-3	8.42
Medium	-16	0.99	30	0.43
Large	84	-0.47	232	-0.28
	----Aurepalle coarse grains----			
Group B	-18	15.32	14	24.64
Rice growers	4	28.97	68	1.99
	----Aurepalle Rice----			
Group B	-121	0.55	-122	0.57
Rice growers	404	-0.43	373	-0.44

a. Lean season corresponds to the two quarters preceding harvest. Harvest season includes the quarter in which harvest occurs and the following quarter.

for the lean and harvest seasons. These vary considerably both within and across villages, and in some cases are extremely large. reasing their stock positions.

With regard to the response of marketed surpluses of wheat/pigeonpea by large farmers in Kanzara and rice by rice growers in Aurepalle, the interpretation is different. The cropping conditions for these groups of households are much more stable, either because of more assured rainfall (in Kanzara) or because of irrigation (in Aurepalle). While significant sales of these commodities occur, alternative cash crops are also grown (cotton in Kanzara, castor in Aurepalle). At the same time, wheat/pigeonpea and rice are the primary food staples for these households. The negative marketed surplus elasticity therefore appears to indicate that the wealth effects of an increase in the price of this commodity lead to an increase in consumption and a reduction of market sales.

Finally, other groups of households that (on net) engaged in a significant amount of market activity, were found to have marketed surplus elasticities that ranged from moderately inelastic to highly elastic.

5.4 Comparative Analysis

The final issue addressed here is the question of how the methods developed here compare with earlier methods of measuring the price response of commodity demand and marketed surplus. In this section elasticities calculated using the "new" method will be contrasted with elasticities computed using Strauss' method.

As has been mentioned before, Strauss' work represents the best work in this area to date by virtue of its recognition of the effect of price changes on net farm revenue. His formulae for computing uncompensated demand and marketed surplus elasticities (using the notation that has been employed throughout the current study) are

$$(5.8) \qquad \epsilon_{ii} = \epsilon_{ii}^{*} + \epsilon_{i}(Q_i - X_i)\cdot\frac{\beta_i}{X_i}$$

$$\mu_i = (\eta_i - \epsilon_{ii})\cdot\frac{X_i}{M_i}.$$

These were calculated for each village-farm type-commodity combination using quarterly means for X_i and M_i, annual means for Q_i, and the BBQ estimates of supply elasticities (η_i).

To facilitate comparison with the elasticities computed using Strauss' method, the new method was modified somewhat. Quarterly averages over the entire year (rather than by season) were used for X_i, M_i, and S_i. The discount factor applied to terms involving expected prices was the arithmetic average of the discount factors applicable to the lean and harvest seasons. Finally, annual average output and the BBQ supply elasticities were used for Q_i and η_i as before.

The results of applying the different methods of computing elasticities are presented in Table 5.12. In all

Table 5.12 Comparison of Different Methods for Computing Elasticities[a]

	Strauss' Method		New Method	
Farm Type[b]	ϵ_{ii}	μ_i	ϵ_{ii}	μ_i
	----Shirapur Grains----			
Small*	-0.320	16.14	-0.152	0.60
Medium*	0.678	8.81	0.866	-6.18
Large*	0.141	17.78	0.331	-0.61
	----Kanzara Sorghum----			
Small	-0.391	7.57	-0.274	1.29
Medium	-0.588	5.86	-0.477	1.62
Large*	-0.954	3.94	-0.718	0.86
	----Kanzara Wheat/pigeonpea----			
Small	-0.619	8.32	-0.423	2.05
Medium*	-0.584	14.92	-0.299	1.90
Large*	-0.060	2.78	0.261	-0.32
	----Aurepalle Coarse grains----			
Group B	-3.123	248.38	-3.138	155.35
Rice growers*	-1.121	7.66	-1.282	3.60
	----Aurepalle Rice----			
Group B	-0.546	0.59	-0.477	0.52
Rice growers*	1.027	2.09	1.887	-0.80

a. ϵ_{ii} = uncompensated demand elasticity.
μ_i = marketed surplus elasticity.

b. Asterisks denote groups that were net sellers.

cases, the demand elasticities computed using Strauss' method are smaller (i.e. more negative) than those computed using the new method. This is not surprising, since the former method does not account for the effects of currently held stocks on household wealth. In several instances these differences are rather dramatic. Moreover, in the case of wheat/pigeonpea demand in Kanzara the computed elasticities are of the opposite sign.

Examination of the marketed surplus elasticities in Table 5.12 reveals that in all cases the elasticities computed using Strauss' method are larger than those computed using the new method. These differences are striking in nearly all cases. Particularly noteworthy is the fact that all elasticities computed using Strauss' method are positive, while in several instances -- i.e. those noted in the earlier discussion -- the new method yields negative elasticities. That the estimates using Strauss' method are uniformly larger than those computed using the new method is true for the much same reason that the demand elasticities differed uniformly. That is, Strauss' method systematically understates wealth effects on consumption by failing to recognize the role of stocks, and therefore tends to overstate the elasticity of demand (and hence marketed surplus).

An additional, albeit less important factor explaining the differences between the two methods has to do with the way in which production enters into the calculations. In

Strauss' method, supply response is not discounted in any way. In contrast, the new method discounts production effects, which are incorporated into the analysis solely through their effects on demand response, in two ways. First, expected prices are discounted directly via the assumed discount rate (b). Second, the derivative of expected price with respect to current price (as implied by the ARMA models of Chapter 4) imposes an additional form of discounting.

In the case of medium and large farm households in Shirapur there is another factor that, in different circumstances, could have led to estimates of marketed surplus elasticities calculated using the new method to exceed those calculated using Strauss' method. Recall that these were the two cases in which significant arbitrage motives were detected. Give the new computational method, this implied and additional increment to the calculated elasticities for these two groups (the second term in equation 5.7). As it turned out, this increment was rather small in the current case. Nonetheless, one can imagine circumstances where this component of marketed surplus response might attain significant proportions.

5.5 Summary

In this chapter systems of commodity demand equations were estimated for each of the three study villages. The econometric results were then combined with outside estimates of supply response and the results of the inventory demand analysis to compute seasonal own-price elasticities of demand and marketed surplus for stored commodities. Finally, the methods developed in this study for computing price response were contrasted with an earlier methodology.

The econometric results of the demand analysis were generally satisfactory. In all instances, demand for stored commodities was found to be income inelastic, while some of the income elasticities for other commodities (especially market-procured goods) were rather large for the various village-farm type combinations. Compensated price elasticities indicated that goods were generally substitutes.

Seasonal own-price (uncompensated) demand elasticities were computed for stored commodities. This analysis indicated that cases profit effects were sizeable in most cases. Differences across seasons of the computed elasticities for individual village-farm type combinations were generally rather small, but seasonal differences in the relative magnitude of stock effects and production effects were pronounced for annually harvested crops. In several instances in which the share of stocks in perceived household wealth was quite large, profit effects gave rise to positive demand elasticities. Computed marketed surplus elasticities for households that engaged in significant market transactions were quite variable. In several instances these were found to be negative.

Finally, the elasticities computed using the new method were compared with those estimated using the methods employed in Strauss' work. The results of this analysis indicated that the earlier method systematically overstated the both demand and marketed surplus elasticities. In some cases, the differences between the two methods was dramatic.

The important methodological conclusion that emerges from the results presented above is that analyses of the demand and marketed surplus response in the context of semi-subsistence agriculture should incorporate both the value of currently held stocks and the expected value of future output response of important (stored) food staples. This is true even when empirically significant arbitrage and food security motives for holding inventories are found to be absent (as was true for many of the village-farm type-commodity combinations here). This is due to the importance of stock effects on consumption of stored commodities (and thence marketed surplus).

Chapter 6

SUMMARY AND CONCLUSIONS

This study has treated two distinct issues related to semi-subsistence agricultural households. First, the behavioral question of what determines household demand for inventories of key food staples was addressed. Empirical analysis was directed at measuring the strength of two likely motives for holding inventories -- arbitrage over time and food security considerations -- using data from three different villages in India. Second, a method was developed for calculating the own-price elasticities of demand and marketed surplus for stored commodities. In order to gauge the potential improvement represented by the new method, elasticities computed using the methods derived here were compared with those derived using the methods of previous research.

In this concluding chapter, the findings on these two issues are synthesized. In Section 6.1, the important results of the previous chapters are summarized. Section 6.2 discusses how these results mesh with existing literature on semi-subsistence agriculture and in what ways the current study represents a departure from previous research. Drawing on this discussion, Section 6.3 offers suggestions for future research.

6.1 Summary

In Chapter 2, a theoretical model of semi-subsistence agricultural households was developed which explicitly accounted for the ability of households to store key food staples over the period between harvests. In addition to several marginal relationships between prices and quantities found in conventional analyses, the first order conditions for the model yielded a simple inventory demand equation in which carryout stocks are a linear function of current consumption of the stored commodity and the difference between its current and expected prices. The coefficients on the price differential and consumption variables were interpreted as indicators of the strength of arbitrage and food security motives for holding stocks.

Applying an appropriate single-equation technique to panel data from three villages in southern India, inventory demand equations for five groups of stored food staples were econometrically estimated in Chapter 4. For each village households were grouped according to wealth status, with separate regressions being estimated for each village-commodity-farm type combination. For four of the fourteen regressions, the model was found to perform relatively well, while in the other ten the model failed (i.e. the structural parameters of interest were jointly insignificant and/or of the wrong sign). In all villages food security motives generally dominated arbitrage motives in determining the level of inventory demand. Empirically significant arbitrage motives were found to exist only for the medium and large farm households in the poorest of the three villages (Shirapur).

These econometric results corroborated hypothesized inter-village differences in the motives for holding inventories of staple foods, namely that food security motives are positively related to the harshness of the agro-climatic environment and that the strength of arbitrage motives is inversely related to the availability of cash cropping alternatives. The empirical evidence was mixed, however, with regard to the importance of food security motives within villages.

Comparative statics analysis in Chapter 2 implied a method for calculating own-price elasticities of demand and marketed surplus for stored commodities. It was shown that in addition to the substitution and income effects of conventional Slutsky analysis, stocks on hand and expected revenue from future production will have added wealth (or profit) effects on current consumption. It was further demonstrated that stocks have two effects on the own-price response of marketed surplus. First, the wealth effects on consumption have a direct impact on marketed surplus response. Second, to the extent that food security and arbitrage motives are important, these will give rise to indirect effects via the response of inventory demand to price movements.

In Chapter 5, seasonal own-price elasticities of demand and marketed surplus for stored commodities were computed using the methodology developed in Chapter 2. This analysis used econometric estimates of the parameters of commodity demand, estimates of the structural coefficients of inventory demand from Chapter 4, and outside estimates of output supply response. The results of this exercise indicated that profit effects were sizeable in most cases. Seasonal differences in the computed demand elasticities were generally rather small, but seasonality in the relative magnitude of stock effects and production effects was pronounced. In several instances, corresponding to the cases in which the share of stocks in perceived household wealth was quite large, profit effects were large enough to cause demand elasticities to be positive.

Computed marketed surplus elasticities for households that engaged in sizeable net market transactions were quite variable, both within and across villages. In several instances -- the same ones for which demand elasticities were positive -- these were found to be negative. While the possibility of backward-bending market supply curves in semi-subsistence agriculture has long been recognized as a theoretical possibility, they have seldom been observed in empirical analyses. The finding of negative marketed surplus elasticities for a rather large proportion of the households considered here is therefore a noteworthy result.

Finally, elasticities computed using the methods developed here were compared with those computed using a more traditional methodology. In all cases, the traditional method yielded larger elasticities for both commodity demand and marketed surplus, a finding largely attributable to the inclusion of stock effects in the new method. In several cases, these differences are dramatic, the most important being that all marketed surplus elasticities calculated using the earlier method are positive.

6.2 Synthesis

The model that was developed in Chapter 2 is firmly grounded within the tradition of household-firm models as applied to semi-subsistence agricultural households. The model borrows heavily from its theoretical antecedents in both its formulation and in many of the assumptions upon which it is based. The innovation to the literature represented by the model lies in its recognition of the ability of households to store important staple foods.

The inclusion of household inventories in the model has led to two important departures -- of varying empirical importance -- from previous work. First, it added an intertemporal dimension to the analysis which necessitated more careful attention to price expectations than has been found in earlier research. As it turned out, these were relatively unimportant in the current study. The reason for this is primarily due to the unexpectedly flat pattern of seasonal prices for the commodities considered here. Time series analysis of prices revealed that in the majority of cases prices followed a random walk. Moreover, there was no evidence that prices followed the sawtoothed seasonal pattern that was expected a priori. This probably explains the absence of empirically significant arbitrage motives in inventory demand for the great majority of households considered here. Of course, this is not to say that price expectations might not play an important role in other circumstances.

Second, the hitherto unexplored effects of inventories on consumption and marketed surplus had to be explicitly incorporated into the analyses of price response. The analysis of Chapter 5 demonstrated rather convincingly that these stock effects were empirically important. The finding of backward-bending market supply curves for several of the groups of households considered was largely attributable to these effects. Furthermore, the comparative analysis provides compelling evidence that the earlier methods of computing elasticities for semi-subsistence households overstate both demand and marketed surplus response of stored commodities.

In addition to the above-mentioned analytical differences, the current study stands out from earlier research by virtue of its use of panel data in econometrically estimating commodity demands. The rich VLS data set permitted a more temporally disaggregated analysis (i.e. quarterly, as opposed to annual) than has been undertaken previously. More important, it alleviated the dependence on spatial variation in prices characteristic of all previous empirical work related to semi-subsistence households. Finally, cross-sectional time-series nature of the data was a prerequisite for the inventory demand analysis which was conducted.

The VLS data set is unique both in terms of its comprehensiveness and the quality of the data. It is unlikely that a similar data set will become available in the foreseeable future. How then can the methods developed here be used in conjunction with more modest data sets?

The important methodological conclusion that emerged from the comparative analysis of Chapter 5 is that both the value of currently held stocks and the expected value of future output of important (stored) staple foods should be include in analyses of commodity demand and marketed surplus response in the context of semi-subsistence agriculture. This is true even when empirically significant arbitrage and food security motives for holding inventories are found to be absent. While fairly comprehensive time series data is needed to estimate these latter effects, data requirements for estimating stock effects on consumption are far more modest. Data on average stocks held during the cropping season might be elicited using so-called rapid appraisal techniques common to many data collection efforts in developing countries. Sampling inventory holdings in this way a few times during the year would in all likelihood produce reasonable estimates of average yearly stocks. An even simpler, albeit less accurate, procedure would be to assume that average annual stocks are some proportion of average annual output -- say 50 percent.

With regard to the indirect effects of price movements on marketed surplus response (i.e. those operating via arbitrage and food security motives in inventory demand), there appears to be no simple prescription. The results of the analysis in Chapter 4 indicated that for about two-thirds of the households considered these were empirically insignificant. In a sense this is a pleasing result in that it implies that little would be lost in ignoring these effects. Two caveats must be added, though. First, it is dangerous to attempt to generalize the results of the current analysis to other locations within or outside of India, especially given that they are taken from fixed effects models estimated for only three (out of 250,000) Indian villages. Second, there appears to be no sure way of knowing whether these indirect effects are empirically important for a given group of households without actually performing the econometric estimation.

6.3 Suggestions for Future Research

Perhaps the most striking empirical result of the current study is that marketed surplus elasticities were found to be negative for a relatively large proportion of the households considered. Many of the early theoretical models of agriculture in developing countries assumed a priori that the market supply curves of peasant farmers were backward-bending. The arguments in support of this view tended to be based on notions of an essential irrationality pervading this class of farmers. Later, with the advent of convincing economic analyses that explained the observed behavior of peasant farmers in terms of the neo-classical paradigm (most notably, the work of T.W. Schultz) a rather heated debate appeared in the development literature concerning these "perverse" market supply curves. At issue was the question of whether these were empirically ascertainable or merely theoretical curiosities. As was noted in Chapter 5, careful empirical analyses of semi-subsistence households have found practically no evidence of "perverse" marketed surplus response. In this light, the empirical results on marketed surplus response reported here are noteworthy.

In the present case, these empirical results were found to be largely attributable to the incorporation of stock effects on consumption into the analysis. One cannot be certain, however, that the relatively large number of households found to have negative marketed surplus elasticities is due to the methodological refinements developed in this study (rather than to peculiarities of the data used). Determining whether this is indeed the case will require additional research in which the new methods are applied. It would be particularly desirable to conduct future research in locations in which stocks account for a large share of total household wealth, since the findings here suggest that these are the instances when negative marketed surplus response is most likely to be uncovered.

The inventory demand analysis indicated that the model developed here worked best in the village characterized by the most marginal agronomic environment and the least diversity in terms of cropping alternatives. This suggests that the most propitious venue for further investigations of the determinants of inventory demand would be in similarly impoverished locale. The Sahelian region of West Africa is one such likely location. Additionally, it would be of interest to conduct an analysis similar to this one in an area in which prices do indeed follow a sawtoothed seasonal pattern.

As has been discussed, the data requirements for conducting inventory demand analysis along the lines suggested here are rather formidable and existing cross-sectional data is inadequate for this task. Nonetheless, time-series data on inventories of staple foods could be collected in the future. Furthermore, such a data collection effort need not be nearly as extensive as the VLS project. One could presumably conduct meaningful analysis using a much shorter time-series of cross-sectional data -- perhaps as short as four quarterly observations if a large enough number of households were sampled over that period.

Finally, the usefulness of the VLS data set has by no means been exhausted in the present study. One likely avenue for future research using this data is a more disaggregated consumption demand analysis. As was mentioned earlier, in the process of organizing the VLS data set, quarterly data for six to eight commodity groups was constructed. This more disaggregated data set is a potentially useful resource to be drawn upon at some later date.

Another interesting future research project would be the estimation of output supply and factor demand systems for the three villages that have been studied here. The supply response parameters used in the analysis of Chapter 5 were drawn from the most careful supply analysis to date for semi-arid tropical India, and, as such, were used without apology. It would nevertheless be of some interest to estimate supply response for the three villages directly, if only to confirm the validity of the parameters which were used here.

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