DYNAMICS OF LABOR DEMAND AND SUPPLY OF RURAL HOUSEHOLDS: A THEORETICAL AND EMPIRICAL ANALYSIS

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Abstract

In this dissertation I develop and test a dynamic, stochastic model of labor demand and supply of farm households in a developing country. Existing estimates of labor demand and supply parameters are usually derived from separable/recursive agricultural household models within a static, perfect foresight framework. It is demonstrated that the introduction of risk results in nonseparability, since the preferences of the household affect the input decisions on the production side.

More explicitly, agricultural production is formulated as a dynamic two-stage process with sequential dependence of decisions, where the uncertainty about the level of output is an important determinant of behavior. The demand for hired labor in the first stage is shown to be dependent on the fixed inputs utilized in that stage, the current and future prices of the variable inputs and a latent variable summarizing the influence of preferences and uncertainty on the production decisions. Similarly labor supply is dependent on that same latent variable and current wages and is modeled separately for males and females within the life-cycle context. Finally both labor demand and supply are influenced by demographic and institutional factors that vary across households.

The conditions that allow separate estimation of the production decision rules independently from the consumption decisions are explored. It is shown that estimation of the labor demand functions via fixed effect methods may yield consistent wage elasticity estimates provided consumption enters the utility function linearly. Given the restrictiveness of these conditions it is argued that it is preferable to directly estimate the parameters of the agricultural technology and then derive the implied input demand elasticities. In this manner one can derive estimates of the change in labor utilized on the farm caused by a perfectly anticipated seasonal changes in wage rates.

The above model is tested by using microeconomic panel data from India. Consistent estimates of the parameters of the utility function and the production technology are derived by choosing appropriate functional forms and using fixed effect econometric techniques.

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CHAPTER I

I.A INTRODUCTION

Labor market participation is the major source of income for millions of landless and small farm households in the rural sectors of developing countries. Thus, the prevailing wage rates and levels of employment, as well as their evolution over time, are important issues to policy making. Extensive research is being carried out on technological improvements and production practices which are intended to increase agricultural output and at the same time utilize labor more evenly season to season. The evaluation of the effects of such technological improvements on rural employment and wage rates requires knowledge of the determinants of consumption, labor supply,the demand for farm inputs and the level of farm production. Also, given the dual role of agricultural households as producers and consumers it is important to know how their behavior as consumers and suppliers of labor affects their behavior as producers, and vice versa. Finally, given the seasonal nature of agriculture, one needs to know how the role of these factors changes from season to season.

There is a wide body of empirical literature trying to provide answers to some of the questions raised above. All of this empirical literature however, ignores risk and dynamics. These two aspects of reality in the rural sectors of developing and developed countries alike, can hardly be disputed. What is questionable however, is their potential effect on the existing estimates derived under static models with perfect foresight. As of yet, only verbal acknowledgement is paid to the issues of risk dynamics in agricultural household modeling.

An important reason for this lack is that dynamic modeling requires time series data which is not widely available in developing countries. Another reason is that it is difficult to derive empirically testable propositions concerning the effects of risk and dynamics. For example, in the context of uncertainty, theoretical propositions are derived under restrictions on (the third derivates of) the utility function which have little empirical content.

One fact is certain: behavior of risk averse individuals under conditions of risk will be different than behavior under perfect foresight. The desirable analytical approach is to construct an empirically tractable model that can account for the presence of these two factors. This study is an attempt in this direction.

The aim of this dissertation is to provide an empirically useful framework for the analysis of the determinants of the labor demand and supply of agricultural households. The framework developed is flexible enough to allow for the introduction of dynamics and uncertainty. It relies on the use of longitudinal data and its applicability is thus limited to countries where such data is available. Since most of the existing literature provides parameter estimates obtained from recursive perfect foresight models applied on cross-sectional data, the results of this model are compared with and contrasted to the estimates obtained under the hypothesis of no uncertainty. It is hoped that this exercise provides a convincing justification for the consideration of risk in agricultural household modeling despite the empirical complications. It is believed that the increase in complexity is compensated by more reliable parameter estimates obtained and more accurate estimation of policy effects.

I.B MOTIVATION

Employment and wage determination in developing countries has been studied by economists in a static, noncompetitive context, where wages are determined by institutional constraints or nutritional considerations ; Leibenstein (1957), Stiglitz (1976), Mirrlees (1975); similarly, labor supply is considered as unresponsive to changes in wage rates (Lewis (1954)). In the past few years, however, researchers have come to question the validity of the above assumptions. Careful analyses of rural labor markets in LDCs have provided strong evidence that wages and employment are determined by competitive forces that make the application of the neoclassical theory of labor markets more relevant and useful (Bardhan (1979), Rosenzweig (1980)). Furthermore, the neoclasssical labor supply theories may be more valid for developing countries than for developed ones because, as Rosenzweig (1984) states:

> " ... labor within age/sex groups is less heterogeneous, non-pecuniary differences in wage paying jobs are likely to be fewer, taxation of earnings may be ignored and the amount of time worked may be more flexible."

A parallel development in the field, which provided a rich framework for analyzing rural behavior, was the model of the agricultural household. This theory treats the agricultural household as playing the dual role of a producer and consumer of an agricultural commodity, thus allowing for the interdependence of consumption and production decisions. Utilizing this framework one can derive richer results than simple consumer theory in its own or theory of the firm alone could provide (for an excellent survey see Singh et al.1986).

There are two polar case versions of the agricultural household model in the literature. The first version emphasizes the absence of certain markets (such as those for land, credit labor and insurance) and attempts to model the implications of the absence of such markets on rural behavior and contractual arrangements. Underlying the missing markets hypothesis are the notions of risk, asymmetry of information and incentive problems with respect to effort. Most of this literature has attempted to rationalize the phenomena of sharecropping, as in Stiglitz and Newbery (1974); and permanent farm labor contracts as in Eswaran and Kotwal (1985). Unfortunately, although these researchers have modelled markets with uncertainty, they have failed to provide empirically testable hypotheses about labor supply and/or demand in that context. These studies consider only the contractual arrangements, not the actual demand and supply of factors under uncertainty.

The other branch of the literature, which is more empirically grounded, assumes a complete set of markets. The main contributions of the complete markets agricultural household model are in the analysis of the interactions between production and consumption. For example, using this framework, one can explain how a rise in the price of output may lead to higher not lower consumption of the commodity which the household both produces and consumes. This may occur because of the following reason: a rise in the product price will raise farm profits and hence family income; under the assumption of normality, more of that commodity (whose price has risen) will be consumed due to the income (profit) effect; if that income (profit) effect is large enough so as to overcome the substitution effect, consumption could rise (and marketed surplus fall) as the price increases. The orthodox demand and supply analysis would lead to the opposite conclusion. Empirical studies on Taiwan by Lau et. al.(1978), Malaysia by Barnum & Squire (1979), Korea and northern Nigeria by Singh & Janakiram (1986) have established the empirical relevance of this prediction of the agricultural household model.

A similar prediction can be derived for the net labor supply of the farm household. On "large" (small) farms where total labor demand exceeds (is less than) the amount of labor supplied by the family, net labor supply is negative (positive); that is labor is "imported". Increases in the market wage rate thus reduce full income for net exporters of labor. Consequently, if utility functions are approximately homothetic and leisure is normal, households without land (exporters of labor to the market) will on average exhibit lower supply than will households with land. Rosenzweig (1980) tested and confirmed these implications , using Indian household data.

The empirical applications of and tests of the propositions derived from agricultural household models with complete markets, are based on the property of recursiveness. As Jorgenson and Lau (1969) first demonstrated, under the assumption of a perfect labor market, the optimal production input decisions of a representative rural household may be modeled independently of its consumption decisions. However, consumption decisions are dependent on the production side of the model since profits are part of full income. In a more general context, the property of recursiveness is valid, provided a market exists for any relevant commodity included by the model. The empirical consequence of "separability" is that it reduces the number of parameters that have to be estimated by a researcher. Thus one can concentrate on the consumption side by just having data on expenditures, prices, profits and demographic variables as in Lau et. al. (1978) Bardhan (1979) and Yotopoulos and Lau (1974) without any reference to production technology. Correspondingly, on the production side one can estimate the output supply and input demand system without any reference to consumption, as in Lau & Yotopoulos (1974) and Barnum & Squire (1979). The number of studies utilizing recursive household models is quite large and a review of the literature will not be repeated here (see Singh et. al (1986)). It will be mentioned, however, that all of the studies on rural household labor demand and supply rely on a static, perfect foresight framework.

There is a number of additional issues arising when one considers rural labor markets. The first one concerns the heterogeneity between male and female labor. The issue of heterogeneity has important implications for policy evaluation, because of the specialization by gender in certain household and farm production activities. All of the agricultural household models concerning labor supply (or labor demand) tend to aggregate labor at the household level. A similar aggregation is done to male and female wage rates in order to derive the aggregate wage rate for household labor. However, as Rosenzweig (1980) first demonstrated, this procedure may be inappropriate, at least on the supply (consumption) side. He found that the own wage elasticities for females were much larger than those for males and that there were substantial cross wage effects. Similar arguments can be used against aggregating male and female labor on the production side where many tasks (such as weeding and transplanting) are sex specific. However, the empirical evidence against considering male and female labor as homogeneous (perfectly substitutable) inputs is missing.

The second issue one has to pay attention to, concerns the role and implications of uncertainty. Rural households face many risks ranging from yield risk to life-cycle risks. Agricultural production is an inherently dynamic process plagued by many sources of uncertainty. During the period between planting and harvest, the weather, pests, and other external forces determine the harvest level, rendering future output uncertain. Farmers form expectations about that future based on their experience and on current information, which also interact with current decisions. At the same time, households are not able to know with certainty what market prices and wage rates will prevail in the future, so they make both labor market participation and current consumption decisions based on uncertain expectations about the path of their future earnings.

The presence of uncertainty, and risk-averse behavior (documented by Binswanger (1980)), has important implications not only with respect to the way the empirical analysis should be carried out but also on the fundamental understanding of rural behavior and production relations. This is because the decisions of risk-averse individuals in the presence of uncertainty will be different than in the absence of risk. The latest work of Binswanger & Rosenzweig (1986) provides a conceptual framework for the analysis of the implications of risk on behavior and on the existence (or lack) of major intertemporal (insurance) and factor markets (land, bullocks).

As mentioned previously, a sufficient condition for the recursiveness of an agricultural household model, is a complete set of markets for all relevant commodities. In a model with uncertainty, this condition translates to a complete set of markets for all state contingent commodities. Given the unrealistic nature of this assumption, especially with respect to the rural sector of developing countries, it is not surprising that the absence of contingent commodity markets, leads to interdependence of consumption and production decisions. It is worth emphasizing however, that the existence of a complete set of markets does not constitute a necessary condition for recursiveness. It is possible that the adverse effects caused by the absence of a certain market can be eliminated by the actions of agents in other functioning markets. For example, as Pitt and Rosenzweig (1986) have shown empirically, it is possible for the market for hired labor to act as a perfect substitute for family labor - which is not traded in the market - so that profits remain unaffected when the farmer becomes ill.

In the context of an agricultural household model with uncertainty, one would tend to think that the assumption of a perfect credit market may lead to recursiveness since farmers can smooth their consumption by borrowing any amount they wish from the credit market. The exposition in Chapter III demonstrates that the production decisions of rural households are dependent on their consumption preferences even under the assumption of a perfect credit market.

Thus the introduction of risk into a dynamic model of the agricultural household leads to nonseparability. The absence of an effective means of insuring incomes against different states of nature, will lead, in the presence of risk aversion, into a situation, whereby preferences (consumption, labor supply decisions) play a role in the determination of the optimal input and output decisions. This was demonstrated explicitly in the first attempt to analyze the implications of risk (yield risk in particular) within the agricultural household model, by Roe and Tomasi

(1986). Upon exploring the conditions under which separability could be obtained, they used a rather restrictive specification for the utility function (negative exponential) and a Cobb-Douglas production function with constant returns to scale and multiplicative risk. Under these specifications they were able to show that the household behaves as if it first maximizes certainty equivalent full income with respect to input and output choices, and then maximizes utility subject to its budget constraint, in which certainty equivalent full income appears. However, other than the simulations of Roe & Graham-Tomasi, there is very little empirical work concerned with the extent of bias caused by nonseparability.

The first study to explicitly test for nonseparability was by Lopez (1984). In his model work on and off the farm enter as two different arguments in the utility function in an adhoc manner. Thus it is not leisure per se that is valued, but rather the hours of work in each particular location. In this context nonseparability results, because the market for on farm work is non-existent. A test was then developed and the hypothesis of separability was rejected. An alternative attempt by Pitt & Rosenzweig (1986), performed an indirect test of separability and did not reject it. Their finding was that farm profits were not affected by a farmer's illness. Given that the market for family labor is non existent, they showed that farmers were able to substitute hired for lost family labor time without a loss in profits.

The major implications of nonseparability concern both the theoretical and the empirical side of the agricultural household modeling effort. On the theoretical side , nonseparability changes the whole comparative statics results. One promising approach is the " virtual price" framework of Neary & Roberts (1980). However, that remains to be extended to dynamic models with uncertainty. On the empirical side, nonseparability causes inconsistency in the parameters estimated under the usual approaches mentioned above. This is because the estimation of a nonseparable model as a separable one, ignores the effects of consumption on the input demand choices. Judging from the conflicting empirical evidence, it appears that the extent or the direction of this bias, depends on the particular model or problem considered.

Closely related to the empirical specification and estimation of the production problem of rural households under risk is the issue of seasonality. Agricultural production is a sequence of operations, the timing of which are determined by the type of crop and the weather conditions. The sequential nature of the decision problems of a farmer mean that decisions are interdependent from period to period within each crop cycle. This gives rise to fluctuations in input, especially labor, utilization. Seasonality in agriculture has always been acknowledged but ignored at the empirical level. An exception is the study by Nath (1974) who attempted to estimate the interseasonal variation in the marginal product of labor in India, by the direct estimation of an agricultural production function. His findings were that the marginal product of labor in the slack season was not significantly different from zero, whereas that in the peak season was positive. These estimates however, are subject to simultaneity (Antle (1983)) and heterogeneity (Mundlak 1961)) bias, since the sequential aspect of labor utilization and the correlation with farmer unobserved characteristics are ignored . More careful specification of the sequential decision process in agricultural production along with the accompanying econometric implications is provided by Antle (1983) for the risk neutral producer; but not for the risk-averse one.

This dissertation attempts to address most of the issues discussed in the preceding paragraphs. A dynamic agricultural household model with uncertainty is developed and analyzed. The emphasis is on labor demand and labor supply. Two types of labor are distinguished based on gender. Price taking behavior is assumed, since the analysis is carried at the household level. Each crop-cycle lasts for two periods. Labor demand within the planting stage of each crop-cycle is generated by a dynamic two stage process where output is uncertain. Farmers are assumed to make their input decisions sequentially by recognizing that their decisions today will have an effect on the input decisions tomorrow. It is shown that at least in the planting stage nonseparability results. Labor supply at any given time is determined within a life-cycle context where future wages and profits are also uncertain. Given the intertemporal nature of the utility maximization problem, each member has to balance the tradeoff of working today at a known wage rate against working tomorrow at an uncertain wage rate.

The ultimate objective of this study is the empirical test of the theoretical model of labor demand and supply under risk. To facilitate the analysis, the relationship between the theoretical, structural model and the final form for empirical estimation is made explicit. Both production and consumption decisions are modeled in the primal form. One difficulty encountered in the empirical implementation of any multiperiod model of consumption or labor supply relates to the specification of an individual's expectations regarding lifetime constraints. This underscores the problem of unavailability of data on both the retrospective and the prospective information used by each consumer to determine observed current choices.[1] The approach taken here overcomes this difficulty. The estimation procedures utilized in the paper - first suggested by MaCurdy (1981) - are designed to estimate the parameters of a lifetime preference function invoking minimal assumptions concerning the constraints faced by a household out-side the decision period. One is able to estimate the parameters needed to infer a lifetime preference function for a household (provided consumption data is available) without modeling expectations. This estimated lifetime preference function can provide an essential component of the information needed in a simulation analysis that may be used to predict a household's response to various changes in lifetime constraints.

On the production side, the parameters of labor demand in the planting and harvesting stage are estimated. Since production is modeled as a two stage process with careful specification of the information set utilized by farmers, one is able to analyze the interseasonal variations in labor utilization. It is argued that nonseparability can be reduced by using fixed effect methods and an "indirect" test of nonseparability is conducted. The empirical results of the model, verify a significant tradeoff in the labor supply of females over time. The results obtained for males however are not significant. On the labor demand side, the elasticities of demand for males and females are shown (after controlling for heterogeneity and nonseparability) to be negative and unequal to eachother; the cross price price elasticities verify that males and females are nonsbstitutable inputs in production.

Finally, in order to obtain estimates of the technology parameters, an agricultural production function is estimated directly. The derived parameters are then used to derive alternative (independent) estimates of the input demand elasticities in each stage. These input demand functions derived from the underlying production technology satisfy all the cross equation restrictions implied by the the first order necessary conditions of the dynamic maximization problem of rural households. These elasticity estimates are then contrasted to those obtained from the direct estimation of the input demand functions after correcting for nonseparability.

It is argued that the direct estimation of the production technology parameters yields more reliable input demand elasticity estimates. Using this approach one does not have to make any additional assumptions on the nature of preferences and or the nature of the stochastic shock to output. As it is explained in detail in chapter III, these additional assumptions are necessary if one were to derive consistent elasticity estimates by estimating the input demand functions.

Chapter II presents the maximization problem of landowning households and the relevance of the assumption of a perfect credit market is scrutinized. Attention is paid to the two stage formulation of the agricultural production process and the issue of nonseparability is discussed. Chapter III contains the empirical specification and Chapter IV description of the data and empirical results. Chapter V contains the direct estimation of an agricultural production function after controlling for heterogeneity and simultaneity. The dissertation concludes with a summary of the results obtained from the proposed model and with suggestions for further research and extentions.

CHAPTER II

THEORETICAL ANALYSIS

This chapter presents an intertemporal model of an agricultural household with uncertainty. Section II.A contains the basic model under the assumption of a perfectly competitive credit market. Section II.B discusses the method of estimation. Finally, section II.C reformulates the basic model in a particular way so as to incorporate the assumption of an imperfect credit market and discusses some of the issues involved.

Any intertemporal model requires a means of transferring consumption across time. The prototype model of Arrow and Debreu distinguishes commodities by their physical characteristics and the date of delivery, implicitly assuming that there is a complete set of markets for each conceivable commodity. A similar approach is used when uncertainty is considered. Commodities are also distinguished, by the state of nature which occurs within the relevant time period (state contingent commodities). Again, the use of this approach implicitly assumes a complete set of markets for these state contingent commodities.

The construction of an empirical model from a theoretical one involves much judgement. The essential assumptions of theory that remain valid given the data vary depending on the circumstances and the nature of the sample. In this study, there are two maintained hypotheses; first in the rural sectors of developing countries, state contingent commodity markets are incomplete and second credit and/or capital markets are perfectly competitive. The first hypothesis can hardly be disputed as a correct characterization of reality. The second assumption however is controversial and deserves more discussion.

The assumption of a perfect credit market has three important consequences: 1) it implies that every farmer has access to the credit market, 2) all farmers face the same rate of return within a given period; and 3) the rate of return on assets is independent of the wealth of the farmer. But under certain conditions, these implications do not necessarily follow. For example, the recent work of Stiglitz and Weiss (1981) has demonstrated that given asymmetry of information in credit markets, it is possible that a perfectly competitive credit market may lead to an equilibrium situation where a group of people may have no access to credit at all i.e. credit is rationed. Along the same lines of argument Binswanger and Rosenzweig (1986) have argued that even if individuals have access to the credit market, they may face different interest rates depending on their assets and individual characteristics.

If indeed credit markets are not perfect, the theoretical (and/or empirical) results may be questionable. In principle, one would want to test the relevance of the maintained hypotheses and proceed from there. However, formal tests of the hypothesis of perfect credit markets are rarely reported in the literature. One of the reasons for this lack of empirical evidence, is the difficulty of obtaining reliable data on household assets and property income. A more important reason is the limitations of economic theory. Even if all necessary data were available and the hypothesis of perfect credit markets were rejected, the researcher is left with the difficult task of formulating an alternative empirical model about which economic theory has few testable propositions to contribute. This task is compounded when one deals with the rural sector of developing countries where the nature (or lack of certain) markets give rise to interlinking of transactions (see Bardhan (1980) and Binswanger and Rosenzweig (1986)).

Rural credit markets and their function in transferring consumption across time have been analyzed by Jodha (1978) and Binswanger et. al. (1980). These studies suggest that credit markets play a smaller role in the smoothing of the consumption patterns of rural households than one would anticipate. Using Indian data, they estimated that credit in all forms provides rarely more than 10 percent of sustenance income. This low number indicates that credit markets are constrained. An implication of such credit market constraints is that consumption is likely to be closely tied to earned income receipts, especially for households with very low assets . Access to credit appears to be tied to asset holdings. Landowning households may be less constrained - if at all - since the asset (land) they posess has a high collateral value .

This study is based on a sample consisting mainly of landowning households. Inferring that landowning households may not be constrained from participating in credit markets, the perfect credit market assumption is a maintained hypothesis for the purposes of this study. A formal test of the hypothesis is not conducted due to lack of data on income and assets. However, the methods of conducting the appropriate tests are discussed in this chapter. Ultimately, a framework for estimation under the maintained hypothesis of imperfect credit markets is also presented.

II.A THE CASE OF A PERFECTLY COMPETITIVE CREDIT MARKET

The model is based on the following assumptions. It is assumed that spot markets for labor and for the homogeneous agricultural commodity are competitive. Thus all agents (households) behave as price takers. Family and hired labor are perfect substitutes in the production process and household members are indifferent between working on or off the farm[2]. Male and female labor, however, are treated as heterogeneous inputs. Each member of the household is endowed each period with a unit of labor time which can be divided between leisure (L) and work (H). Wealth is transferred from period to period by holding an asset with a fixed and known real rate of return. It is assumed that wealth at the end of the lifetime (A_{T+1}) is equal to zero (or given exogenously) which amounts to the restriction that at the end of the lifetime all outstanding loans are repaid. This avoids the complications arising out of voluntary intergeneration transfers or bequests.

Households maximize discounted expected lifetime utility subject to their budget and asset accumulation constraint. By postulating a utility function at the household level it is assumed that households make consistent centralized decisions and so there is no need to be concerned with the problems of deriving an aggregate utility function from the direct utility function of each member. The lifetime preference function of a household is assumed to be strongly separable over time[3] and satisfying the typical concavity assumptions, with utility at time t given by:

$$U(t) = U(C_t, L_{mt}, L_{ft}, X_t)$$

where C_t = consumption of the composite commodity at period t

L_{mt} = hours of leisure of male members at period t

L_{ft} = hours of leisure of female members at period t

X_t = observable and unobservable factors affecting tastes at period t.

and each variable is adjusted for the length of period t.

On the production side, households produce an agricultural commodity every crop cycle, with the use of family and hired male and female labor, land, bullocks and other forms of capital. Hence, in addition to their decision on labor supply, they must choose how much output they want to produce (or equivalently, how much total labor they want to utilize on their farm). Since family and hired labor of the same gender are perfect substitutes in farm production the amount of labor hired in or out to the market can be derived as the difference between the total labor of each gender utilized on the farm (N_t) and the family labor[4].

In order to address explicitly the seasonality and the sequential nature of agricultural production, each crop cycle is assumed to last two periods (stages). In stage 1 (t an odd number) production inputs are chosen and the crop is planted and grown. The choice of inputs in this first stage is based on expected output conditional on the information at that stage, since random events such as weather changes and pests may occur during plant growth. The output of the first stage which is observed by the farmer (but not the econometrician) in the beginning of the second stage, is the standing crop. In the second stage (t an even number) all uncertainties concerning production are resolved and the standing crop is harvested using labor. In principle farmers are also subject to output and input price risks. In this paper, output variation is considered the main source of risk within each crop cycle. This assumption is supported by the research of Binswanger et. al. (1980). The above may be summarized by the following notation:

$$Q(t) = F_t\,(N_{mt}, N_{ft}, K_t, Z, Y_t, \epsilon_{t+1}) \qquad t = \text{odd}$$

$$Q(t) = F_t\,(N_{mt}, N_{ft}, Q(t-1)) \qquad t = \text{even}$$

where $Q(t)$ = output in period t

$F_t(.)$ = production function in period (stage) t

N_{it} = labor input in period t of type i i = m, f

Z = fixed factors like land

Y_t = observed and unobserved characteristics of the head of the household such as experience, education, managerial ability etc.

ϵ_{t+1} = stochastic disturbance to the production technology due to weather variability,pests,droought, etc., common across all farmers, and generated by a covariance stationary process

K_{jt} = quantity of non-labor inputs like fertilizers, pesticides, land, etc., used in period t j=1,..,n

The information set of the farmer in period t where <u>t is an odd</u> number is specified as:

$$I_{odd} = \left[\begin{array}{l} W_{it},\ W_{it+1},\ g(\epsilon_{t+1}),\ P_{it},\ \text{past values of all relevant} \\ \text{wage rates, weather conditions in the present and past} \\ \text{period, } N_{it+1} = N_i^{o}(N_{it}) \end{array}\right]$$

where i=m,f. (m=male,f=female)

Thus farmers are assumed to know the wages that will prevail in the market within a given crop-cycle as well as the distribution of the disturbance term (i.e. g(.)) in the production function. The assumption that farmers know the wage rates of the harvesting stage in a given crop crop-cycle is made so as to facilitate the analysis on the labor demand side; under this setting, in the planting stage farmers face only one source of risk, yield risk (ϵ_{t+1}). Note however that no assumption is made with respect to the wage rates in future crop cycles. The assumption of the knowledge of the wage rates within each crop-cycle could be justified as being set by contractual arrangements. Given that the demand for labor in the second stage of production cannot be known in advance because of weather uncertainty, both (net) buyers and sellers of labor each year face uncertainty about wage rates in the harvesting season. As Bardhan (1983) argues, a risk averse individual from a labor exporting household would find it optimal to enter into a contract that sets the second stage wage rate in advance. Similarly, a net buyer (importer) of labor would find it optimal to enter into a contract so as to ensure that labor will be available when needed. In addition farmers know that their input decisions are sequentially dependent as in Antle (1983) and they know the exact functional form of this interdependence (i.e they know $N^{o}_{i}(.)$).

The information set when <u>t an even number</u> is:

$$I_{even} = \left[W_{mt},\ W_{ft},\ \epsilon_t,\ \text{profits},\ Q(t-1),\ \text{past values of all relevant variables} \right].$$

Notice that 1) the wage rates of the next crop cycle do not enter the information set of the household allowing one to treat the future path of wages as uncertain and 2) profits are realized at the beginning of stage 2 (t odd). Thus the maximization problem of a rural household may be expressed as follows (assuming two crop-cycles within each calendar year):

$$V_1 = \text{Max} \quad E_1\left(\sum_{t=1}^{T} \beta^{t-1}\, U(C_t, L_{mt}, L_{ft}) \right)$$

$$\text{w.r.t.} \quad \{C_t, L_{mt}, L_{ft}, N_{mt}, N_{ft}, A_t\} \qquad t = 1, \ldots, T$$

where $t=1$ is the planting stage in crop-cycle 1 in year 1

$t=2$ is the harvesting stage in crop-cycle 1 in year 1

$t=3$ is the planting stage in crop-cycle 2 in year 1

$t=4$ is the harvesting stage in crop-cycle 2 in year 1 etc.

subject to the asset accumulation and time constraints:

$$\tilde{A}_{t+1} = (1+r)A_t$$

$$L_{it} + H_{it} = 1 \qquad\qquad i=m,f$$

$$A_1 = \text{a given number}, \qquad A_{T+1} = 0$$

The assets held at the end of stage 1, where t is an odd number are given by the expression:

$$A_t = \bar{A}_t + \hat{W}_t - \hat{C}_t - \sum_{i=m,f} W_{it}N_{it} - \sum_{j=1}^{n} P_{jt}K_{jt}$$

Correspondingly, the expression describing assets held at the end of stage 2 (t an even number) changes to:

$$A_t = \bar{A}_t + \hat{W}_t + \Pi_t - \hat{C}_t$$

where: Π_t stands for profits in period t and

$$\Pi_t = Q\left(N_{mt}, N_{ft}, N_{mt-1}, N_{ft-1}, K_{jt-1}, Z, Y_t, \epsilon_t\right) - \sum_{i=m,f} W_{it}N_{it}$$

H_{it} : hours of work of member i at period t $\quad i = m,f$

W_{it} : real wage of member i at period t $\quad i = m,f$

1+r : gross real rate of return

$\bar{A}_t$: value of assets held at the beginning of period t in real terms

A_t : value of assets held at the end of period t in real terms

$\hat{W}_t = W_{mt} + W_{ft}$: value of time endowment (= 1) in period t. in real terms

$\hat{C}_t = C_t + \sum_{i=m,f} W_{it}L_{it}$: value of consumption and leisure in real terms

P_{jt} : relative price of non-labor input j at period t

$\beta = 1/(1+\rho)$: where ρ is the subjective discount rate

$E_t = E/I_t$: expectation conditional on the information set at t.

Upon maximization one obtains the following first-order necessary conditions (FONC) for t = odd :

(2.1) $U_c(t) = \lambda(t)$

(2.2) $U_{Lm}(t) = \lambda(t)W_{mt}$

(2.3) $U_{Lf}(t) = \lambda(t)W_{ft}$

(2.4) $\lambda(t) = (1+r)\beta E_t\{\lambda(t+1)\}$

(2.5) $$\lambda(t)W_{mt} = (1+r)\beta E_t \left[\lambda(t+1) \left\{ \frac{\partial Q(t+1)}{\partial N_{mt}} + \frac{\partial Q(t+1)}{\partial N_{mt+1}} \frac{\partial N^o{}_m(t+1)}{\partial N_{mt}} + \frac{\partial Q(t+1)}{\partial N_{ft+1}} \frac{\partial N^o{}_f(t+1)}{\partial N_{mt}} - W_{mt+1} \frac{\partial N^o{}_m(t+1)}{\partial N_{mt}} - W_{ft+1} \frac{\partial N^o{}_f(t+1)}{\partial N_{mt}} \right\}\right]$$

(2.6) $$\lambda(t)W_{ft} = (1+r)\beta E_t \left[\lambda(t+1) \left\{ \frac{\partial Q(t+1)}{\partial N_{ft}} + \frac{\partial Q(t+1)}{\partial N_{mt+1}} \frac{\partial N^o{}_m(t+1)}{\partial N_{ft}} + \frac{\partial Q(t+1)}{\partial N_{ft+1}} \frac{\partial N^o{}_f(t+1)}{\partial N_{ft}} - W_{mt+1} \frac{\partial N^o{}_m(t+1)}{\partial N_{ft}} - W_{ft+1} \frac{\partial N^o{}_f(t+1)}{\partial N_{ft}} \right\}\right]$$

where $\lambda(t)$ is the Lagrangean multiplier associated with the period t asset accumulation constraint.

Similarly the FONC for t=even are:

(2.7) $U_c(t) = \lambda(t)$

(2.8) $U_{Lm}(t) = \lambda(t)W_{mt}$

(2.9) $U_{Lf}(t) = \lambda(t)W_{ft}$

(2.10) $\lambda(t) = (1+r)\beta\ E_t\ \{\lambda(t+1)\}$

(2.11) $\lambda(t)[\partial Q(t)/\partial N_{it}) - W_{it}] = 0 \quad i = m,f$

The set of these first order conditions can be interpreted as follows:

1) at any point in time the household will allocate consumption and the two types of leisure in such a way that it cannot make itself better off by foregoing one unit of consumption and using the proceeds to "purchase" any type of leisure. This is the usual static result obtained from utility maximization.

2) The "Euler equation" for consumption (or $\lambda(t)$) given by conditions (2.4 or 2.10) states that along the optimal path the household cannot alter its expected utility by giving up one unit of consumption in period t, investing its cost in any available asset and consuming the proceeds in period t+1. The utility cost of giving up one unit of consumption in period t is given by $\lambda(t)$ (or $U_c(t)$). The discounted expected utility gain is given by $(1+r)\beta\ E_t\ \{\lambda(t+1)\}$. It must be emphasized that this is a general result that will hold even if labor cannot be freely chosen and trading is not possible in many assets. All that is required is that there exist at least one asset which is either held in

positive amounts or for which borrowing is possible.

3) At any period t, where t is an odd number, the household will allocate labor inputs up to the point where the discounted expected utility gain due to the increased output next period is equal to the discounted expected utility cost of the increase in the labor input of period t. Condition (2.11) can be rewritten as:

$$(1+r)\beta E_t\left[\frac{\lambda(t)W_{mt}}{(1+r)\beta} - W_{mt+1}\frac{\partial N^o{}_m(t+1)}{\partial N_{mt}} - W_{ft+1}\frac{\partial N^o{}_f(t+1)}{\partial N_{mt}}\right] =$$

$$= (1+r)\beta E_t\left[\lambda(t+1)\left\{\frac{\partial Q(t+1)}{\partial N_{mt}} + \frac{\partial Q(t+1)}{\partial N_{mt+1}}\frac{\partial N^o{}_m(t+1)}{\partial N_{mt}} + \right.\right.$$

$$\left.\left. + \frac{\partial Q(t+1)}{\partial N_{ft+1}}\frac{\partial N^o{}_f(t+1)}{\partial N_{mt}}\right\}\right]$$

Thus the household, when making labor input decisions in the planting stage (t an odd number) will take into consideration both the direct effect of the labor input on the "unobservable" output of the planting stage and on the current costs as well as the indirect effect the increased input may have on costs and output in the next period.

4) Closer inspection of conditions (2.5) and (2.6) reveals that the input choices of stage 1 (t odd) depend on λ(t) and $E_t(\lambda(t+1))$ and thus indirectly on the parameters of the utility function . This is similar to the nonseparability result of Roe &

Tomasi (1986) and it is an implication of the maintained hypothesis of lack of a complete set of markets for state contingent commodities.

5) However at stage 2 (t even) this is not the case. Condition (2.11) corresponds to the usual first order condition of profit maximization and this is obtained because at this stage there is no uncertainty with respect to output. Taking advantage of the separability in stage 2 one can solve for the inputs used in stage 2 as functions of the inputs in stage 1 in order to obtain the function $N^{o}_{i}(.)$ which the farmer is assumed to know at t-odd.

II.B METHOD OF ESTIMATION

There are several methods for estimating the above FONCs, all varying in terms of complexity and rigor. One of the most general methods developed by Hansen and Singleton (1982) is aimed at estimating directly the "Euler equation" (condition (2.4)) together with the other first order conditions . This procedure allows for important complications to be introduced. These include more flexible functional forms than the ones common in the dynamic economic literature and a variable and uncertain rate of discount. Applications of this method can be found in Hansen & Singleton (1982) (finance), Mankiw, Rotemberg & Summers (1985) (intertemporal substitution) and Shapiro (1986) (dynamic demand for capital and labor).

An alternative method is to estimate the closed form decision rules derived from the first order conditions . A variant of this method as developed by MaCurdy (1983), requires some approximations that remove some of the theoretical sharpness deriving from the rational expectations literature. The compensating advantage is that one can obtain the case of perfect foresight as a special case. Since the objective of this study is to highlight the differences between the case of perfect foresight and that of uncertainty within the context of a dynamic agricultural household model, the latter method will be adopted.

This approach derives functions for consumption and hours of work that decompose current decisions at any point in time into one component that summarizes the individual's history and expectations and a second set of arguments only of variables actually observed in the current period. In order to provide the reader with a clear understanding of the technique used here, we'll start with a brief reference to the case of perfect foresight as treated in Heckman and MaCurdy (1980) and MaCurdy (1981). Under perfect foresight the FONC of the household are

(A) $U_c(t) = \lambda(t)$

(B) $U_{Lm}(t) = \lambda(t)W_{mt}$

(C) $U_{Lf}(t) = \lambda(t)W_{ft}$

(D) $\lambda(t) = ((1+r)/(1+\rho))\lambda(t+1)$.

By solving each of the first order conditions (A)-(C) one can derive the corresponding consumption and labor supply decision rules as functions of $\lambda(t)$ and the relevant wage rate. Using condition (D) then, which allows us to express labor supply at any time as a function of the marginal utility of wealth at time $t=1$ $(\lambda(1))$, we can obtain the "λ-constant" demand and labor supply decision rules. For example, solving (A)-(C) for C_t, L_{mt} and L_{ft} and using (D) yields:

(E) $C_t = C(\lambda(1))$

(F) $L_{mt} = L_m(\lambda(1), W_{mt})$

(G) $L_{ft} = L_f(\lambda(1), W_{ft})$

Estimation of the labor supply equations then, can be carried out by treating $\lambda(1)$ as an individual or household specific fixed effect (that is time invariant). This may be done provided the functional form of the utility function is such that it yields decision rules where $\lambda(1)$ enters additively upon logarithmic transformation. This way one can account for a worker's future plans in a parametrically simple way. In effect all that is required for the estimation of the utility function parameters is panel data and information on individual characteristics, hours of work and wages.

The term $\lambda(1)$ is a function of the known path of future wages for males and females, the path of profits, the initial level of assets and all individual or household characteristics.

In theory one could obtain an explicit solution for $\lambda(1)$ by substituting expressions (E)-(G) into the budget constraint and then solve this with respect to $\lambda(1)$. In practice however an analytic solution for $\lambda(1)$ is extremely difficult to obtain even for the simplest functional forms. As a result one has to resort to linear approximations since the arguments of the $\lambda(1)$ function are known.

In the case of uncertainty, the relation between $\lambda(t)$ and $\lambda(1)$ changes. However, similar econometric methods can be used even under uncertainty, under resonable assumptions and provided appropriate instrumental variables are used. The following discussion explains. Rewritting the FONC (2.1)-(2.4) yields:

(2.1)' $C_t = C(\lambda(t))$

(2.2)' $L_{mt} = L_m(\lambda(t), W_{mt})$

(2.3)' $L_{ft} = L_f(\lambda(t), W_{ft})$

(2.4) $\lambda(t) = (1+r)\beta E_t\{\lambda(t+1)\}$.

The "Euler equation" describing the optimal path of the marginal utility of consumption -condition (2.4) above- implies that the difference between $\lambda(t)$ and $\lambda(t+1)$ depends on the discrepancy between the expected marginal utility of consumption as of period t and the actual marginal utility of consumption as of period t+1. By manipulating condition (2.4) one can express it as (see App. A, expression (3)):

$$(2.12) \qquad \ln\lambda(t) = \sum_{j=1}^{t} b^{*}(j) + \ln\lambda(1) + \sum_{j=2}^{t} \epsilon^{*}(j)$$

where $b^{*}(j) = \ln((1+\rho)/(1+r)) - \ln(E_{j-1}[\exp(\epsilon^{*}(j)])$ and ϵ^{*} is the one period ahead forecast error which under the rational expectations hypothesis has a zero conditional expectation $(E_{t-1}(\epsilon*(t))=0)$ and is uncorrelated with all the elements of the information set I_t $(E_{t-1}[\epsilon^{*}(t)*I_t]=0)$. Thus one can obtain the case of perfect foresight as a special case when $\epsilon*(j)=0$ and $b^{*}(j)=\ln((1+\rho)/(1+r))$ for all j. Expression (2.12) suggests a simple rule of behavior under uncertainty. At the start of the lifetime individuals set the initial value of their life-cycle component $\lambda(1)$ so that it incorporates all the information they have available at that time concerning their expectations of future wages, and profits. As each time period comes around individuals acquire additional information about their current and future prospects and they respond to this new information by adjusting the value of their life-cycle component according to equation (2.12). As it is apparent from this expression, one needs to make additional assumptions concerning the behavior of the b(j) term over time and across individuals if one intends to use similar techniques to those used under perfect foresight. In this study estimation will be carried out under the following main assumptions:

1) the discount rate $(1 + \rho)$ is common across all consumers and time invariant

2) the interest rate $(1 + r)$ is common across all individuals and time invariant. Each one of these assumptions can be relaxed one at a time. The assumption of time invariance alone, can be relaxed by incorporating time dummy variables as it is done in the next chapter. Similarly, the assumption of the interest rate being common across all individuals can be relaxed by incorporating dummy variables for each individual in the sample (or by first differencing). However, relaxing both of these assumptions at once creates serious complications for estimation.

3) The distribution generating the forecast errors is common across all individuals and over time so that $E_{t-1}[\exp(\epsilon^*(t))]$ does not vary with a change in individual characteristics or over time. This is admittedly a strong assumption. In general one would expect the moments of the prediction errors to be a function of individual characteristics and C_t, L_{it}.

Given these assumptions, expression (2.12) can be rewritten as:

$$(2.12)' \quad \ln\lambda(t) = b^* t + \ln\lambda(1) + \sum_{j=2}^{t} \epsilon^*(j)$$

which relates $\lambda(t)$ to $\lambda(1)$ in the case of uncertainty. Finally, after taking first differences we can obtain expression (2.13):

$$(2.13) \quad \ln\lambda(t) - \ln\lambda(t-1) = b^* + \epsilon^*(t)$$

The presence of the forecast error term $\epsilon^*(t)$ even after taking first differences suggests that the case of uncertainty at the empirical level, can be handled by using appropriate instruments for the right hand side variables of the estimated equations.

Similar techniques can be applied for the estimation of the labor demand side of the model. As it is shown in the next chapter, the assumption of a Cobb - Douglas technology for each stage yields "semi-reduced forms" for the input demand functions where the covariance of the ratio of the marginal utility of consumption in period t+1 to that in period t with the random factors affecting output (e.g. $E_t[(\lambda(t+1)/\lambda(t))\exp(U(t+1)])$ enters multiplicatively. Taking logarithms and using fixed effect econometric methods will result in estimates of the demand elasticities that are free of the bias caused by nonseparability as first discussed by Roe & Graham-Tomasi (1986).

IIC. <u>THE CASE OF IMPERFECT CREDIT MARKETS</u>.

A simple way of incorporating credit market imperfections, is to allow for the rate of return on assets to be a function of the level of wealth. More formally, if A_t is the level of wealth at the end of period t and $\bar{A}_t$ is the wealth at the beginning of period t then one can express the asset accumulation constraints as:

$$A_t = \bar{A}_t + \hat{W}_t - \hat{C}_t - \sum_{i=m,f} W_{it}N_{it} - \sum_{j=1}^{n} P_{jt}K_{jt} \qquad \text{for } t = \text{odd}$$

$$A_t = \bar{A}_t + \hat{W}_t - \hat{C}_t + \Pi_t \qquad \text{for } t = \text{even}$$

where the notation used is identical to that in section II.A and the law of motion of assets as:

$$\bar{A}_{t+1} = (1+r)R(A_t)$$

This framework is more general since it contains the case of perfectly competitive markets as a special case when $R(A_t)=A_t$ and $R'(A_t) = 1$. One can then proceed to derive the new FONCs. The only condition that would change compared to the set of conditions (2.1) through (2.11) in section II.A is the one relating to the "Euler equation" (previously (2.4) or (2.10)). Under the new framework farmers now must take into account the effect their increased wealth may have on the current and future rates of return on wealth. The new "Euler equation" is presented below:

$$\lambda(t) = \beta\, E_t \{ \lambda(t+1)(1+r)R'(A_t) \}$$

where $\beta = (1/(1 + \rho))$

This first order condition for $\lambda(t)$, may be rewritten as:

$$\lambda(t)R'(A_{t-1}) = ((1 + \rho)/(1 + r))\, \lambda(t-1)\, (1 + \epsilon_{\lambda t})$$

where $\epsilon_{\lambda t}$ is the forecast error which under the rational expectations hypothesis will be uncorrelated with any of the elements of the information set of the farmer at period t-1. In order to relate this to the technique outlined in section II.A and in Appendix A, one can take logs of both sides of the above equation and obtain:

$$\ln\lambda(t) = \ln((1+\rho)/(1+r)) + b + \ln\lambda(t-1) - \ln R'(A_{t-1}) + \eta_t$$

where b is the population mean of $\ln(1 + \epsilon_{\lambda t})$ which can be allowed to vary over time if time variables are included in the specification and η_t is an error term representing the mean innovation relative to variables dated t-1 or earlier.

Based on the extension of the model presented above, one can derive testable propositions concerning credit market imperfections. The first ones to conduct such a test within the context of a life-cycle model, were Altonji and Siow (1987). The test relies on the asymmetry of responses of consumption and labor supply to anticipated changes in income. More explicitly, using some relatively innocuous assumptions on the second and third derivatives of $R(A_t)$ it can be shown that the consumption response to increases in income will be larger in absolute value than the responses to decreases in income. Their test results were rather incoclusive since their derived estimates were not significantly different from zero and were subject to large standard errors.

Unfortunately, the same test cannot be conducted with our data since detailed information on household income by each season and by stage in each season is not available. However, an alternative procedure will be attempted, based on somewhat intutitive arguments, using the information on household labor income only. Under severe credit constraints the major source of operating finance would be other family members. Thus, current family labor income (exclusive of individual earnings) would affect an individual's valuation of his/her time. A test of binding credit constraints is made by determining whether or not family income is a determinant of X(t). If the coefficient on current family income is not significant, holding $\lambda(1)$ fixed, then the credit constraint is not important, and the perfect credit market hypothesis cannot be rejected.

The reader is cautioned that this test is conducted under the maintained hypothesis - which is not tested - that the utility function of the household is additively separable in male and female leisure. In this setting, a significant coefficient for the family income variable may occur due to the nonseparability of the utility function rather than the effects of credit constraints.

CHAPTER III

EMPIRICAL SPECIFICATION

In this chapter functional forms amenable to estimation are presented, and the method of estimation is discussed in detail. Section III.A contains the empirical specification of the labor supply side and section III.B the specification for the labor demand side.

III.A LABOR SUPPLY SIDE

An essential element for the estimation of the life-cycle model considered here, is that the marginal utility of wealth enters linearly in the decision rules (after transformation). One may then take first differences and eliminate all the time invariant terms including the unobservable marginal utility of wealth. The utility function of the farm household i is specified as:

$$(3.1)\quad U_i(t) = Z_i(t)C_i(t)^{\sigma^c} - Y_{mi}(t)H_m(t)^{\sigma^m} - Y_{fi}(t)H_f(t)^{\sigma^f}$$

where: $C_i(.)$: total consumption of the aggregate consumption good

$Z_i(t)$: household characteristics affecting consumption

$0 < \sigma^c < 1$: time invariant parameter

$\sigma^m>1$, $\sigma^f>1$: time invariant parameters common across all male heads of households and their spouses. (these three conditions on the σ's guarantee concavity)

$H_{ki}(t)$: hours of work by member k (k=m,f)

$Y_{ki}(t)>0$: a function of individual characteristics (k=m,f) affecting preferences towards work

$Y_{ki}(t)$: $\{\exp(-X_{ki}(t)\Psi^* - v^*_{ki}(t))\}$ k = m,f

where $X_{ki}(t)$ is a vector of measured individual characteristics of individual k in household i in period t, Ψ^* vector of parameters and $v^*_{ki}(t)$ a vector of unobserved characteristics.

Given this functional form for the utility function and expression (3) relating $\lambda(t)$ to $\lambda(1)$ derived in Appendix A the FONCs yield the following labor supply equations to be estimated:

$$\ln H_{ki}(t) = F_{ki}(1) + b_k t + \delta_k \ln W_{ki}(t) + X_{ki}(t)\Psi + \eta_{ki}(t) \qquad (3.2)$$

$$k = m,f$$

$$i = 1,\dots,n$$

where:

$$F_{ki}(1) = \delta_k[\ln\lambda(1)_i - \ln\sigma^k] \qquad k = m,f$$

$$\delta_k = 1/(\sigma^k - 1)$$

$$\Psi = \delta_k\Psi^*$$

$$\eta_{ki}(t) = v_{ki}(t) + \sum_{j=2}^{t} \epsilon_{ki}(j)$$

$$v_{ki}(t) = \delta_k v^*_{ki}(t)$$

$$\epsilon_{ki}(t) = \delta_k \epsilon^*_{ki}(t)$$

$$b_k = \delta_k b^*_k \quad \text{and}$$

$$b^*_k = \ln((1+\rho)/(1+r)) - \ln(E_{t-1}[\exp(\epsilon^*(t))])$$

The term $F_{ki}(1)$ will be treated as an individual specific effect that is invariant over time. Since $\lambda(1)$ is correlated with $W_{ki}(t)$ and $X_{ki}(t)$, the treatment of $F_{ki}(1)$ as a random effect would be incorrect. Similarly direct estimation of the above equation by OLS would yield inconsistent estimates because then $F_{ki}(1)$ is included in the error term. Given the availability of panel data one may take first differences so as to eliminate this fixed effect, and thus obtain consistent estimates of δ_k and Ψ_k. After taking first differences one obtains:

$$\text{(3.3)} \quad D\ln H_{ki}(t) = b_k + \delta_k \, D\ln W_{ki}(t) + \\ + \Psi \, DX_{ki}(t) + Dv_{ki}(t) + \epsilon_{ki}(t)$$

where $DY(t) = Y(t) - Y(t-1)$

The parameter δ_k corresponds to the pure intertemporal substitution elasticity of labor supply holding initial wealth ($\lambda(1)$) constant. In the context of the seasonal model considered here, δ_k is the elasticity relevant for predicting how an individual's labor supply responds to changes in wages arising from perfectly foreseen seasonal fluctuations. In order to derive an estimate of the own gross uncompensated elasticity one needs to know how the term $F_{ki}(1)$ is affected by an increase in the wage rate at time t. As mentioned previously, analytical solutions for $\lambda(1)$ and therefore $F_{ki}(1)$ are difficult to obtain. A reduced form approximation for $F_{ki}(1)$ will be postulated based on the insights are provided by the theoretical model above. It is assumed that $F_{ki}(1)$ is a linear function of the individual characteristics, the wage rate of the individual and that of its spouse, the profits realized and initial assets. By theoretical arguments based on the concavity of the utility function one can show that (see Heckman & MaCurdy (1980)):

$$\frac{\partial F_{ki}(1)}{\partial W_k(t)} < 0 \quad , \qquad \frac{\partial F_{ki}(1)}{\partial A(1)} < 0$$

In estimating labor supply functions the first serious problem is that of finding an appropriate wage as an independent variable. If the hourly wage is derived as total wage earnings divided by hours worked and hours worked also appear as the dependent variable there is the well known "measurement error" problem (if hours worked are too high the wage rate definitionally will be too low giving rise to a negative bias). There may also be a simultaneity problem because labor supplied and the wage rate may be jointly determined by other variables not included in the regression (incorporated in the error term). Added to this is the practical problem that those who did not participate in the labor market did not have a wage rate to report even though the wage rate in the market may have been positive.

One solution to all these problems mentioned above is to estimate the wage rate as determined by other independent variables like human capital related variables, for the workers who reported work at some wage rate and from this equation estimate a predicted wage rate for everybody in the sample including the ones who did not have an actual wage rate to report. This method however, as Gronau (1974) and Lewis (1974) pointed out, may be subject to selectivity bias, which may lead to a bias in the estimates of labor supply parameters.

The first one to use this method in a study of rural labor markets in developing countries was Rosenzweig (1980). His finding was that in Indian rural labor markets the chief source of wage rate variability is geographical rather than personal, once sex has been taken into account. The major implication of this is that the selectivity bias inherent in a wage imputation procedure based on a specification where market conditions are the major sources of wage variability, may not be significant. Rosenzweig however, does not test explicitly for selectivity bias. The unimportance of selectivity bias in the wage imputation procedure discussed above, is demonstrated in Appendix B.

Some additional considerations arise within the context of the life-cycle model with uncertainty considered here. The presence of uncertainty implies that the structural error terms of the hours of work equation contain forecast errors as one of the components. This formulation has three implications for empirical analysis: (1) because wages are uncertain the current wage rate contains unanticipated components so lnW(t) is correlated with current and past values of $\epsilon(t)$. Thus in addition to the usual reasons for treating wages as endogenous variables in an empirical analysis, uncertainty about the future provides one more reason for such treatment. (2) Similarly if measured taste shifter variables entering into the matrix X(t) are uncertain and not realized until period t, then X(t) must also be treated as endogenous variables. Therefore in addition to assuming that X(t) is uncorrelated with unobserved taste factors v(t) one must also assume that X(t) is known to the farmer prior to period 1 if the elements of X(t) are to be treated as predetermined variables in the labor supply equation. (3) Finally variables used to predict either lnW(t) or the elements of X(t) must also be uncorrelated with unanticipated elements if they are to be valid instruments. A natural criterion for the selection of instrumental variables in this case is variables dated t or earlier.

The typical procedure in the US studies using models similar to the life cycle model considered here is to assume a wage function of the form:

(3.4) $\ln W(t) = b_0Y' + b_1Y't + b_2Y't^2 + w_t$

where Y' : vector whose columns are human capital variables and variables used to proxy the labor demand conditions that the worker is facing

t : age

b_0, b_1, b_2 : vectors of parameters constant across all individuals and over time

w_t : random error representing the effects of unobservables

Upon taking first differences one obtains:

(3.5) $\ln W(t) - \ln W(t-1) = a_0 + a_1Y' + a_2Y't + w_t - w_{t-1}$

where a_0, a_1, a_2 are linear functions of b_0, b_1, b_2, which facilitates the choice of instrumental variables as well as the choice of the instrumental variable regression equation. Examples of this procedure can be found in MaCurdy (1981,1983) and in Ham (1986). As it is demonstrated in Appendix B, human capital variables play a small role in explaining wage variations in the female wage rates of the sample, but they are significant determinants of male wage rates. For this reason only demand variables or village specific variables will be used as instrumental variables for the wage rates of females. More explicitly, the instrumental variables for the wage rates of male heads of households are the age of the head, age squared, years of education, a dummy variable for the cast, the village level wage rate for males, the amount of rainfall and dummy variables for village and the stage in the production process. Similar instruments are used for female wage rates except the human capital related variables. In order to account for the presence of uncertainty which implies that the current demand variables (dated t) may be useful in predicting $\epsilon_{ik}(t)$ and hence may be correlated with it, the village level wage rates and rainfall of previous periods are used as instruments instead. It was found that the village level wage rate of the previous period and the village level wage rate of the corresponding season and stage of the previous year were the most appropriate instruments. Also the rainfall of last period was used as an instrument of the wage rate instead of current rainfall.

III.B LABOR DEMAND SIDE

It is assumed that the single stage production functions are of Cobb-Douglas form. Despite the well known technological restrictions it imposes (unitary elasticity of substitution, constant input elasticity,homogeneity) the Cobb-Douglas function is used for the following reasons:

A) It can be viewed as a first order logarithmic approximation to a general function (see Fuss, McFadden, Mundlak (1978)).

B) Recursive substitution of the single stage functions yields a composite production function also of Cobb-Douglas form as it is demonstarted below. In addition one can obtain explicit solutions for the input demand functions. In the alternative case where the single stage production functions are represented by second order flexible functional forms (such as quadratic or translog) recursive substitution yields a higher order polynomial in the inputs. In this case estimation becomes difficult due to problems of collinearity and degrees of freedom and closed form solutions of the input demand functions are not possible.

C) The function is linear (upon transformation) and parsimonious in the parameters and these parameters are in the easily interpreted elasticity form.

D) The Cobb-Douglas form is the most commonly used form in the estimation of agricultural technology.

The presentation in the remainder of this section will be reduced to two periods (stages) since on the production side the interdependence of input decisions occurs within each crop cycle and not across crop cycles. The relation between inputs and output in stage 1 (planting) is described by:

$$(3.6) \qquad Q(1) = \alpha_o \, F(1)^{\alpha_1} \, M(1)^{\alpha_2} \, K^{\alpha_3} \, \exp(\epsilon(2))$$

where Q(1) = the output of stage 1 (standing crop)

F(1) = total hours of female labor (family and hired) used on farm i in stage 1

M(1) = total hours of male labor (family and hired) used on the farm during stage 1

K = vector of "fixed" inputs such as hectares of cultivated land, hectares of irrigated land, value of pesticides (Rs), fertilizers in quintals and bullock hours used in stage 1.

$\epsilon(2)$ = disturbance term summarising the effects of random factors affecting output (rainfall, desease etc.)

Note that since the disturbance term $\epsilon(2)$ is realised at the beginning of stage 2, Q(1) the standing crop is not observable by the farmer in the first stage thus implying that the choice of inputs in the first stage is made based on the subjective expectations of the farmer. In any case Q(1) is an unobservable variable to the econometrician at any point in time.

Similarly the production function for stage 2 (harvesting) is characterized by:

$$(3.7) \qquad Q(2) = \beta_0 \, F(2)^{\beta_1} \, M(2)^{\beta_2} \, Q(1)^{\beta_3}$$

where Q(2) : the value of the harvested crop at the end of stage in Rs

F(2) : total hours of female labor (family and hired) used on the farm during stage 2

M(2) : total hours of male labor (family and hired) used on the farm during stage 2

Q(1) : standing crop

At this stage all uncertainties concerning production are eliminated. Substituting expression (3.6) for Q(1) in (3.7) yields the "composite production function":

$$(3.8) \qquad Q(2) = \delta_o \, F(2)^{\delta_1} \, M(2)^{\delta_2} \, F(1)^{\delta_3} \, M(1)^{\delta_4} \, K^{\delta_5} \, \exp\{\epsilon(2)\}$$

where the δi's are functions of the single stage production functions the α's and β's. An important feature of this model is that it is not necessary to know the structural coefficients of the single stage production functions. Estimation can be carried out by employing only the composite production function parameters δ.

At stage 2 the choice of labor inputs is based on the static profit maximization conditions:

$$(3.9)\quad \lambda(2)\left[\left.\frac{\partial Q(2)}{\partial F(2)}\right|_{Q(1)=\text{Given}} - W_f(2)\right]=0$$

$$(3.10)\quad \lambda(2)\left[\left.\frac{\partial Q(2)}{\partial M(2)}\right|_{Q(1)=\text{Given}} - W_m(2)\right]=0$$

Solving these FONC (3.9) and (3.10) with respect to F(2) and M(2) and replacing Q(1), which is unobserved by the econometrician, by expression (3.6) yields the following "reduced forms" for F(2) and M(2) - ignoring constant terms:

$$(3.11)\quad F^o(2) = F(1)^{\delta_3/\Delta}\ M(1)^{\delta_4/\Delta}\ K^{\delta_5/\Delta}\ W_m(2)^{-\delta_2/\Delta}\ W_f(2)^{-(1-\delta_2)/\Delta}\ \exp\{\epsilon(2)/\Delta\}$$

$$(3.12)\quad M^o(2) = F(1)^{\delta_3/\Delta}\ M(1)^{\delta_4/\Delta}\ K^{\delta_5/\Delta}\ W_m(2)^{-(1-\delta_1)/\Delta}$$

$$W_f(2)^{-\delta_1/\Delta} \exp\{\epsilon(2)/\Delta\}$$

where $\Delta = 1 - \delta_1 - \delta_2$

Thus consistent estimates of the elasticities of labor demand in stage 2 can be obtained by applying the "within" estimator to the logarithmic versions of the above equations.

Next, recognizing the sequential interdependence of decisions amounts to modeling the farmer as knowing the dependence of F(2) and M(2) on both F(1) and M(1) as described by equations (3.11) and (3.12) . Substituting F(2) and M(2) into expression (3.8) yields:

$$(3.13)\quad Q^o(2) = F(1)^{\delta_3/\Delta} M(1)^{\delta_4/\Delta} W_f(2)^{-\delta_1/\Delta} W_m(2)^{-\delta_2/\Delta} K^{\delta_5/\Delta} \exp\{\epsilon(2)/\Delta\}$$

In stage 1 the choice of F(1) and M(1) is made based on the FONC

$$(3.14)\quad \lambda(1)W_f(1) = E_1\left[\lambda(2)\left(\frac{\partial Q^o(2)}{\partial F(1)} - W_f(2)\frac{\partial F^o(2)}{\partial F(1)} - W_m(2)\frac{\partial M^o(2)}{\partial F(1)}\right)\right]$$

$$(3.15)\quad \lambda(1)W_m(1) = E_1\left[\lambda(2)\left(\frac{\partial Q^o(2)}{\partial M(1)} - W_f(2)\frac{\partial F^o(2)}{\partial M(1)} - W_m(2)\frac{\partial M^o(2)}{\partial M(1)}\right)\right]$$

Solving the above system of two equations with respect to F(1) and M(1) yields the following "reduced forms" for the input demands in stage 1 - ignoring constant terms:

$$(3.16)\quad F^{o}(1) = W_m(1)^{-\delta_4/\Gamma}\ W_f(1)^{-(1-\delta_1-\delta_2-\delta_4)/\Gamma}$$

$$W_m(2)^{-\delta_2/\Gamma}\ W_f(2)^{-\delta_1/\Gamma}\ K^{\delta_5/\Gamma}\ E_1(\frac{\lambda(2)}{\lambda(1)}\exp\{\epsilon(2)/\Gamma\})$$

$$(3.17)\quad M^{o}(1) = W_m(1)^{-(1-\delta_1-\delta_2-\delta_3)/\Gamma}\ W_f(1)^{-\delta_3/\Gamma}$$

$$W_m(2)^{-\delta_2/\Gamma}\ W_f(2)^{-\delta_1/\Gamma}\ K^{\delta_5/\Gamma}\ E_1(\frac{\lambda(2)}{\lambda(1)}\exp\{\epsilon(2)/\Gamma\})$$

where $\Gamma = 1 - \delta_1 - \delta_2 - \delta_3 - \delta_4$

Inspection of equations (3.16) and (3.17) reveals the problem of nonseparability mentioned in chapter II. The presence of the term $E_1(\lambda(2)/\lambda(1),\ \exp\{\epsilon(2)/\Gamma\})$ in the input demand functions implies that the consumption preferences of the household as represented by the term $\lambda(t)$ ($= U_c(t)$), do play a role in the production decisions of the farmer. This is a direct consequence of the existence of uncertainty and risk aversion in consumption and has important implications on the estimation method that should be used. If one were to use estimation techniques that do not control for the presence of this term then the derived estimates would be biased since then $E_1(\lambda(2)/\lambda(1), \exp\{\epsilon(2)/\Gamma\}$ would be part of the error term thus causing nonseparability (simultaneity) bias.

For the information of the reader, it is worth pointing out that separability would result, if linearity in consumption was assumed ($\sigma^c=1$) . This can be demonstrated as follows. The first order conditions (2.1)-(2.11) in chapter II can be utilized so as to express the above term as :

$$E_1\left[\frac{U_c(2)}{U_c(1)} \exp\{\epsilon(2)/\Gamma\}\right]$$

or after carrying through the expectation operator E_1 as:

$$E_1\left[\frac{U_c(2)}{U_c(1)}\right] E_1\left[\exp\{\epsilon(2)/\Gamma\}\right] \quad + \text{COV}_1\left(\frac{U_c(2)}{U_c(1)}, \exp\{\epsilon(2)/\Gamma\}\right)$$

where $\text{COV}_1\ (X, Y) = E_1\left((X - E_1X)(Y - E_1Y)\right)$

If it is assumed that the utility function of the farm household is linear in $C(t)$, then the term $\text{COV}_1(U_c(2)/U_c(1), \exp\{\epsilon(2)/\Gamma\})$ will drop out since $\text{COV}_1(1, \exp\{\epsilon(2)/\Gamma\}) = 0$; similarly the term $E_1(\lambda(2)/\lambda(1)) = E_1(U_c(2)/U_c(1))$ is constant over time and across farmers; finally the term $E_1(\exp\{\epsilon(2)/\Gamma\})$ is common across all farmers and independent of time, if $\epsilon(2)$ is serially uncorrelated. Alternatively, if weather (rainfall) is serially correlated, one could include current (and/or past values of) rainfall as explanatory variables (or year dummies).

The case of uncertainty with risk aversion considered here calls for more attention. By the FONC (2.4) in chapter II reproduced here:

$$E_t(\lambda(t+1)/\lambda(t)) = ((1+\rho)/(1+r)) \qquad \text{for all } t$$

one can deduce that this term is time invariant across all farmers if the interest rate (r) does not vary over time. Also given the perfect capital market assumption this interest rate is common for all farmers. In any case, these two restrictive assumptions could be relaxed somewhat by allowing the interest rate to vary over time and incorporating time dummies in the regression, or by allowing the interest rate to vary across farmers the farmer and including a dummy variable for each farmer in the sample.

All that remains now is the term $COV_1(.)$. Certainly in the case of risk aversion, this term would be unequal to zero and correlated with the other variables included in the regression. The following discussion explores the additional structure or assumptions needed so that consistent estimates can be obtained by fixed effect econometric methods.

One approach is to explore the conditions under which the covariance term conditional on the information set at time t is time invariant. In other words:

$$COV_t\left[\lambda(t+1)/\lambda(t),\ \exp(\epsilon(t+1)/\Gamma)\right] =$$

$$= COV_{t+j}\left[\lambda(t+j+1)/\lambda(t+j),\ \exp(\epsilon(t+j+1)/\Gamma)\right]$$

where j = even number and t = odd number

An interpretation of this, is that the forecast error about the marginal utility of wealth at any period t is correlated with the forecast error about the factors affecting crop yields and that this correlation is time invariant. The conditional covariance term is time invariant when the joint distribution of the vector $(\lambda(t+1)/\lambda(t), \exp\{\epsilon(t+1)/\Gamma\}, I_t)$ satisfies certain conditions. As Anderson (1958) shows, under the assumption that a vector of random variables follows a multivariate stationary normal distribution (say the vector $(\lambda(t+1)/\lambda(t), \exp\{\epsilon(t+1)/\Gamma\}, I_t)$), the conditional mean of this distribution $E\ (\lambda(t+1)/\lambda(t), \exp\{\epsilon(t+1)/\Gamma\} / I_t)$ depends on the current information set, whilst the conditional variance (or covariance) depends only on the joint distribution. Given stationarity, it follows that the conditional covariance of this vector is time invariant. This assumption has also been utilized by Hansen and Singleton (1983), in their study of stochastic consumption and the temporal variation of asset returns .

It is thus argued, that inclusion of farmer specific dummies will reduce, if not eliminate, the nonseparability bias arising in the case of of uncertainty with risk aversion. Upon taking logarithms, the term $E_t(\lambda(t+1)/\lambda(t), \exp\{\epsilon(t+1)/\Gamma\})$ reduces to:

$$\ln\left[\frac{1+\rho}{1+r}\, E_t[\exp\{\epsilon(t+1)/\Gamma\}] + \Sigma_{\lambda\epsilon}(i)\right]$$

where $\Sigma_{\lambda\epsilon}(i) = \mathrm{COV}\ (\lambda(t+1)/\lambda(t),\ \exp\{\epsilon(t+1)/\Gamma\})$ for farmer i. If the stochastic term $\epsilon(t+1)$ is generated by a serially uncorrelated process with zero mean, then this term reduces further to $\ln\{\Sigma_{\lambda\epsilon}(i)\}$, which can be treated as a farmer specific effect. If the process $\epsilon(t+1)$ is serially correlated, then one may use the approximation

$$\ln\left(\frac{1+\rho}{1+r} E_t[\exp\{\epsilon(t+1)/\Gamma\}] + \Sigma_{\lambda\epsilon}(i)\right) \approx$$

$$\ln\left(\frac{1+\rho}{1+r} E_t[\exp\{\epsilon(t+1)/\Gamma\}]\right) + \ln\left(\Sigma_{\lambda\epsilon}(i)\right)$$

In that case, the inclusion of year dummies or the level of current rainfall (in addition to individual dummies) will be more appropriate.

The following chapter contains empirical results obtained under the specifications discussed above.

CHAPTER IV

EMPIRICAL ANALYSIS

In this chapter, the labor supply and labor demand decision rules derived in the previous chapter, are estimated. There are three sections. The first describes the data and the data transformations; the second contains the estimates of the labor supply part of the model under the perfect credit markets hypothesis as well as an informal test of credit market constraints; the third contains the estimates of the labor demand part and a test of the significance of farmer fixed effects.

IV.A DATA

The panel data used was extracted from the Village Level Studies (VLS) conducted by the International Crops Research Institute for The Semi-Arid Tropics (ICRISAT). For the VLS, ten villages were selected to represent four broad agroclimatic zones of semi-arid India. For a detailed description of the VLS data set the reader is referred to Singh, Binswanger and Jodha (1985).

Both sides of the model are estimated using data from the three villages of Aurepalle Shirapur and Kanzara. Resident investigators have interviewed a stratified random sample of 30 cultivator and 10 labor households in each village every two to four weeks starting in May 1975 up until June 1984. The three villages have different cropping patterns.

The major crops grown in Aurepalle are paddy, sorghum, groundnuts, pigeonpeas, pearl millet and castor. The red (Alfisol) soils in this village have a low moisture-holding capacity, so all non-irrigated crops are grown only in the rainy season (kharif). As a result, about two-thirds of total labor use on farmer fields occurs in the rainy season. Shirapur has medium deep and deep black (Vertisol) soils which have a high moisture-holding capacity. Thus most non-irrigated cropping occurs in the post rainy season (rabi) of September to March. The predominant crops here are sorghum chickpea and safflower. Some pearl millet and pigeonpeas are sown on the shallow black soils in the rainy season. Cotton is the primary crop of the Kanzara village being sown in rows in the rainy season mixed with sorghum and pigeonpea on the medium-deep black soils. More than 90% of total crop labor use occurs in the rainy season in Kanzara. For details on seasonal labor demand, market participation and unemployment in these villages see Ryan et. al. (1984).

The data for the estimation of the labor demand side of the model was extracted from the master data on the three villages out of the Plot and Cultivation file (VLS-Y). This file records input-output data for each plot by operation. It also includes information on the characteristics of each plot such as soil type, ownership and irrigation status, and cropping patterns. The data of the original file was aggregated at many levels to obtain a manageable data base. The finest level of aggregation that provided a set of continuous time series observations was at the household level. All the observations on households during each crop-cycle were aggregated into two, one for each stage of the crop-cycle. Stage one corresponds to the preharvest operations: land preparing, planting, seeding, weeding, irrigating etc. Stage two corresponds to harvesting operations including threshing. The time period covered by stage one is longer than that of stage two and the duration of each stage varies from crop cycle to crop cycle and from village to village. A balanced panel sample with 414 observations was developed for the estimation of the production side of the model using household level input-output information from the rainy (kharif) and post-rain (rabi) seasons for 46 households for 9 crop cycles. On the production side, village level wage rates were constructed for males (and females) for each stage by summing total cash and kind payments to males (females) in each stage and dividing this sum by the total male (female) hours worked in each stage in each village.

The labor supply side of the model was estimated using the Labor, Draft Animal and Machinery Utilization file (VLS-K) of the master data. This file records both on- and off- farm activities, collected on a two to four week "full recall basis" starting in 1979. Before 1979, household time allocation of each household member was collected only for the day immediately preceding each interview. Data for male heads of household and their spouses was extracted and matched to their individual and household characteristics. Information on individual characteristics was obtained form the Characteristics file (VLS-C).

The observations on labor allocation of heads and spouses were aggregated to correspond roughly to stage one and two on the labor demand side of the model[4]. Only the last five years of the labor supply file were used since wages received by each individual and by source were not recorded for the years prior to 1979. A balanced panel sample of 51 male heads of households and 61 spouses for 10 crop cycles (20 stages) was constructed. The measure of total hours of work offered was constructed by summing the hours worked on own farm with hours worked for other other farmers, hours worked in government sponsored projects, hours worked in nongovernment projects and hours of involuntary unemployment. To adjust for the difference in the length of each stage, the average hours of work offered per month in each stage was used[5]. Individual wage rates for the labor supply side of the model were derived by taking a weighted sum of the hourly wage rates (in cash and in kind) received by each individual from government, nongovernment and farm work. The individual wage rates were also used for the estimation of the wage functions contained in Appendix B. Village level composite wage rates were constructed by taking a weighted sum of the government, nongovernment and farmwork hourly wage rates at the village level. Finally, all the wage rate measures constructed as well as the variables expressed in value terms (such as value of output, value of pesticides etc.) were divided by a measure of the consumer price index which has a value equal to 1 in 1975. Tables 1.A.1 - 1.A.3 below contain the descriptive statistics on the main variables used in the study. Detailed description on how each of the variables was constructed is contained in Appendix D.

TABLE IV.A.1

```
------------------------------------------
      MEANS OF VARIABLES USED FOR
 THE ESTIMATION OF LABOR SUPPLY OF MALES
------------------------------------------
 VARNAME|  OBS          MEAN    STD. DEV.
--------+---------------------------------
   INDWG|  1020    .32678415   .413051356
     AGE|  1000   48.5799998    9.8939626
 EDUCYRS|  1000         2.46   3.47857737
  VWGMHR|  1020   .778875258   .158356908
  VWGFHR|  1020   .385487632   .090778888
  INC_ID|  1020   236.892518   670.364555
  RAINMM|   969   15.0723863   16.5850528
 NOMMEMB|  1020   2.00784314     1.168753
 NOFMEMB|  1020   1.74901961   .974527902
 NOCHILD|  1020          2.2   1.73267394
 FAMSIZE|  1020   5.95686275   2.93770821
 TWKDNEW|  1020   33.0348039   33.9501545
  AVHRMO|  1020    89.259657   79.0698805
```

TABLE IV.A.2

```
------------------------------------------
  TABLE OF MEANS OF VARIABLES USED FOR
THE ESTIMATION OF LABOR SUPPLY OF FEMALES
------------------------------------------
 VARNAME|  OBS          MEAN    STD. DEV.
--------+---------------------------------
   INDWG|  1220   .189573023   .227902937
     CPI|  1220   1.49793443    .18045243
     AGE|  1160   43.1758618   10.1234966
 EDUCYRS|  1160           .5   1.41786944
  VWGMHR|  1220   .782970206   .160309034
  VWGFHR|  1220   .388892312   .088587827
  INC_ID|  1213   277.092582    660.09568
  RAINMM|  1159    15.134605   17.7111978
 NOMMEMB|  1220    1.9442623   1.06868693
 NOFMEMB|  1220          1.8    .81172701
 NOCHILD|  1220   2.09836066   1.39028527
 FAMSIZE|  1220   5.84262295   2.09099472
 TWKDNEW|  1220   28.7930328   32.6681426
  AVHRMO|  1220   80.0662854   80.8406153
```

TABLE IV.A.3

```
-----------------------------------------
      MEANS OF THE VARIABLES USED
 FOR THE PRODUCTION SIDE OF THE MODEL
-----------------------------------------

VARNAME|  OBS        MEAN     STD. DEV.
-------+---------------------------------
  TOUTV|  414  4842.78496   6286.01994
    CLT|  414  13.1490095   14.8336391
    IRR|  414  1.04946857   2.01366855
  MALE1|  414  794.951691   918.528831
  FEML1|  414  687.770531   1008.04601
 CHILD1|  414  18.6835749   65.7724367
  BULL1|  414  475.845411   569.726055
  MALE2|  414  264.258454   315.716577
  FEML2|  414  601.792271   723.925468
 CHILD2|  414  22.6352657   72.5082933
  BULL2|  414  29.1859903   49.0103186
  PESTV|  414  50.2574516   154.389654
 TFERTQ|  414  115.579541   196.325524
 MACHRS|  414  96.6500966   210.670027
 TBMAHR|  414  601.681498   705.196759
  PLOTV|  414  86.6576592   85.8260842
  TAREA|  414  13.3775119   15.0767126
    CPI|  414  1.29019323   .239262311
RLWGHM1|  414  1.12514568   .320681377
RLWGHM2|  414  .834085146   .291806953
RLWGHF1|  414  .521119216   .233630121
RLWGHF2|  414   .46676241   .131654948
RLWGHC1|  133  .205733862   .068522403
RLWGHC2|  238  .255219628   .101051036
RLWGHB1|  414  2.52053034   .866853329
RLWGHB2|  317  1.39467431   .500713978
```

IV.B.1 ESTIMATION OF THE LABOR SUPPLY SIDE OF THE MODEL

Estimation of the labor supply functions expression (3.2) in Chapter III, was carried under two specifications. The first i) assumes that the interest rate (r) does not vary over time and ii) it constrains the intercepts in the labor supply equations to be equal in each period. The second specification allows the interest rate to vary over time by including dummy variables for each time period in the sample. In either specification the interest rate is assumed to be the same for all individuals in the sample. This is a direct consequence of the perfect credit market assumption.

Up to this point, the elements of the vector X(t) containing the factors affecting tastes toward work) were unspecified. The vector X(t) might include the age of the individual, the education of the individual, his/her caste, the number of children, and the level of rainfall. Since the estimation was carried out on first differences which removed the unobservable marginal utility of wealth, the effects of all time-invariant elements of X(t) would also have been removed. The two variables which vary over time: the number of children and rainfall, were included in the regressions but did not change the results significantly. Thus the vector X(t) is entirely net out of the regressions presented herein.

As mentioned in Chapter III, the appearence of the forecast error term $\epsilon_{ki}(t)$ in the labor supply equations under uncertainty, acts as a constraint on the intrumental variables one can use for the imputed wage rates. Two different estimates are presented for males and females depending on the instrumental variables used for the wage rate. The first formulation uses the current (period t) village level wage rate and rainfall as instrumental variables. This is the case of perfect foresight, since the use of the current village level wage rate as an instrumental variable precludes any correlation with the error term in the regression. In the other formulation under uncertainty the instrumental variables used are: the village level wage rate and rainfall of last period (t-1) together with the wage prevailing in the same stage in the same crop-cycle of the previous agricultural year (t-4).

Tables IV.B.1 and IV.B.2 contain the estimates of the intertemporal elasticity of substitution for male heads of households (δ_m), under perfect foresight and uncertainty respectively. Tables IV.B.3 and IV.B.4 correspondingly, allow the interest rate to vary over time. These estimates indicate that there is no significant tradeoff in the labor supply of males, over time. This result may be due to the fact that the major function of male heads is supervision and management of the day-to-day farm operations. There would be little room for intertemporal substitution, since management and supervision are required in certain amounts every period, like fixed inputs. An alternative explanation may lie in the (ir)relevence of the maintained hypothesis of perfect credit markets.

There is evidence of intertemporal substitution of leisure for females. Tables IV.B.5 through IV.B.8 contain the estimates of the intertemporal elasticity of substitution (δ_f) for female spouses. These estimates are positive and strongly significant under all specifications. In addition, they all have values much larger than the range of estimates (.10 -.23) derived by MaCurdy (1981) for females in the U.S. using yearly data. This is an anticipated result. The duration of each time period in this study is short (2-3 months). Leisure (or labor supply) is likely to be more intertemporally substitutable across shorter periods of time than it would be across longer ones. The maximization of discounted expected utility, thus leads households to allocate labor supply over time in such a way that more female labor is supplied during periods of high wage rates and less is supplied in the periods of low wage rates. This statement needs to be qualified since cross wage effects are ignored. The results of Rosenzweig (1980) suggest that such cross wage effects between male and female labor supply may be quite strong. This issue certainly deserves more attention in a further study.

The single estimate of the intertemporal elasticity of substitution is not adequate for describing the differences in labor supply across individuals in response to exogenous wage rate changes. In order to derive an estimate of how labor supply in period t responds to an increase in the wage rate of period t (or t+j, $j \geq 1$), one needs to know how the term $F_{ki}(1)$ is affected by an increase in the wage rate in period t (or t+j). As mentioned earlier analytical solutions for $\lambda(1)$ and therefore $F_{ki}(1)$ are difficult to obtain. However, one can infer that $F_{ki}(1)$ is a complicated function of initial assets, the expected paths of the male and female wage rates, the interest rate, the rate of time preference and parameters representing unobserved taste variables. In addition, in the context of the agricultural household model considered here, $F_{ki}(1)$ will also be a function of the determinants of expected profits at any point in time (such as the paths of crop and input prices (other than labor) and the availability of new production technologies). It is apparent that it is a difficult task to postulate even a reduced form that captures all the determinants of $F_{ki}(1)$.

The procedure followed in this dissertation, is to regress the estimate of the unobservable marginal utility of wealth for each farmer on the time invariant characteristics of the farmer and a measure of initial assets. The results of this effort (for females only) is presented in Tables IV.B.9-10. The estimate of the unobservable fixed effect for females was derived according to the formula:

$$F_{fi}(1) = (1/T) \sum_{j=1}^{T} [\ln H_{fi}(j) - \hat{b}t_i(j) - \hat{\delta}_f \ln W_{fi}(j)]$$

where $\hat{b}$ is the estimated constant of the regression, $\hat{\delta}_f$ is the estimate of the intertemporal elasticity of substitution, T is the length of the sample and $t_i(j)$ is the age of individual i in the sample period j . Two estimates of the fixed effect are derived based on the two different specifications concerning the variability of the interest rate over time[6]. Both estimates are derived under the specification of uncertainty.

The measure of initial assets (TASSETR), was derived by summing the nominal value of owned land, livestock, implements, buildings, consumer durables, stocks, financial assets and liabilities in the year 1979 (the first year of the labor supply sample) and deflating by the CPI.

According to these regressions the effect of education (EDUCYRS) on the marginal utility of wealth is to depress it. This result consistent with the notion that education enhances the resources of the household (managerial effect) and hence generates a positive wealth effect. The wealth effect translates into a negative effect on the marginal utility of wealth and hence has a negative effect on labor supply. Similarly the value of initial assets (TASSETR) has a depressing effect on the marginal utility of wealth as theory predicts. Since the rest of the variables are insignificant they will not be discussed.

Finally in order to conduct an indirect test of the perfect credit market hypothesis, we included a measure of income as an element of the X(t) vector. The test of binding credit constraints is whether or not family labor income (exclusive of individual earnings) has a significant coefficient. The reader is warned that in principle the measure of income included in X(t) should be complete, in the sense that it consists of income from all sources (transfer income, profits etc.). However, given that such a measure of family income was not available, we used labor income alone.

In any case, these preliminary results indicate that the perfect credit market hypothesis may not hold. Income has a significant coefficient under all specifications for both males and females. Any further work concerning rural behavior must therefore confront this issue explicitly.

TABLE IV.B.1 - PERFECT FORESIGHT

SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED LABOR SUPPLY EQUATION FOR MALE HEADS OF HOUSEHOLDS

```
  Source|      SS          df        MS               Number of obs =     969
---------+------------------------------              F(  1,    967) =    0.06
   Model|  .094981365       1  .094981365              Prob > F      =  0.7970
Residual|  1596.25009     967  1.65072398              R-square      =  0.0001
---------+------------------------------              Adj R-square  = -0.0010
   Total|  1596.34507     968  1.64911681              Root MSE      =  1.2848

Variable|  Coefficient    Std. Error       t       Prob > |t|       Mean
---------+-------------------------------------------------------------------
 AVHRMOM|                                                        -.0231851
---------+-------------------------------------------------------------------
MWAGE1  |    -.0656998      .2738936    -0.240      0.810        .0135183
   _cons|     -.022297      .0414396    -0.538      0.591              1.
---------+-------------------------------------------------------------------
```

MWAGE1: Imputed wage rate for males. Instruments used: age, age squared years of education, dummy for caste, log of village level wage rate in period t, rainfall (mm's) in period t, dummy for stage dummies for village.

TABLE IV.B.2 - UNCERTAINTY

```
-------------------------------------------------------------------------
      SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
       LABOR SUPPLY EQUATION FOR MALE HEADS OF HOUSEHOLDS
-------------------------------------------------------------------------


  Source|      SS          df         MS             Number of obs =     765
---------+-----------------------------              F(  1,    763) =    0.51
   Model|  .849534974       1  .849534974            Prob > F      =  0.4826
Residual|  1272.90089     763  1.66828426            R-square      =  0.0007
---------+-----------------------------              Adj R-square  = -0.0006
   Total|  1273.75043     764   1.6672126            Root MSE      =  1.2916

Variable|  Coefficient    Std. Error       t       Prob > |t|       Mean
---------+---------------------------------------------------------------
 AVHRMOM|                                                       -.0809759
---------+---------------------------------------------------------------
MWAGE2  |     -.3488676      .488883    -0.714      0.476        .0066462
   _cons|     -.0786573     .0468115    -1.680      0.093              1.
---------+---------------------------------------------------------------
```

MWAGE2: Imputed wage rate for males. Instruments used: age, age squared years of education, dummy for caste, log of village level wage rate in period t-1, rainfall (mm's) in period t-1, log of village level wage rate in period t-4, dummy for stage, dummies for villages.

TABLE IV.B.3 - PERFECT FORESIGHT

```
-------------------------------------------------------------------------
       SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
        LABOR SUPPLY EQUATION FOR MALE HEADS OF HOUSEHOLDS
-------------------------------------------------------------------------

  Source|       SS        df        MS            Number of obs =     969
--------+----------------------------             F( 19,    949) =    1.47
   Model|  45.7141342     19  2.40600707          Prob > F      =  0.0867
Residual|  1550.63094    949  1.63396305          R-square      =  0.0286
--------+----------------------------             Adj R-square  =  0.0092
   Total|  1596.34507    968  1.64911681          Root MSE      =  1.2783

Variable| Coefficient    Std. Error       t      Prob > |t|      Mean
--------+----------------------------------------------------------------
 AVHRMOM|                                                      -.0231851
--------+----------------------------------------------------------------
MWAGE1  |   -.3616068     .3334202     -1.085     0.278        .0135183
   dv521|    .0551308     .2575349      0.214     0.831        .0526316
   dv522|   -.2273768     .2540355     -0.895     0.371        .0526316
   dv611|   -.4142818     .2659572     -1.558     0.120        .0526316
   dv612|   -.4820211      .261202     -1.845     0.065        .0526316
   dv621|   -.1712286     .2531525     -0.676     0.499        .0526316
   dv622|   -.4430932     .2534765     -1.748     0.081        .0526316
   dv711|    -.182651     .2609085     -0.700     0.484        .0526316
   dv712|   -.7582932     .2636924     -2.876     0.004        .0526316
   dv721|   -.1839286     .2536375     -0.725     0.469        .0526316
   dv722|   -.3970906     .2540866     -1.563     0.118        .0526316
   dv811|   -.2282509     .2603182     -0.877     0.381        .0526316
   dv812|   -.3958566     .2550181     -1.552     0.121        .0526316
   dv821|   -.6867969     .2558503     -2.684     0.007        .0526316
   dv822|    -.321475     .2535308     -1.268     0.205        .0526316
   dv911|   -.5672338     .2646002     -2.144     0.032        .0526316
   dv912|   -.4641467     .2592277     -1.790     0.074        .0526316
   dv921|   -.7335322     .2549134     -2.878     0.004        .0526316
   dv922|   -.2615375     .2531439     -1.033     0.302        .0526316
   _cons|    .3429487     .1834433      1.870     0.062               1.
--------+----------------------------------------------------------------
```

MWAGE1: Imputed wage rate for males. Instruments used: age, age squared years of education, dummy for caste, log of village level wage rate in period t, rainfall (mm's) in period t, dummy for stage dummies for village.

TABLE IV.B.4 - UNCERTAINTY

```
--------------------------------------------------------------------
     SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
       LABOR SUPPLY EQUATION FOR MALE HEADS OF HOUSEHOLDS
--------------------------------------------------------------------


   Source|       SS         df        MS          Number of obs =     765
---------+-----------------------------           F( 15,    749) =    1.06
    Model|  26.4046938     15  1.76031292         Prob > F      =  0.3937
 Residual|  1247.34573    749  1.66534811         R-square      =  0.0207
---------+-----------------------------           Adj R-square  =  0.0011
    Total|  1273.75043    764   1.6672126         Root MSE      =  1.2905

 Variable|  Coefficient    Std. Error      t       Prob > |t|       Mean
---------+----------------------------------------------------------------
  AVHRMOM|                                                      -.0809759
---------+----------------------------------------------------------------
 MWAGE2  |    -.3394251        .57469    -0.591      0.555       .0066462
    dv621|     .2080368      .2604211     0.799      0.425       .0666667
    dv622|    -.0071539       .263553    -0.027      0.978       .0666667
    dv711|     .3028083      .2556799     1.184      0.237       .0666667
    dv712|    -.2763707       .256154    -1.079      0.281       .0666667
    dv721|     .2390449      .2557909     0.935      0.350       .0666667
    dv722|     .0680905      .2602881     0.262      0.794       .0666667
    dv811|     .2420368      .2558896     0.946      0.345       .0666667
    dv812|     .0306385      .2576171     0.119      0.905       .0666667
    dv821|    -.2223294      .2563583    -0.867      0.386       .0666667
    dv822|     .1141346      .2559196     0.446      0.656       .0666667
    dv911|    -.0750573      .2556242    -0.294      0.769       .0666667
    dv912|     -.000727      .2560424    -0.003      0.998       .0666667
    dv921|    -.2998784      .2562453    -1.170      0.242       .0666667
    dv922|     .1613325      .2565139     0.629      0.530       .0666667
    _cons|    -.1110271      .1807279    -0.614      0.539             1.
---------+----------------------------------------------------------------
```

MWAGE2: Imputed wage rate for males. Instruments used: age, age squared years of education, dummy for caste, log of village level wage rate in period t-1, rainfall (mm's) in period t-1, log of village level wage rate in period t-4, dummy for stage, dummies for villages.

TABLE IV.B.5- PERFECT FORESIGHT

```
-----------------------------------------------------------------------------
SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
LABOR SUPPLY EQUATION FOR FEMALES (SPOUSES OF HEADS OF HOUSEHOLDS)
-----------------------------------------------------------------------------
   Source|       SS         df         MS              Number of obs =   1159
---------+------------------------------              F(  1,   1157) =  20.23
    Model|  62.2894213       1  62.2894213             Prob > F      = 0.0000
 Residual|  3563.08296    1157  3.07958769             R-square      = 0.0172
---------+------------------------------              Adj R-square  = 0.0163
    Total|  3625.37238    1158  3.13071881             Root MSE      = 1.7549

 Variable|  Coefficient   Std. Error       t       Prob > |t|       Mean
---------+--------------------------------------------------------------------
 AVHRMOF|                                                         .0235893
---------+--------------------------------------------------------------------
 FWAGE1  |     1.275086     .2835167     4.497       0.000          .0124309
    _cons|     .0077389     .0516675     0.150       0.881                1.
---------+--------------------------------------------------------------------
 FWAGE1:Imputed wage rate for females. Instruments used:
        log of village level wage rate in period t, rainfall (mm's) in
        in period t, dummy for stage and dummies for villages
```

TABLE IV.B.6 - UNCERTAINTY

SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED LABOR SUPPLY EQUATION FOR FEMALES (SPOUSES OF HEADS OF HOUSEHOLDS)

```
  Source|      SS          df        MS              Number of obs =      915
---------+-----------------------------              F(  1,    913) =     6.84
   Model|  21.4664041       1  21.4664041            Prob > F      =   0.0089
Residual|  2866.51677     913  3.13966787            R-square      =   0.0074
---------+-----------------------------              Adj R-square  =   0.0063
   Total|  2887.98317     914  3.15971901            Root MSE      =   1.7719

Variable|  Coefficient    Std. Error       t       Prob > |t|        Mean
---------+--------------------------------------------------------------------
 AVHRMOF|                                                          .0115079
---------+--------------------------------------------------------------------
FWAGE2  |     1.195832      .4573327     2.615      0.009         .0134551
   _cons|    -.0045821      .0588999    -0.078      0.938               1.
---------+--------------------------------------------------------------------
```

FWAGE2: Imputed wage rate for females. Instruments used:
log of village level wage rate in period t-1, rainfall (mm's) in in period t-1, dummy for stage and dummies for villages, log village level wage rate in period t-4.

TABLE IV.B.7 - PERFECT FORESIGHT

```
-----------------------------------------------------------------------
     SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
  LABOR SUPPLY EQUATION FOR FEMALES (SPOUSES OF HEADS OF HOUSEHOLDS)
-----------------------------------------------------------------------

  Source|      SS         df       MS              Number of obs =    1159
---------+------------------------------           F( 19,  1139) =    3.16
   Model|  181.301768     19   9.5421983           Prob > F      =  0.0000
Residual|  3444.07061   1139    3.023767           R-square      =  0.0500
---------+------------------------------           Adj R-square  =  0.0342
   Total|  3625.37238   1158  3.13071881           Root MSE      =  1.7389

Variable|  Coefficient    Std. Error       t     Prob > |t|       Mean
---------+-------------------------------------------------------------
 AVHRMOF|                                                      .0235893
---------+-------------------------------------------------------------
FWAGE1  |     1.813914      .3259895     5.564     0.000       .0124309
   dv521|    -.5166639      .3158205    -1.636     0.102       .0526316
   dv522|    -.5405109      .3184184    -1.697     0.090       .0526316
   dv611|     -.230189      .3169944    -0.726     0.468       .0526316
   dv612|    -.9217809      .3190908    -2.889     0.004       .0526316
   dv621|     .0974238       .315812     0.308     0.758       .0526316
   dv622|    -1.195844      .3260432    -3.668     0.000       .0526316
   dv711|    -.0526412      .3151657    -0.167     0.867       .0526316
   dv712|    -.0036342      .3152046    -0.012     0.991       .0526316
   dv721|    -.5929413      .3149943    -1.882     0.060       .0526316
   dv722|    -.4740063      .3194986    -1.484     0.138       .0526316
   dv811|    -.7458884      .3150849    -2.367     0.018       .0526316
   dv812|    -.3808526      .3158694    -1.206     0.228       .0526316
   dv821|    -.3507711      .3149837    -1.114     0.266       .0526316
   dv822|    -.5062455      .3191117    -1.586     0.113       .0526316
   dv911|    -.8811496      .3150157    -2.797     0.005       .0526316
   dv912|    -.3047155      .3150774    -0.967     0.334       .0526316
   dv921|    -.1400175      .3148714    -0.445     0.657       .0526316
   dv922|    -.3174966      .3184055    -0.997     0.319       .0526316
   _cons|      .425142      .2231485     1.905     0.057             1.
---------+-------------------------------------------------------------
```

FWAGE1:Imputed wage rate for females. Instruments used:
log of village level wage rate in period t, rainfall (mm's) in
in period t, dummy for stage and dummies for villages

TABLE IV.B.8 - UNCERTAINTY

```
----------------------------------------------------------------------
       SIMULTANEOUS EQUATION ESTIMATION OF FIRST DIFFERENCED
 LABOR SUPPLY EQUATION FOR FEMALES (SPOUSES OF HEADS OF HOUSEHOLDS)
----------------------------------------------------------------------

  Source|     SS         df       MS              Number of obs =     915
--------+----------------------------             F( 15,   899) =    1.93
   Model| 90.1609615     15  6.01073077           Prob > F      =  0.0175
Residual| 2797.82221    899  3.11214929           R-square      =  0.0312
--------+----------------------------             Adj R-square  =  0.0151
   Total| 2887.98317    914  3.15971901           Root MSE      =  1.7641

Variable| Coefficient    Std. Error      t        Prob > |t|       Mean
--------+-------------------------------------------------------------
 AVHRMOF|                                                       .0115079
--------+-------------------------------------------------------------
FWAGE2  |    1.082069      .6052227      1.788       0.074      .0134551
   dv621|    .5848278      .3194861      1.831       0.068      .0666667
   dv622|   -.1857306      .3237892     -0.574       0.566      .0666667
   dv711|     .725091       .321647      2.254       0.024      .0666667
   dv712|    .5512972      .3317703      1.662       0.097      .0666667
   dv721|    .2076328      .3260191      0.637       0.524      .0666667
   dv722|    .2848431      .3343571      0.852       0.394      .0666667
   dv811|   -.1456536      .3199333     -0.455       0.649      .0666667
   dv812|    .3454191       .320539      1.078       0.281      .0666667
   dv821|    .2641159      .3198518      0.826       0.409      .0666667
   dv822|    .2996688      .3260209      0.919       0.358      .0666667
   dv911|   -.1251516      .3216893     -0.389       0.697      .0666667
   dv912|    .2966256      .3239902      0.916       0.360      .0666667
   dv921|     .565844        .32282      1.753       0.080      .0666667
   dv922|    .4595621      .3264309      1.408       0.160      .0666667
   _cons|   -.2782775      .2260068     -1.231       0.219             1.
--------+-------------------------------------------------------------
```

FWAGE2: Imputed wage rate for females. Instruments used:
log of village level wage rate in period t-1, rainfall (mm's) in
in period t-1, dummy for stage and dummies for villages, log
village level wage rate in period t-4.

TABLE IV.B.9

```
------------------------------------------------------------------------
CORRELATION OF THE ESTIMATED FIXED EFFECT (MARGINAL UTILITY OF WEALTH)
    WITH TIME INVARIANT INDIVIDUAL AND HOUSEHOLD CHARACTERISTICS
      FIXED EFFECT DERIVED USING THE PARAMETERS OF TABLE IV.B.6
------------------------------------------------------------------------
   SOURCE|      SS          DF         MS           NUMBER OF OBS =     58
---------+------------------------------            F(  5,     52) =   4.25
    MODEL|  24.5596777       5  4.91193553           PROB > F      = 0.0026
 RESIDUAL|  60.0298409      52  1.15442002           R-SQUARE      = 0.2903
---------+------------------------------            ADJ R-SQUARE  = 0.2221
    TOTAL|  84.5895185      57  1.48402664           ROOT MSE      = 1.0744

 VARIABLE|  COEFFICIENT    STD. ERROR       T       PROB > |T|      MEAN
---------+--------------------------------------------------------------
  FXEFLSF|                                                       5.108745
---------+--------------------------------------------------------------
  EDUCYRS|   -.0975043      .1129765     -0.863       0.392            .5
    DCAST|   -.1667558      .3473759     -0.480       0.633      .4655172
      DV3|   -.8715643      .3559991     -2.448       0.018      .3275862
      DV5|    .2871696      .4297121      0.668       0.507      .2931034
 TASSETR|   -.0000115      5.42E-06     -2.114       0.039      23599.87
    _CONS|    5.706851      .2588154     22.050       0.000            1.
---------+--------------------------------------------------------------
```

TABLE IV.B.10

```
-----------------------------------------------------------------------------
CORRELATION OF THE ESTIMATED FIXED EFFECT (MARGINAL UTILITY OF WEALTH)
     WITH TIME INVARIANT INDIVIDUAL AND HOUSEHOLD CHARACTERISTICS
       FIXED EFFECT DERIVED USING THE PARAMETERS OF TABLE IV.B.8
-----------------------------------------------------------------------------
   SOURCE|      SS          DF        MS              NUMBER OF OBS =      58
---------+-----------------------------               F(  5,     52) =    1.53
    MODEL|  75.2430691       5  15.0486138            PROB > F      =  0.1970
 RESIDUAL|  511.843631      52  9.84314675            R-SQUARE      =  0.1282
---------+-----------------------------               ADJ R-SQUARE  =  0.0443
    TOTAL|    587.0867      57  10.2997667            ROOT MSE      =  3.1374

 VARIABLE| COEFFICIENT    STD. ERROR       T      PROB > |T|       MEAN
---------+-------------------------------------------------------------------
  FXEFLSF|                                                      -6.324929
---------+-------------------------------------------------------------------
  EDUCYRS|    .3294888       .329893     0.999     0.323               .5
    DCAST|   -.6648179      1.014343    -0.655     0.515         .4655172
      DV3|   -.9324454      1.039523    -0.897     0.374         .3275862
      DV5|    1.071602      1.254766     0.854     0.397         .2931034
  TASSETR|   -.0000145      .0000158    -0.917     0.364         23599.87
    _CONS|   -5.846516      .7557447    -7.736     0.000               1.
---------+-------------------------------------------------------------------
```

TABLE IV.B.11 - UNCERTAINTY

```
-------------------------------------------------------------------------
   INDIRECT TEST OF THE PERFECT CREDIT MARKET HYPOTHESIS - MALES
                        WITHOUT YEAR DUMMIES
-------------------------------------------------------------------------
   Source|     SS         df        MS             Number of obs =    765
---------+-----------------------------            F(  2,   762) =   5.30
    Model|  17.4821142     2  8.74105708           Prob > F      = 0.0052
 Residual|  1256.26831   762  1.64864608           R-square      = 0.0137
---------+-----------------------------            Adj R-square  = 0.0111
    Total|  1273.75043   764   1.6672126           Root MSE      =  1.284

 Variable|  Coefficient    Std. Error       t      Prob > |t|       Mean
---------+---------------------------------------------------------------
  AVHRMOM|                                                     -.0809759
---------+---------------------------------------------------------------
 MWAGE2  |   -.4108254      .4863884     -0.845     0.399       .0066462
   DIFINC|    .0002956      .0000931      3.176     0.002      -24.62431
    _cons|   -.0709675      .0465981     -1.523     0.128             1.
---------+---------------------------------------------------------------
```

MWAGE2:Same as in Table IV.B.2

TABLE IV.B.12 - UNCERTAINTY

```
------------------------------------------------------------------------------
    INDIRECT TEST OF THE PERFECT CREDIT MARKET HYPOTHESIS - MALES
                          WITH YEAR DUMMIES
------------------------------------------------------------------------------
  Source|       SS         df         MS               Number of obs =    765
---------+-----------------------------               F( 16,    748) =   1.44
   Model|  37.9683807     16  2.37302379               Prob > F      = 0.1179
Residual|  1235.78205    748  1.65211503               R-square      = 0.0298
---------+-----------------------------               Adj R-square  = 0.0091
   Total|  1273.75043    764   1.6672126               Root MSE      = 1.2853

Variable| Coefficient    Std. Error       t       Prob > |t|       Mean
---------+--------------------------------------------------------------------
AVHRMOM|                                                          -.0809759
---------+--------------------------------------------------------------------
MWAGE2  |    -.317147      .5724641     -0.554     0.580        .0066462
  DIFINC|     .000267      .0001009      2.646     0.008       -24.62431
   dv621|    .0933831      .2629798      0.355     0.723        .0666667
   dv622|    -.119218      .2658994     -0.448     0.654        .0666667
   dv711|     .125029      .2633785      0.475     0.635        .0666667
   dv712|   -.2773567      .2551345     -1.087     0.277        .0666667
   dv721|    .1314218      .2579999      0.509     0.611        .0666667
   dv722|    -.037653      .2623149     -0.144     0.886        .0666667
   dv811|    .0870178      .2615195      0.333     0.739        .0666667
   dv812|    .0174564      .2566399      0.068     0.946        .0666667
   dv821|   -.3354414      .2588924     -1.296     0.195        .0666667
   dv822|    .0002573      .2585095      0.001     0.999        .0666667
   dv911|    -.198877      .2588724     -0.768     0.443        .0666667
   dv912|   -.0438232      .2555428     -0.171     0.864        .0666667
   dv921|   -.4022051      .2581392     -1.558     0.120        .0666667
   dv922|    .0529755      .2587548      0.205     0.838        .0666667
   _cons|   -.0118234      .1838724     -0.064     0.949               1.
---------+--------------------------------------------------------------------
MWAGE2:Same as in Table IV.B.2
```

TABLE IV.B.13 - UNCERTAINTY

```
------------------------------------------------------------------------------
    INDIRECT TEST OF THE PERFECT CREDIT MARKET HYPOTHESIS - FEMALES
                          WITHOUT YEAR DUMMIES
------------------------------------------------------------------------------
   Source|       SS         df        MS                Number of obs =    913
---------+----------------------------                  F(  2,   910) =   4.74
    Model|  29.4442287       2  14.7221144              Prob > F      = 0.0090
 Residual|   2826.2158     910  3.10573165              R-square      = 0.0103
---------+----------------------------                  Adj R-square  = 0.0081
    Total|  2855.66003     912  3.13120618              Root MSE      = 1.7623

 Variable| Coefficient    Std. Error       t          Prob > |t|       Mean
---------+--------------------------------------------------------------------
  AVHRMOF|                                                         .0071919
---------+--------------------------------------------------------------------
   FWAGE2|    1.308993      .4600247      2.845        0.005       .0136618
   DIFINC|    .0001723      .0001093      1.576        0.115      -21.70772
    _cons|   -.0069503      .0586727     -0.118        0.906             1.
---------+--------------------------------------------------------------------
FWAGE2:Same as in Table IV.B.6
```

TABLE IV.B.14 - UNCERTAINTY

```
------------------------------------------------------------------------------
    INDIRECT TEST OF THE PERFECT CREDIT MARKET HYPOTHESIS - FEMALES
                         WITH YEAR DUMMIES
------------------------------------------------------------------------------
  Source|       SS       df       MS                  Number of obs =     913
---------+-----------------------------              F( 16,   896) =    2.05
   Model|  100.978482    16  6.31115514               Prob > F      =  0.0086
Residual|  2754.68155   896  3.07442137               R-square      =  0.0354
---------+-----------------------------              Adj R-square  =  0.0181
   Total|  2855.66003   912  3.13120618               Root MSE      =  1.7534

Variable|  Coefficient    Std. Error       t      Prob > |t|      Mean
---------+--------------------------------------------------------------------
 AVHRMOF|                                                         .0071919
---------+--------------------------------------------------------------------
  FWAGE2|     1.171236      .6021605      1.945     0.052        .0136618
  DIFINC|     .0002068      .0001186      1.744     0.082       -21.70772
   dv621|     .4830237      .3227936      1.496     0.135        .0668127
   dv622|    -.2714423      .3250343     -0.835     0.404        .0668127
   dv711|     .5942895      .3289716      1.807     0.071        .0668127
   dv712|     .5446183      .3297826      1.651     0.099        .0668127
   dv721|     .1222461      .3284199      0.372     0.710        .0668127
   dv722|     .1976075      .3351574      0.590     0.556        .0668127
   dv811|    -.2802115      .3275053     -0.856     0.392        .0668127
   dv812|      .345365      .3185971      1.084     0.279        .0668127
   dv821|      .173549      .3223032      0.538     0.590        .0668127
   dv822|     .2067197      .3277121      0.631     0.528        .0668127
   dv911|    -.2267455      .3254756     -0.697     0.486        .0668127
   dv912|     .1860806      .3236041      0.575     0.565        .0657174
   dv921|     .5185586      .3254382      1.593     0.111        .0657174
   dv922|     .3638924      .3283305      1.108     0.268        .0668127
   _cons|    -.2011504      .2288434     -0.879     0.380              1.
---------+--------------------------------------------------------------------
FWAGE2:Same as in Table IV.B.6
```

IV.C ESTIMATION OF THE LABOR DEMAND SIDE OF THE MODEL

This section presents the estimates of the labor demand functions as presented in chapter III (equations (3.16), (3.17)). The functions estimated here treat bullock labor as a variable input. No attempt is made here to derive the parameters of the underlying production technology. The reason for this is that separate estimation of each equation in each stage (i.e (3.11) and (3.12) for the harvesting stage, or (3.16) and (3.17) for the planting stage) may yield different parameters for the underlying production technology. The derivation of the underlying technology parameters can be carried out only if the implied cross equation restrictions on the parameters of the input demand functions are imposed.

In order to test the relevence of these restrictions in our sample two different methods were followed. First, estimation of the system of equations (3.11), (3.12), (3.16) and (3.17) in terms of the parameters δ_1, δ_2, δ_3, δ_4, δ_5, δ_6, δ_7, δ_8, δ_9 was attempted by using the full information maximum likelihood (FIML) method (or iterated SURE). Unfortunately the iterated SURE estimator did not converge due to collinearity problems. Given the failure of the first approach, an alternative test was conducted based on the following reasoning. The nonlinear model implies a set of linear parameter restrictions across the input demand function parameters; if the linear parameter restrictions do not hold then the nonlinear restrictions do not hold either. Estimation of the the same system of equations as seemingly unrelated equations (SURE) subject to the <u>linear</u> restrictions implied by the nonlinear model led to the rejection of the null hypothesis that the linear restrictions are true ($\chi^2(18) = 71.77$).

Thus each input demand equation was estimated independently without imposing any cross equation restrictions or accounting for possible correlation of the error terms across the input demand equations. As it is well known (Johnston (1984)), joint estimation of a system of equations with the same right hand side variables does not improve efficiency, inspite the possible correlation of the error terms of the equations (due to the farmer fixed effect). The estimates of the labor demand for females and males in the planting stage (a version of expressions (3.16) and (3.17) in Chapter III) are presented in Tables IV.C.1 - IV.C.2.

However these estimates may be biased, since they ignore the correlation of the error term with the right hand side variables in each equation (heterogeneity and nonseparability bias). In order to eliminate this source of bias, estimation was carried out by taking deviations from farmer means. These results are presented in Tables IV.C.3 and IV.C.4. The hypothesis of equal constant terms across all farmers was rejected at the 5% significance level (under the null hypothesis $F_{Male}(45,359)=3.313$ and $F_{Female}(45,359)=5.442$).

The regressions of the fixed effects on observable time invariant farmer characteristics (and village dummies), presented in Tables IV.C.7 and IV.C.8, reveal that there is a strong correlation between the estimated fixed effect and these variables. Education seems to have the strongest explanatory power in the variation of the fixed effects thus verifying once more the managerial efficiency effect of education (see Jamison & Lau (1982)). Finally, the results of including the year effect are presented in Tables IV.C.5 and IV.C.6. The hypothesis of the equality of the intercept terms across years was rejected at the 5% significance level (under the null hypothesis $F_{Male}(8,388)=3.79$ and $F_{Female}(8,388)=4.0866$).

Comparison of the results under perfect foresight and uncertainty reveals that accounting for heterogeneity and nonseparability has a serious effect on the sign of the estimated parameters. For example, after accounting for fixed effects the sign of the own price elasticity for female labor reverses. Both labor demand functions are negatively correlated with their respective wage rates. Finally, male and female labor appear to be non-substitutable inputs since the cross-price elasticities are of opposite signs.

As it was discussed in chapter III the estimates obtained above may not be consistent due to the presence of the unobservable marginal utility of consumption in the input demand functions. The lack of generality of the assumptions required for the consistency of the fixed effect estimators and the difficulty of empirically testing the relevance of these assumptions necessitates an alternative approach. In the next chapter, the parameters of an agricultural production function are directly estimated. These technological parameters are then used to derive the implied input demand elasticities. This way one can make sure that all the cross equation restrictions imposed by theory are satisfied and at the same time obtain elasticity estimates that are free of the nonseparability bias.

TABLE IV.C.1

```
------------------------------------------------------------------------
              DEMAND FOR MALE LABOR-PERFECT FORESIGHT
------------------------------------------------------------------------

   SOURCE|      SS          DF         MS             NUMBER OF OBS =     414
---------+------------------------------              F(  9,    404) =  265.35
    MODEL|  537.233641       9  59.6926268            PROB > F      =  0.0000
 RESIDUAL|  90.8824361     404  .224956525            R-SQUARE      =  0.8553
---------+------------------------------              ADJ R-SQUARE  =  0.8521
    TOTAL|  628.116077     413  1.52086217            ROOT MSE      =   .4743

 VARIABLE|  COEFFICIENT     STD. ERROR        T       PROB > |T|       MEAN
---------+--------------------------------------------------------------------
    MALE1|                                                          6.032794
---------+--------------------------------------------------------------------
   MWAGE1|   -.0948536       .1361005      -0.697       0.486        .0732421
   FWAGE1|   -.0391967       .1024427      -0.383       0.702       -.7605751
   MWAGE2|    .4040894       .1500761       2.693       0.007       -.2483453
   FWAGE2|   -.0731223       .0920897      -0.794       0.428       -.8031104
   BWAGE1|   -.0457991       .1037906      -0.441       0.659        .8638667
      CLT|     .837963       .0292161      28.682       0.000         2.06087
     IRR9|    .0506269       .0062352       8.120       0.000       -5.699583
    PESTV|   -.0110844       .0140931      -0.787       0.432        1.260352
   TFERTQ|    .1144385       .0128698       8.892       0.000        3.050566
    _CONS|    4.317609       .1509054      28.611       0.000              1.
---------+--------------------------------------------------------------------
```

TABLE IV.C.2

DEMAND FOR FEMALE LABOR-PERFECT FORESIGHT

```
  SOURCE|     SS          DF        MS              NUMBER OF OBS =     414
---------+-----------------------------             F(  9,    404) =   96.45
   MODEL|  1019.39014      9  113.265571            PROB > F      =  0.0000
RESIDUAL|  474.422824    404  1.17431392            R-SQUARE      =  0.6824
---------+-----------------------------             ADJ R-SQUARE  =  0.6753
   TOTAL|  1493.81297    413  3.61698055            ROOT MSE      =  1.0837

VARIABLE|  COEFFICIENT    STD. ERROR        T       PROB > |T|       MEAN
---------+--------------------------------------------------------------------
   FEML1|                                                          5.387462
---------+--------------------------------------------------------------------
  MWAGE1|     1.677761      .3109586      5.395      0.000        .0732421
  FWAGE1|     .2308812      .2340582      0.986      0.325       -.7605751
  MWAGE2|     .5319934      .3428897      1.552      0.122       -.2483453
  FWAGE2|    -.3542488      .2104039     -1.684      0.093       -.8031104
  BWAGE1|     .2844012      .2371377      1.199      0.231        .8638667
     CLT|     .7151255       .066752     10.713      0.000         2.06087
    IRR9|     .1312403       .014246      9.212      0.000       -5.699583
   PESTV|    -.0821152      .0321995     -2.550      0.011        1.260352
  TFERTQ|     .2052126      .0294046      6.979      0.000        3.050566
   _CONS|     3.793828      .3447844     11.003      0.000              1.
---------+--------------------------------------------------------------------
```

TABLE IV.C.3

```
------------------------------------------------------------------------
             DEMAND FOR MALE LABOR-FARMER EFFECTS REMOVED
------------------------------------------------------------------------

  SOURCE|      SS          DF        MS              NUMBER OF OBS =      414
---------+------------------------------             F(   9,    405) =    63.58
   MODEL|  90.7226453       9  10.0802939            PROB > F       =  0.0000
RESIDUAL|  64.2110777     405  .158545871            R-SQUARE       =  0.5856
---------+------------------------------             ADJ R-SQUARE   =  0.5763
   TOTAL|  154.933723     414  .374236046            ROOT MSE       =  .39818

VARIABLE|  COEFFICIENT    STD. ERROR       T       PROB > |T|       MEAN
---------+--------------------------------------------------------------
  MALE1|                                                        1.15E-08
---------+--------------------------------------------------------------
  MWAGE1|    -.2308714      .1235665     -1.868      0.062      -3.94E-09
  FWAGE1|    -.2748054      .1010276     -2.720      0.007      -2.69E-08
  MWAGE2|     .3189451      .1812596      1.760      0.079       1.29E-08
  FWAGE2|    -.0101894      .1480598     -0.069      0.945      -1.60E-08
  BWAGE1|     .0708444      .1205863      0.587      0.557       1.40E-08
     CLT|     .7510873      .0391742     19.173      0.000      -2.81E-09
    IRR9|     .0319271       .008244      3.873      0.000       6.33E-09
   PESTV|     .0296159      .0154377      1.918      0.056      -7.20E-10
  TFERTQ|     .1017479      .0130743      7.782      0.000      -1.08E-09
---------+--------------------------------------------------------------
```

TABLE IV.C.4

```
--------------------------------------------------------------------------
           DEMAND FOR FEMALE LABOR-FARMER EFFECTS REMOVED
--------------------------------------------------------------------------
  SOURCE|      SS           DF        MS             NUMBER OF OBS =     414
--------+-----------------------------               F(  9,    405) =   16.45
   MODEL|  103.079206        9  11.4532451           PROB > F      =  0.0000
RESIDUAL|  282.039743      405  .696394427           R-SQUARE      =  0.2677
--------+-----------------------------               ADJ R-SQUARE  =  0.2514
   TOTAL|  385.118948      414  .930239006           ROOT MSE      =   .8345

VARIABLE|  COEFFICIENT     STD. ERROR       T      PROB > |T|       MEAN
--------+-----------------------------------------------------------------
   FEML1|                                                         -6.62E-09
--------+-----------------------------------------------------------------
  MWAGE1|     .8922331      .2589709      3.445     0.001        -3.94E-09
  FWAGE1|    -.4181578      .2117338     -1.975     0.049        -2.69E-08
  MWAGE2|     .3610941      .3798843      0.951     0.342         1.29E-08
  FWAGE2|    -.2583886      .3103039     -0.833     0.406        -1.60E-08
  BWAGE1|     .5512641       .252725      2.181     0.030         1.40E-08
     CLT|     .7376978      .0821013      8.985     0.000        -2.81E-09
    IRR9|     .0463383      .0172777      2.682     0.008         6.33E-09
   PESTV|     .0042562      .0323544      0.132     0.895        -7.20E-10
  TFERTQ|     .0958042      .0274011      3.496     0.001        -1.08E-09
--------+-----------------------------------------------------------------
```

TABLE IV.C.5

```
-----------------------------------------------------------------------
 DEMAND FOR MALE LABOR-FARMER FIXED EFFECTS AND YEAR EFFECTS REMOVED
-----------------------------------------------------------------------

  SOURCE|      SS         F        MS              NUMBER OF OBS =    414
--------+----------------------------               F( 17,    397) =   37.41
   MODEL|  95.3869531    17  5.61099724             PROB > F       =  0.0000
RESIDUAL|    59.54677   397  .149991864             R-SQUARE       =  0.6157
--------+----------------------------               AJ R-SQUARE   =  0.5992
   TOTAL|  154.933723   414  .374236046             ROOT MSE       =  .38729

VARIABLE|  COEFFICIENT    ST. ERROR      T      PROB > |T|       MEAN
--------+--------------------------------------------------------------
   MALE1|                                                       1.15E-08
--------+--------------------------------------------------------------
  MWAGE1|    -.1731671     .2192284    -0.790     0.430       -3.94E-09
  FWAGE1|    -.2121487     .1544582    -1.374     0.170       -2.69E-08
  MWAGE2|     .1111963     .2839112     0.392     0.696        1.29E-08
  FWAGE2|     .1536536     .1563543     0.983     0.326       -1.60E-08
  BWAGE1|     .1387432     .1634465     0.849     0.396        1.40E-08
     CLT|     .7390708     .0394994    18.711     0.000       -2.81E-09
    IRR9|     .0234965     .0083911     2.800     0.005        6.33E-09
   PESTV|     .0214471     .0154136     1.391     0.165       -7.20E-10
  TFERTQ|     .0976096     .0134452     7.260     0.000       -1.08E-09
    DV76|     .0962035     .0835624     1.151     0.250        .1111111
    DV77|    -.1465333     .0730962    -2.005     0.046        .1111111
    DV78|    -.2326178     .0657388    -3.539     0.000        .1111111
    DV79|     .0288968     .0819862     0.352     0.725        .1111111
    DV80|     .1779671     .0642663     2.769     0.006        .1111111
    DV81|    -.0050193     .1060358    -0.047     0.962        .1111111
    DV82|     .0724963     .0830566     0.873     0.383        .1111111
    DV83|    -.0130066     .0882762    -0.147     0.883        .1111111
--------+--------------------------------------------------------------
```

TABLE IV.C.6

```
----------------------------------------------------------------------
DEMAND FOR FEMALE LABOR-FARMER FIXED EFFECTS AND YEAR EFFECTS REMOVED
----------------------------------------------------------------------

  SOURCE|      SS          F        MS              NUMBER OF OBS =     414
--------+-----------------------------               F( 17,    397) =   11.22
   MODEL|  124.996747    17  7.35274984              PROB > F       =  0.0000
RESIDUAL|  260.122201   397   .65521965              R-SQUARE       =  0.3246
--------+-----------------------------               AJ R-SQUARE   =  0.2956
   TOTAL|  385.118948   414  .930239006              ROOT MSE       =  .80946

VARIABLE|  COEFFICIENT    ST. ERROR       T      PROB > |T|       MEAN
--------+-------------------------------------------------------------
   FEML1|                                                       -6.62E-09
--------+-------------------------------------------------------------
  MWAGE1|     2.736175      .4582014     5.972     0.000       -3.94E-09
  FWAGE1|     .5282188      .3228275     1.636     0.103       -2.69E-08
  MWAGE2|    -1.519983      .5933925    -2.562     0.011        1.29E-08
  FWAGE2|    -.2651605      .3267904    -0.811     0.418       -1.60E-08
  BWAGE1|     1.295466      .3416136     3.792     0.000        1.40E-08
     CLT|      .719225      .0825562     8.712     0.000       -2.81E-09
    IRR9|     .0268842      .0175379     1.533     0.126        6.33E-09
   PESTV|    -.0088308      .0322154    -0.274     0.784       -7.20E-10
  TFERTQ|     .1105858      .0281013     3.935     0.000       -1.08E-09
    DV76|     .1950995      .1746509     1.117     0.265        .1111111
    DV77|    -.6420347      .1527757    -4.202     0.000        .1111111
    DV78|    -.3518531      .1373982    -2.561     0.011        .1111111
    DV79|    -.3114637      .1713564    -1.818     0.070        .1111111
    DV80|     .0874772      .1343206     0.651     0.515        .1111111
    DV81|      1.11673      .2216216     5.039     0.000        .1111111
    DV82|    -.3222616      .1735937    -1.856     0.064        .1111111
    DV83|     .0381907      .1845029     0.207     0.836        .1111111
--------+-------------------------------------------------------------
```

TABLE IV.C.7

REGRESSIONS OF FIXED EFFECTS ON INDIVIDUAL CHARACTERISTICS
FIXED EFFECT ESTIMATE DERIVED FROM MALE LABOR DEMAND FUNCTION

```
  SOURCE|      SS          DF        MS              NUMBER OF OBS =       45
---------+-----------------------------              F(  6,     38) =     8.72
   MODEL|  22.3011559      6  3.71685931             PROB > F      =   0.0000
RESIDUAL|  16.1941282     38  .426161269             R-SQUARE      =   0.5793
---------+-----------------------------              ADJ R-SQUARE  =   0.5129
   TOTAL|  38.4952841     44   .87489282             ROOT MSE      =   .65281

VARIABLE|  COEFFICIENT     STD. ERROR       T        PROB > |T|        MEAN
---------+--------------------------------------------------------------------
  FXEFM1|                                                           -1.946913
---------+--------------------------------------------------------------------
 EDUCYRS|    -.072429       .0182119      -3.977       0.000              -1.8
   DCAST|    -.1558429      .3030397      -0.514       0.610                .6
     DV3|     .8043871      .3743754       2.149       0.038          .1333333
     DV5|     .0372533      .2366089       0.157       0.876          .4666667
  DVABLE|    -.0270751      .3730943      -0.073       0.943          .0888889
 FAMSIZE|    -.0034876      .0440391      -0.079       0.937          6.844444
   _CONS|    -2.082139      .3986672      -5.223       0.000                1.
---------+--------------------------------------------------------------------
```

TABLE IV.C.8

```
------------------------------------------------------------------------------
     REGRESSIONS OF FIXED EFFECTS ON INDIVIDUAL CHARACTERISTICS
   FIXED EFFECT ESTIMATE DERIVED FROM FEMALE LABOR DEMAND FUNCTION
------------------------------------------------------------------------------

  SOURCE|      SS           DF         MS               NUMBER OF OBS =      45
---------+------------------------------                F(   6,     38) =    6.62
   MODEL|  16.8026321        6  2.80043869              PROB > F        =  0.0001
RESIDUAL|   16.067069       38  .422817604              R-SQUARE        =  0.5112
---------+------------------------------                ADJ R-SQUARE    =  0.4340
   TOTAL|  32.8697011       44  .747038662              ROOT MSE        =  .65024

VARIABLE|  COEFFICIENT    STD. ERROR       T        PROB > |T|        MEAN
---------+--------------------------------------------------------------------
  FXEFF1|                                                          -2.416662
---------+--------------------------------------------------------------------
 EDUCYRS|    -.0691051      .0181403     -3.809       0.001             -1.8
   DCAST|    -.2077682      .3018486     -0.688       0.495               .6
     DV3|     .2969272      .3729038      0.796       0.431         .1333333
     DV5|     .3581262      .2356788      1.520       0.137         .4666667
  DVABLE|    -.0004436      .3716278     -0.001       0.999         .0888889
 FAMSIZE|    -.0086674       .043866     -0.198       0.844         6.844444
   _CONS|    -2.563743      .3971002     -6.456       0.000               1.
---------+--------------------------------------------------------------------
```

CHAPTER V

ESTIMATION OF AN AGRICULTURAL PRODUCTION FUNCTION

In this chapter an agricultural production function is estimated. Labor is distinguished by gender and by the stage (planting and harvesting) of the production process in which it is applied. Section V.A contains a summary of the problems present in any empirical analysis of production technology. Section V.B contains the empirical results. Methods are used to control for heterogeneity and an exogeneity test with respect to the harvesting stage inputs is conducted and not rejected. The estimated technology parameters are then used to derive the implied input demand elasticities. It is argued that these derived input elasticity estimates are more appropriate for use in policy analyses because these estimates are consistent and satisfy all the cross equation restrictions imposed by theory.

V.A HETEROGENEITY, SIMULTANEITY AND ESTIMATION PROCEDURES

The economic development literature abounds with estimates of agricultural production functions. The majority of the studies are motivated by the debate focussing on whether the marginal product of labor in the rural sector is zero, as it is implicitly assumed by the influencial model of Lewis (1954). The accumulated empirical evidence on that issue is at best unclear. One reason for such conflicting evidence, rests on biases arising from specification errors.

Given that the literature on production function estimation has been very extensive we will only attempt a comprehensive presentation of the problems associated with the direct estimation of an agricultural production function. Although the Cobb-Douglas is by far the most common functional form estimated, general notation will be used since the arguments that follow apply to any functional form chosen. Let

(5.1) $Y = \beta X + u$

be the equation that is to be estimated, where Y is a vector denoting the quantity (or value) of output, X is a matrix of input quantities (or values), β is the parameter vector to be estimated and u a random disturbance. Note that the vector Y and the matrix X can be any transformation of the original data (logarithimic etc.). Application of ordinary least squares requires that X and u are uncorrelated. Otherwise the estimate of β will be inconsistent. Although the correlation of X and u may not be so significant in other applications it becomes a serious problem when estimating a production function. This is mainly due to two reasons: a) the dynamic nature of the agricultural production process and b) the unobservable variables (by the econometrician) that are assumed to be incorporated into the error term.

The above argument can be illustrated by interpreting each element u_{it} of the vector u as consisting of three components

(5.2) $u_{it} = \mu_i + k_t + \epsilon_{it} \quad i=1,\ldots,N \quad t=1,\ldots,T$

where μ_i refers to the systematic variation of the error term across farms i=1,..,N, k_t to the systematic variation of the error term across periods t=1,...,T and ϵ_{it} the nonsystematic component that varies across farms and time. The term μ_i is usually interpreted as an indicator of the technical efficiency or ability or management of farmer i, whereas the term k_t represents improvements in technical efficiency over time and/or differences in weather between periods. In the econometric literature, there are two approaches that differ in terms of the statistical properties attributed to the terms μ_i and k_t. The *random effects* literature treats μ_i and k_t as two random variables with given distributions across farms and time that are uncorrelated with the matrix X. The *fixed effects* literature treats μ_i and k_t as parameters that differ across farms and time but allows correlation with the matrix X. In general, the choice of assumptions about μ_i and k_t is not an easy one and tests have been developed to help researchers decide which estimator fits their sample better; Hausman (1978), Mundlak (1978). Given the nature of our problem however the choice is clear. It is natural to think of managerial ability as being associated with higher use of certain (if not all) inputs. For the purposes of this chapter,it is assumed that the terms μ_i and k_t are fixed effects and the appropriate estimator is used.

Under this decomposition of the error term one can easily show that ordinary least squares estimation will lead to biased estimates since the μ_i and k_t terms are treated as part of the error term even though they are correlated with X. In cross-sectional studies for example where $k_t=0$ and $u_i = \mu_i + \epsilon_i$ one can show that the sign of the bias of each coefficient β_j (where β_j is an element of β) depends on the covariance of the input X_j with the μ_i term. This problem with the cross sectional estimation of a production function was first noted by Marschak & Andrews (1944) and later extended by Mundlak (1961) and Hoch (1962). It has now come to be called *heterogeneity bias* (or management and time bias). The reader is reminded that the most cross-sectional estimates of production function parameters are subject to this source of bias in various degress as in Bardhan (1973) and Barnum & Squire (1978).

One way of resolving the heterogeneity bias is to obtain panel (longitudinal) data where the same farms are observed for at least two periods. Then use of the *within estimator* - where each observation is replaced by its deviation from the farm, year and overall sample mean - will yield estimates free of the heterogeneity bias since by differencing the terms μ_i and k_t drop out of the error term. For the first use of the within estimator in agricultural production fuction estimation the reader is referred to Mundlak (1961) and Hoch (1962).

However use of the within estimator does not necessarily imply that the estimates of the parameter vector β will be consistent. This is because there may be another source of bias caused by the correlation of the ϵ_{it} component with the X matrix of inputs. This is commonly referred to as the *simultaneity bias* and it can easily arise in every decision problem of economics. Within our framework simultaneity bias may arise when farm inputs are responsive to changes in the level of rainfall or the number of sunny days or other factors that are not captured by the μ_i and k_t terms. A simple way of resolving this problem is to assume that farmers maximize anticipated output as in Hoch (1962) or expected profits as in Zellner-Kmenta-Dreze (1966) or even expected utility of profits as in Blair & Lusky (1974). Under any one of these alternative assumptions, the input demand functions are dependent on expected output and thus the error term entering into the production process affecting actual output does not enter into the input demand functions. These are the arguments that have been used in the production literature for the past twenty years in order to absolve it free of the simultaneity bias.

The assumption of expected profit (or expected utility of profits) maximization, inspite its theoretical attractiveness and convenient empirical side effects has some questionable implications in terms of relevence. Under this assumption the input decisions of a farmer are all collapsed into a single time period. In reality however agricultural production is a sequence of operations where the inputs of each operation depend on the outcome of the previous one. For example one can think of agricultural production as a two stage process with stage one being all preharvest operations and stage two harvesting. In this framework the input decisions of the farmer in the second stage (harvest labor) will depend on the output of the first stage (standing crop) which in turn depends on the rainfall in the first stage. The arguments above can be illustrated by the following. Letting y_1 and y_2 be the logarithms of output in stage 1 and stage 2 respectively and x_1 and x_2 be the logarithms of the the inputs in the corresponding stages, then one could imagine the following relation for the production technology in the planting stage:

(a) $$y_1 = \alpha_o + \alpha_1 x_1 + \epsilon_1$$

where ϵ_1 are the random factors affecting the output of the first stage. Similarly the output of the harvesting stage could be be derived by combining harvesting labor x_2 with the standing crop y_1 or

(b) $$y_2 = \beta_o + \beta_1 y_1 + \beta_2 x_3 + \epsilon_2$$

where ϵ_2 are the random factors affecting output in the harvesting stage. Given that y_1 is unobservable one can substitute it by expression (a) into expression (b) and obtain:

$$\text{(c)} \qquad y_2 = (\beta_o + \beta_1\alpha_o) + \beta_1\alpha_1 x_1 + \beta_2 x_2 + (\beta_1\epsilon_1 + \epsilon_2)$$

By simply aggregating inputs of all stages into one composite measure, say x, it becomes apparent that x will be correlated with the error term, since a component of it (x_2) is correlated with ϵ_1. Thus given the sequential nature of agricultural production it is difficult to argue that all inputs are independent of the error component ϵ_{it} as the assumption of expected (utility of) profit maximization would imply. For an extensive treatment of the empirical implications of the sequential nature of agricultural production within a Cobb-Douglas framework the reader is referred to the work of Mundlak (1963), Mundlak & Hoch (1965) and Antle (1983).

An additional concern arising in the estimation of agricultural production functions, relates to the aggregation of male and female labor into one composite measure of labor hours. Detailed analysis of the rural sector in developing countries (K. Bardhan (1984)),suggests that there is specialization between males and females with respect to agricultural perations. Given this specialization in operations by gender, it is likely that the aggregation of male and female labor into one homogeneous input may be subject to specification error. For aggregating males and females into one input, implicitly assumes perfect substitutability. If in reality this substitutablity does not hold, then estimates may be biased.

For example, suppose x_1 and x_2 stand for the logarithms of male and female hours and x is the logarithm of total hours of labor (sum of male and female hours). Also let y be the logarithm of the value of output. If the "correct" form of the production function is

$$y = \beta_1 x_1 + \beta_2 x_2$$

then a regression of y on x may yield an a biased estimate of the marginal productivity of labor, unless $\beta_1 = \beta_2$ or unless x_2 is constant or proportional to x_1. This is, because

$$(\beta_1 x_1 + \beta_2 x_2) = \beta_1(x_1 + x_2) + (\beta_2 - \beta_1)x_2$$

Thus if one includes in the equation, only the term βx, it would mean that the term $(\beta_2 - \beta_1)x_2$ is omitted from the formulation and a bias is incurred. The direction of the bias depends on the sign of $\beta_2 - \beta_1$ and the correlation of x_2 with the omitted variables.

It is thus apperent that a serious effort in estimating an agricultural technology, must address the problems summarized above. The next section presents empirical estimates derived after controlling for heterogeneity and simultaneity biases.

V.B RESULTS

The production function estimated allows the inputs of the harvesting and planting stages (for male and female labor), to be included as distinct inputs in the production process. For a more detailed description of the technology and the sequential decisions in agricultural production, the reader is referred to chapter III. The functional form of the technology is assumed to be Cobb-Douglas. The agricultural production function estimated is:

$$(5.3)\quad TOUTV = \delta_0\,(FEML2)^{\delta_1}\,(MALE2)^{\delta_2}(FEML1)^{\delta_3}\,(MALE1)^{\delta_4}\,(CLT)^{\delta_5}\,(IRR)^{\delta_6}\,(PESTV)^{\delta_7}\,(TFERTQ)^{\delta_8}\,(BULL1)^{\delta_9}\,\exp\{U(i,t)\}$$

where $i = 1,\ldots,46$ and $t = 1,\ldots,9$

Inputs in the planting stage are: male (MALE1) and female (FEML1) labor hours, area cultivated in hectares (CLT), area irrigated in hectares (IRR), value of pesticides in 1975 rupees (PESTV), quantity of organic and inorganic nitrogen potash and phosphate in quintals (TFERTQ), and hours of bullock labor (BULL1). In the harvesting stage the two inputs are male (MALE2) and female (FEML2) labor hours. Output (TOUTV) is measured as the total output value of main products and by-products in 1975 rupees. The disturbance term U(i,t), is assumed to be composed of the sum of the following terms:

$$U(i,t) = \mu(i) + k(t) + \epsilon(i,t)$$

where $\mu(i)$: represents the systematic variation of the error term across farms and can be interpreted as an indicator of the ability or managerial efficiency of farmer i.

k(t) : represents the systematic variation of the error term across periods and common across all farmers (rainfall, desease etc.)

$\epsilon(i,t)$: represents the nonsystematic component, varying across famers and over time, distributed normally with mean zero and variance σ^2 and independently over time.

Table V.B.1 below presents the empirical estimates obtained by ordinary least squares. These estimates are obtained by ignoring fixed effects. Table V.B.2 presents the estimates obtained from the "within estimator", where each observation is replaced by its deviation from the farm mean. Finally, Table V.B.3 presents the estimates obtained by adding year dummies.

The first hypothesis to be tested, was the one concerning heterogeneity. The equality of the farmer specific intercept terms was rejected (F(45,359)=4.203), thus verifying the correlation between managerial efficiency (ability) and input usage. The next hypothesis test, concerned the significance of year effects. Dummy variables for each agricultural year in the sample were included in the regression where each variable is expressed as a deviation (of the log) from the farm mean (of the logs). Year effects were also found significant (F(8,396)=4.451 under the null).

According to the model proposed in this dissertation, the inputs of the planting stage are independent of the realization of k(t). As it is demonstrated in chapter III, taking deviations from individual means will reduce the possible correlation of the first stage inputs with the error term. In the same manner the correlation with the error term due to nonseparability, will also be eliminated. Thus simultaneity, bias at least for the parameters of the planting stage inputs is likely to be minimal. The harvesting stage inputs however, are chosen after the realization of k(t). If that is the case, then they are more likely to be correlated with the error term. One would tend to infer that this source of bias might be eliminated after the inclusion of year dummies. A version of an exogeneity test, as suggested by Nakamura and Nakamura (1981) was conducted (see Appendix C). The hypothesis of exogeneity of MALE2 and FEML2 was not rejected.

TABLE V.B.1

```
---------------------------------------------------------------------------
                PRODUCTION FUNCTION ESTIMATES - OLS
---------------------------------------------------------------------------

  SOURCE|      SS          DF        MS              NUMBER OF OBS =     414
--------+-----------------------------               F(  9,    404) =   85.93
   MODEL|  477.196989       9  53.0218876            PROB > F      =  0.0000
RESIDUAL|  249.271163     404   .61700783            R-SQUARE      =  0.6569
--------+-----------------------------               ADJ R-SQUARE  =  0.6492
   TOTAL|  726.468152     413  1.75900279            ROOT MSE      =   .7855

VARIABLE|  COEFFICIENT     STD. ERROR        T       PROB > |T|        MEAN
--------+------------------------------------------------------------------
   TOUTV|                                                           7.784746
--------+------------------------------------------------------------------
   FEML2|     .1414008       .0486734      2.905       0.004        5.674495
   MALE2|      .153669       .0426966      3.599       0.000        4.749968
   FEML1|     .0892494       .0337489      2.645       0.008        5.387462
   MALE1|     .2462527       .0983624      2.504       0.013        6.032794
     CLT|     .4009381       .0983691      4.076       0.000         2.06087
    IRR9|     .0236594       .0100703      2.349       0.019       -5.699583
   PESTV|     .0880072        .022563      3.901       0.000        1.260352
  TFERTQ|     .0689163       .0236133      2.919       0.004        3.050566
   BULL1|    -.3535863       .0706039     -5.008       0.000        5.482538
   _CONS|     5.211991       .3918008     13.303       0.000              1.
--------+------------------------------------------------------------------
```

TABLE V.B.2

```
-----------------------------------------------------------------------
      PRODUCTION FUNCTION ESTIMATES - FARMER EFFECTS REMOVED
-----------------------------------------------------------------------

  SOURCE|      SS          DF        MS           NUMBER OF OBS =     414
--------+-----------------------------            F(  9,    405) =   17.57
   MODEL|  63.7556285      9  7.08395872          PROB > F      =  0.0000
 ESIDUAL|  163.260207    405  .403111623          R-SQUARE      =  0.2808
--------+-----------------------------            ADJ R-SQUARE  =  0.2649
   TOTAL|  227.015836    414  .548347429          ROOT MSE      =  .63491

 ARIABLE|  COEFFICIENT    STD. ERROR       T      PROB > |T|       MEAN
--------+--------------------------------------------------------------
   TOUTV|                                                       2.53E-08
--------+--------------------------------------------------------------
   FEML2|    .2993625       .048245      6.205      0.000      -3.34E-08
   MALE2|    .0649525      .0418365      1.553      0.121       2.88E-09
   FEML1|    .0803336      .0392828      2.045      0.042      -6.62E-09
   MALE1|    .0396822      .0898632      0.442      0.659       1.15E-08
     CLT|     .086568      .0989667      0.875      0.382      -2.81E-09
    IRR9|   -.0026312      .0134921     -0.195      0.845       6.33E-09
   PESTV|    .0713296      .0234747      3.039      0.003      -7.20E-10
  TFERTQ|    .0679627      .0220759      3.079      0.002      -1.08E-09
   BULL1|    -.037435      .0688068     -0.544      0.587       6.91E-09
--------+--------------------------------------------------------------
```

TABLE V.B.3

```
------------------------------------------------------------------------
   PRODUCTION FUNCTION ESTIMATES - FARMER AND YEAR EFFECTS REMOVED
------------------------------------------------------------------------

  SOURCE|     SS          DF        MS              NUMBER OF OBS =     414
--------+-----------------------------              F( 17,    397) =   12.04
   MODEL|  77.222652      17  4.54250894            PROB > F      =  0.0000
RESIDUAL| 149.793184     397  .377312805            R-SQUARE      =  0.3402
--------+-----------------------------              ADJ R-SQUARE  =  0.3119
   TOTAL| 227.015836     414  .548347429            ROOT MSE      =  .61426

VARIABLE| COEFFICIENT    STD. ERROR       T       PROB > |T|        MEAN
--------+---------------------------------------------------------------
   TOUTV|                                                         2.53E-08
--------+---------------------------------------------------------------
   FEML2|    .2763597      .0473071     5.842      0.000        -3.34E-08
   MALE2|    .0677654      .0410022     1.653      0.099         2.88E-09
   FEML1|    .0667146      .0384183     1.737      0.083        -6.62E-09
   MALE1|    .0938958      .0898412     1.045      0.297         1.15E-08
     CLT|    .1204286      .0995346     1.210      0.227        -2.81E-09
    IRR9|   -.0088249       .013292    -0.664      0.507         6.33E-09
   PESTV|    .0547295      .0233924     2.340      0.020        -7.20E-10
  TFERTQ|    .0802654      .0225782     3.555      0.000        -1.08E-09
   BULL1|   -.0759458      .0679158    -1.118      0.264         6.91E-09
    DV76|   -.3658989      .0949413    -3.854      0.000         .1111111
    DV77|    .0263231      .0931761     0.283      0.778         .1111111
    DV78|   -.0292937      .0956684    -0.306      0.760         .1111111
    DV79|    .1504534      .0933549     1.612      0.108         .1111111
    DV80|   -.1485969      .0925662    -1.605      0.109         .1111111
    DV81|    .0454919      .0936492     0.486      0.627         .1111111
    DV82|     .237386      .0916231     2.591      0.010         .1111111
    DV83|    .2644949      .0937153     2.822      0.005         .1111111
--------+---------------------------------------------------------------
```

An alternative approach of deriving the parameters of the production function is via the input demand functions. The input demand functions can be interpeted as being derived by the first order conditions of profit maximization and thus depend on the underlying technology parameters. These parameters inherited from the underlying production function impose cross equation restrictions across the parameters of the input demand functions. For example, inspection of the system described by equations (3.11), (3.12), (3.16) and (3.17) reveals that the parameters of these equations are nonlinear functions of the technology parameters δ_1, δ_2, δ_3, δ_4, δ_5, δ_6, δ_7, δ_8, δ_9.

Estimation of the underlying production function parameters can be carried out by estimating the input demand functions as a system and imposing the nonlinear cross equation restrictions implied. This approach however, imposes stronger conditions than the direct estimation of the production function does. For, in addition to the relevence of the functional form assumed for the production function, it requires that farmers maximize expected profits (or expected utility of profits) (see Fuss et.al. (1978)). Furthermore, the presence of the marginal utility of wealth in the input demand functions complicates matters, since it may lead to biased estimates. Given these drawbacks, one can easily surmise that the derivation of elasticity estimates from estimated technology parameters is a more preferable approach.

The reader is reminded however, that these derived elasticity estimates are obtained holding the marginal utility of wealth constant. These elasticities describe the change in the demand for inputs caused by perfectly anticipated seasonal variations in wages that leave the marginal utility of wealth unaffected. An unanticipated permanent shift in the seasonal wage profile faced by farmers is going to affect their marginal utility of wealth which will ultimately have an effect on both labor supplied and labor utilized on the farm. Table V.B.4 below presents the derived elasticity estimates and for comparison purposes the elasticity estimates obtained from the estimation of the input demand functions in chapter IV.

TABLE V.B.4

DERIVED ELASTICITIES FROM THE PRODUCTION FUNCTION PARAMETER ESTIMATES VERSUS ELASTICITY ESTIMATES OBTAINED FROM DIRECT ESTIMATION OF THE LABOR DEMAND FUNCTIONS

Elasticity of: w.r.to:		FEML1	MALE1	FEML2	MALE2
FWAGE1		-1.135	-0.135	*	*
	(a)	0.231	-0.039		
	(b)	-0.418	-0.275		
	(c)	0.528	-0.212		
MWAGE1		-0.189	-1.189	*	*
	(a)	1.677	-0.095		
	(b)	0.892	-0.231		
	(c)	2.736	-0.173		
FWAGE2		-0.558	-0.558	-1.42	-0.42
	(a)	-0.354	-0.073		
	(b)	-0.258	-0.010		
	(c)	-0.265	0.153		
MWAGE2		-0.137	-0.137	-0.103	-1.103
	(a)	0.532	0.404		
	(b)	0.361	0.319		
	(c)	-1.519	0.111		
FEML1		*	*	0.102	0.102
	(a)	*	*		
	(b)	*	*		
	(c)	*	*		
MALE1		*	*	0.143	0.143
	(a)	*	*		
	(b)	*	*		
	(c)	*	*		
CLT		0.243	0.243	0.184	0.184
	(a)	0.715	0.837		
	(b)	0.738	0.751		
	(c)	0.719	0.739		

Continued on the next page

TABLE V.B.4 Cont'd

Elasticity of:		FEML1	MALE1	FEML2	MALE2
w.r.to:					
IRR9		-0.017	-0.017	-0.013	-0.013
	(a)	0.131	0.056		
	(b)	0.046	0.032		
	(c)	0.027	0.023		
PESTV		0.11	0.11	0.083	0.083
	(a)	-0.082	-0.011		
	(b)	0.004	0.029		
	(c)	-0.008	0.021		
TFERTQ		0.162	0.162	0.122	0.122
	(a)	0.205	0.114		
	(b)	0.096	0.102		
	(c)	0.111	0.097		
BULL1		-0.153	-0.153	-0.116	-0.116
	(a)	*	*		
	(b)	*	*		
	(c)	*	*		

Notes : (a) Estimates obtained under perfect foresight from Tables IV.C.1 and IV.C.2.
(b) Estimates obtained after controlling for farmer fixed effects from Tables IV.C.3 and IV.C.4.
(c) Estimates obtained after controlling for farmer fixed effects and year effects from Tables IV.C.5 and IV.C.6.
The reader is cautioned that the elasticities in (a),(b) and (c) were obtained by treating bullocks as a variable input, whereas the estimation of the production function trated bullock labor as a fixed input.

In the first stage a one percent increase in wages paid to females would result in a decrease of 1.14 percent in the demand for female labor. Similarly, a one percent increase in male wages results in a 1.19 percent decrease in demand for male labor. In both cases we observe elastic downward sloping demand for wage labor in the planting stage. This is also true in the harvest stage. In the harvesting stage, the elasticity of demand for female labor is found to be 1.42 and for male labor the own wage elasticity is 1.10. The interesting thing about these results are, that the own elasticity for female labor in the harvest stage is higher than the planting stage - result that challenges the common assumption that harvest labor demand is inelastic. Since mean hours of female labor in the harvest stage is twice the mean hours of males in the same stage (see Table IV.A.3) this result is all the more relevant. Thus, studies which assume inelastic demand for labor during the harvest period are potentially flowed.

The second interesting aspect is that the elasticity of demand for male labor in the harvest stage is lower than in the planting stage. This contrasts with the relationship between elasticities for female labor in the two stages and provides a further justification of the concern about heterogeneity of farm labor.

In general, the fact that the signs of the cross-wage elasticities are the same as the signs of the own wage elasticities (negative) indicates that male and female labor are complements in production within each stage and across stages. These complementarity results can be interpreted as a reflection of the gender specificity of agricultural tasks and put to question the common practice of aggregating male and female labor into one homogeneous input.

The negative elasticities with respect to the area irrigated are a consequence of the negative marginal productivity of irrigation. However since the estimate of the marginal productivity of irrigation is not significant the reader should not place much value on this result. The nonsignificance of irrigation and bullock hours are mostly due to collinearity problems rather than due to overuse of these inputs.

CHAPTER VI

VI.A SUMMARY

The evaluation of the effects of pricing policies intended to affect employment and wages in the rural sector of developing countries requires knowledge of the factors determining the labor demand and supply decisions of farm households. The existing empirical estimates are derived from models that ignore the effects of uncertainty and intertemporal decision making. This dissertation provides an empirical framework that accounts for the effects of seasonality, uncertainty and dynamics while yielding estimates that are more reliable for policy analysis.

It was demonstrated that the introduction of risk and intertemporal decision making into an otherwise typical model of the farm household leads to nonseparability. By this is meant that the rural households' consumption and leisure preferences affect the level of inputs used in farm production. This result contrasts sharply with the usual empirical practice of estimating the production side of the farm household model without accounting at all for the role of consumption and leisure choices of the household on the level of farm inputs.

The second part of this dissertation contains an empirical framework that despite nonseparability, allows for separate estimation of production and consumption decisions (which is much simpler than the joint estimation) and at the same time yields consistent estimates. The approach consists of using functional forms that yield labor demand and labor supply functions in which the marginal utility of wealth (MUW) enters additively after logarithmic transformation. Under the assumption of a perfectly competitive credit market and using the dynamic optimality condition that is satisfied by the MUW, one can treat it as a fixed effect. Then the unobservable MUW can be removed from the estimated equations by first differencing or by taking deviations from the farm mean.

This method was shown to be relatively easy for estimating the labor supply side of the model. The cases of perfect foresight and uncertainty were highlighted, and estimates were derived under both cases. It was argued that the distinction between perfect foresight and uncertainty (at least on the labor supply side) amounted to using "appropriate" instrumental variables for the imputed wage rate.

Similarly, on the labor demand side of the model, the conditions under which independent estimation of the input demand functions (without any reference to the consumption and leisure choices of the household) which would yield consistent estimates were explored. It was argued that according to the framework proposed above one obtains consistent estimates of the input demand elasticities if consumption enters linearly in the utility function and if the stochastic term affecting agricultural output (weather etc.) is serially uncorrelated. For the case in which consumption enters in the utility function nonlinearly, it was argued that the use of fixed effect methods would still reduce the bias caused by nonseparability if the joint distribution of the marginal utility of wealth and the stochastic term entering the production function is multivariate stationary normal. Estimates of the input demand elasticities for both male and female labor used in production were then derived by using the within estimator.

Given that the estimating the labor demand functions above may yield unreliable estimates even under the method outlined above an alternative approach was followed. The alternative consists of directly estimating the parameters of the production technology and then deriving the implied input demand elasticities. According to the discussion in chapter IV, the direct estimation of the production function may also yield inconsistent estimates unless care is taken to eliminate the effects of heterogeneity and simultaneity. Thus the production function estimates were derived after controlling for heterogeneity and testing for (and rejecting) simultaneity. Comparison of the implied labor demand elasticities with those derived from the estimation of the labor demand functions revealed that the results derived under the alternative methods were very different.

The choice between the two approaches was then based on the argument that direct estimation of the production function yields more reliable elasticity estimates that satisfy all the theoretical restrictions. This is because direct estimation of the input demand functions requires additional assumptions about the joint distribution of the forecast error and the random elements affecting output.

B. EXTENSIONS

It is believed that this investigation provides significant insights into both the decision making process of farm households and about the empirical methods that should be applied to obtain consistent parameter estimates. Further research building on the questions raised in this study or addressing some of the shortcomings of this study is thus imperative. Scattered throughout the main text there are many suggestions for related extentions. The following paragraphs provide a comprehensive summary of these ideas.

Estimation was carried out under the assumption of perfect credit markets. The preliminary results suggest that credit constraints may have an effect on the estimates of labor supply response to changes in wages. A framework was presented for a rigorous test of the perfect credit market hypothesis but this test could not be conducted due to the demands imposed on the available data and the extent of disaggregation of the data. Accounting for credit constraints at the empirical level is very important to the farm household modeling approach and should be pursued further.

The empirical analysis of this study did not account for the fact that some individuals report zero hours of work in some periods. An alternative would entail using the method proposed by Heckman and MaCurdy (1980) which is a generalization of the Tobit method to panel data. Given the heuristic nature of this dissertation it was decided to postpone use of the fixed-effect tobit method for a later study.

Also in this thesis, wage functions were estimated in order to derive imputed wage rates for farmers that did not participate in the market and had no reported wage earnings. One possible alternative is to use an estimate of the value of the marginal product of the individual as an estimate of his/hers value of time, as in Jacoby (1987).

Family and hired labor were assumed to be homogeneous and thus perfectly substitutable. Given the results of this research concerning the heterogeneity between male and female labor it becomes clear that any rigorous test concerning the issue of heterogeneity between family and hired labor must first control for the gender composition of family and hired labor.

It would be useful to conduct further research using different functional forms for the technology and the utility function as well as different specifications within the same general framework of this dissertation. The decomposition of the production process in two stages each described by a Cobb-Douglas function was carried out in order to highlight the problem of nonseparability in the first stage. The Cobb-Douglas functional form allows one to derive explicit solutions for the input demand functions and also keep track of the cross-equation restrictions implied by the dynamic optimization problem. As discussed in chapter III more flexible functional forms (quadratic or translog) do not generally lead to closed form solutions for the input demand functions and thus are not useful in analyzing the response of input utilization to changes in wages. If however, the objective of the research is to identify the contribution of certain inputs in total output and hence profits or the substitution possibilities between inputs functional forms other than Cobb-Douglas may be more desirable. One may also introduce more detail into the model by specifying the production process as a sequence of three or more stages (operations). Alternatively, if data is available only at the yearly level one may specify the production process as a single stage process with output being uncertain.

The utility function was specified as separable in male and female labor. The research of Rosenzweig (1980) suggests there exist substantial cross wage effects between males and females. A test of the separability of the utility function in male and female leisure can be conducted by following the nonparametric approach developed by Irish, Deaton and Browning (1985). Within their framework, which is an extention of Heckman and MaCurdy (1980), one can test for separability of the utility function between consumption and leisure as well as for separability between male and female leisure. However, given that their approach is nonparametric one cannot obtain estimates of the parameters of the utility function which may be useful for welfare analyses.

This dissertation is the first empirical attempt in accounting for the role of dynamics, seasonality and uncertainty in the labor demand and labor supply decisions of agricultural households in developing countries. An essential component for the empirical application of the proposed model is the availability of longitudinal household level data. Additional collection of household panel data from other developing countries will not only provide a testing ground for the relevance of this model in different environments but also enhance our understanding of rural behavior in developing countries.

FOOTNOTES

1. For the theory and examples of building estimable models of this type the reader is referred to the work of Sargent (1979) and Hansen and Sargent (1980). For a dynamic model of labor demand and supply within the agricultural household context with explicit expectation formulation see Skoufias (1984).

2. The alternative is to adopt the general lifetime utility function $U(C_1, L_1, C_2, L_2, \ldots, C_t, L_t)$. Assuming that T is reasonably large, the matrix of own and cross substitution terms involving labor supply of one individual only, has dimensions (T+1) x (T+1) - one for each period. Since T + 1 of these are own substitution effects - by symmetry of the Slutsky matrix - we then have to calculate a total of $\frac{(T+1)^2}{2} - \frac{(T+1)}{2}$ distinct cross-substitution effects. Of course, this number becomes even larger when we distinguish between male and female leisure each period. However, the assumption of intertemporal separability has some serious implications: 1) it implies tht the marginal utility of consumption (or leisure) consumed at any t is independent of the amount of the consumer good (and leisure) consumed at all other dates t R t. 2) If one also assumes tht leisure time at any given date is a normal good then intertemporal separability implies that leisure times at different dates are net substitutes. In short, intertemporal separability combined with normality of leisure time implies that all cross substitution effects of wage rate changes on hours of work are negative--or rise in the wage rate at some t accompanied by a reduction in initial assets that keeps lifetime utility constant will always increase leisure times at all other dates t R t.

3. More formally we can distinguish among two types of landowning households: 1) labor importing households which are defined as households for which $N_i - H_i > 0$ where $H_i = 1 - L_i$ $i = 1, 2$ and (2) labor exporting households defined by $H_i - N_i > 0$ $i = 1,2$.

4. More explicitly, stage 1 of the kharif season was assumed to last from day 106 (April 15) till day 272 (September 28) of the calendar year; stage 2 of the kharif season, was from day 273 (September 29) till day 319 (November 14). For the rabi season stage 1 was from day 320 (November 15) till day 31 (January 31) of the next calendar year and stage 2 from day 32 (February 1) till day 105 (April 14).

5. The variable AVHRMO for both males and females was created as follows:

AVHRMO=(TOTAL WORKDAYS*8/(167/30)) for stage 1 in the kharif season
AVHRMO=(TOTAL WORKDAYS*8/(47/30)) for stage 2 in the kharif season
AVHRMO=(TOTAL WORKDAYS*8/(79/30)) for stage 1 in the rabi season
AVHRMO=(TOTAL WORKDAYS*8/(73/30)) for stage 2 in the rabi season

6. In the case where the interest rate is allowed to vary over time, the estimate of b used, was the average of all the coefficients of the year dummies in Table IV.B.8 (the average of year dummy coefficients being equal to .2566743).

7. An alternative method of accounting for the simultaneity of the harvesting stage inputs is to estimate the production function jointly with the harvesting stage inputs as in Antle and Hatchett (1986). Following the suggestion of Lahiri and Schmidt (1978) on the estimation of triangular sustems, they estimated the production function jointly with the harvesting stage inputs by using iterared SURE. This method, as well as three stage least squares (3SLS), were applied in the context of our model with no success.

8. Inputs that were measured in actual quantities (i.e. quintals of fertilizer, hours of male labor etc.) and were not used by a farmer at any point in time were replaced by 0 after the logarithmic transformation. An exception with the variable IRR (irrigated area in hectars); observations of the variable IRR that were zero before logarithmic transformation were replaced by -9 after logarithmic transformation.

APPENDIX A

RELATION OF $\lambda(t)$ WITH $\lambda(1)$ IN THE CASE OF UNCERTAINTY

Write $\lambda(t) = \exp\{\ln E\lambda(t)\}$. One can always relate the actual value of $\ln\lambda(t)$ to its expected value in period t-1 by the equation: $\ln\lambda(t) = E_{t-1}\{\ln\lambda(t)\} + \epsilon^{*}(t)$ or expressed differrently by:

$$(1) \quad \lambda(t) = \exp\{E_{t-1}[\ln\lambda(t)] + \epsilon^{*}(t)\}$$

where $\epsilon^{*}(t)$ represents the one-period forecast error which arises from unexpected realizations of wages, profits and weather. Under the rational expectations hypothesis $E_{t-1}(\epsilon^{*}(t))=0$. Taking the expectation of relation (1) above yields:

$$E_{t-1}[\lambda(t)] = \exp\{E_{t-1}[\ln\lambda(t)]\}E_{t-1}[\exp\{\epsilon^{*}(t)\}]$$

or by rewriting

$$\exp\{E_{t-1}[\ln\lambda(t)]\} = \frac{E_{t-1}[\lambda(t)]}{E_{t-1}[\exp\{\epsilon^{*}(t)\}]}$$

Substituting this into expression (1) yields:

$$(2) \quad \lambda(t) = \frac{E_{t-1}[\lambda(t)]}{E_{t-1}[\exp\{\epsilon^{*}(t)\}]}\exp\{\epsilon^{*}(t)\}$$

From the FONCs we have $\lambda(t) = \frac{1+r}{1+\rho}E_{t}[\lambda(t+1)]$

Substituting into (2) yields:

$$\lambda(t) = \frac{\frac{1+\rho}{1+r}\lambda(t-1)}{E_{t-1}[\exp(\epsilon^*(t))]}\exp(\epsilon^*(t))$$

Taking natural logs yields:

$$\ln\lambda(t) = b^*(t) + \ln\lambda(t-1) + \epsilon^*(t)$$

where $b^*(t) = \ln\left(\frac{1+\rho}{1+r}\right) - \ln(E_{t-1}[\exp(\epsilon^*(t))])$

By repeated substitution one can obtain

$$(3)\ \ln\lambda(t) = \sum_{j=1}^{t} b^*(j) + \ln\lambda(1) + \sum_{j=2}^{t} \epsilon^*(j)$$

This equation suggests that the marginal utility of wealth at time t follows a random walk with drift. Notice however that if one assumes:

1) the discount rate $(1 + \rho)$ is common across all individuals

2) the interest rate $(1 + r)$ is common across all individuals and constant over time and

3) the distribution generating the forecast erros is common across all individuals so that $E_{t-1}[\exp(\epsilon^*(t))]$ does not vary with a change individual characteristics or <u>over time</u> then the term $b^*(j)$ will be time invariant i.e. $b^*(j) = b^*$ for all j. This allows us to rewrite expression (3) as:

$$\ln\lambda(t) = b^*t + \ln\lambda(1) + \sum_{j=2}^{t} \epsilon^*(j)$$

In the case of perfect foresight $\epsilon^{*}(j)=0$ and $b^{*}(j)=\ln(1+\rho)-\ln(1+r)$ for all j. Finally, after taking first differences one obtains:

$$\ln\lambda(t) - \ln\lambda(t-1) = b^{*} + \epsilon^{*}(t).$$

APPENDIX B

ESTIMATION OF WAGE FUNCTIONS

The purpose of this Appendix is to estimate wage functions for the male heads of households and their spouses. The typical procedure, originally proposed by Mincer (1962) and now standard in the labor economics literature, is to regress the logarithm of the individual wage rate on human capital and demand variables considered significant determinants of individual wage rates. Once these functions have been estimated, they can be used to derive imputed wage rates for the individuals that have no reported wage rate because they worked on their own farm and did not participate in the village labor market.

Simple as it may sound, this method of imputing wage rates to individuals that did not report a wage may cause serious problems; Gronau (1974) and Lewis (1974) . Since the imputed wage derived under the method described above is based on parameters of wage functions derived using a sample consisting of workers only, selectivity bias may arise. Heckman in his pioneering article of (1979) was the first one to formulate an econometric method that could eliminate it. The essence of the selectivity bias argument is that the unmeasured factors affecting tastes for work (ϵ_h) such as ability, may be correlated with the unmeasured factors that affect wage rates (ϵ_w) such as productivity or motivation. The framework developed by Heckman amounts to treating selectivity bias as another variant of specification error and provided a method for estimating this missing variable. Since the procedure is commonly used in the literature we will not elaborate on the details more than necessary. It consists of two steps: 1) estimating a participation likelihood function (using probit) which is used to derive the "missing" variable lambda (λ) for each individual and 2) estimating a typical wage function by ordinary least squares with the constructed variable lambda (λ) as one of the explanatory variables.

The determinants of participation in the labor market are assumed to include: the age of the individual (AGE) , his/her years of education (EDUCYRS), a dummy variable indicating whether the individual belongs to the two highest castes (DCAST), a dummy variable for the stage in the production process (planting=1, harvesting=0) (DVSTG), the level of rainfall in mm's (RAINMM), the total area owned by the household in hectares (OWNED), the ratio of the number of children in the household to the total size of the family (CHFSZ) and the percentage of land intercropped by the household that the individual belongs to (INTRCRP), in that particular cropping cycle.

As Table 1 indicates, the empirical results conform with the a priori expectations. Older and more educated males are less likely to participate in the market. The dummy variable for caste indicates a (non significant) positive effect on the likelihood of participation as does the proportion of children to family size. The amount of area owned has a significanlty negative effect as one would expect since small farmers or landless households will tend to export labor in the labor market whereas larger farmers would tend to import labor. Finally, the extent of intercropping seems to have strongly positive effect on participation. This is contrary to what one would expect given the role of intercropping in evening out labor utilization within a farm and over time.

For female spouses, (Table 10) age seems to play little role in participation even though it is negative. Education and caste seem to have a strongly negative effect along with area owned. Intercropping has a similar positive effect on participation as in males as does the number of children adjusted for family size.

Tables 2 & 11 contain the estimated wage functions for males and females corrected for selectivity by using only human capital variables as explanatory variables. The results indicate that age and caste do have a significant effect in explaining wage variation across male heads of households but not so for females. The selectivity parameter lambda has a nonsignificant coefficient for both males and females indicating the absence of selectivity bias. The introduction of village specific variables - prevailing wage rate for males at the village level (LNVWGM) and the amount of rainfall (RAINMM) - as proxies for the demand conditions in the village increases the explanatory power of the regressions extensively; see Tables 3 & 12 respectively. However, the human capital variables retain their significance in the regression for males, unlike in Rosenzweig (1980). Lambda has a nonsignificant coefficient in these regressions also.

Finally, separate regressions were estimated for males (Tables 4-9) and for females (Tables 13-18) for the planting and harvesting stages. Chow tests were conducted for structural change. The hypothesis of the equality of coefficients of the wage functions across stages (with the demand variables) was not rejected at the 5% and 1% significance level for both males and females ($F_{Male}(288,322)=1.1458$ and $F_{Female}(341,358)=1.1342$ under the null hypothesis).

This Appendix provided an empirical confirmation of the intuitive arguments of Rosenzweig (1980) that in estimating rural labor wage functions the selectivity bias inherent, may not be significant. In addition, it was demonstrated that human capital variables do play a role in explaining wage variations across males even though they are not significant for females.

```
-----------------------------------------
     MEANS OF VARIABLES USED FOR THE
 ESTIMATION OF WAGE FUNCTIONS FOR MALES
-----------------------------------------
 VARNAME|  OBS         MEAN    STD. DEV.
--------+---------------------------------
   INDWG|  2106  .250755831   .410939546
     CPI|  2106  1.43871795   .216392293
  RLIDWG|  2106  .170363234   .279292641
     AGE|  1982  49.6424317   10.6986154
   DISAB|  1982  1.15539859   .557694665
 EDUCYRS|  1982  2.36831483   3.18733059
  RLVWGM|  2106  .493355462   .155248625
  RLVWGF|  2106  .233031162   .088786771
 TWGEARN|  2106  87.7563421   192.660228
  FAMINC|  2106  270.518364   556.064158
  INC_ID|  2106  182.762022    503.15711
   PLOTV|  1182  120.619289   117.120297
     CLT|  1182  9.18874788   11.2607856
     IRR|  1182  1.08978004   1.81263161
   OWNED|  1182   7.0607445   9.53601433
 INTRCRP|  1180  44.4647663   41.0187452
  RAINMM|  2017  15.5641936   17.6471788
 NOMMEMB|  2080      2.1125   1.13615534
 NOFMEMB|  2080  1.89326923   1.10843236
 FAMSIZE|  2080  6.21730769   2.85363467
  CH_FSZ|  2080  .331580645   .200428501
```

TABLE 1

```
-----------------------------------------------------------------
        ESTIMATION OF THE PROBABILITY OF PARTICIPATION
          POOLED SAMPLE FOR MALE HEADS OF HOUSEHOLDS
-----------------------------------------------------------------

    Log-Likelihood..............   -503.83
    Restricted (Slopes=0) Log-L.   -593.03
    Chi-Squared ( 8)............    178.40
    Significance Level..........    .32173E-13

 Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
-----------------------------------------------------------------

ONE        1.57835      .3689         4.279 ( .00002)   1.0000
AGE       -.425638E-01  .5738E-02    -7.418 ( .00000)   50.192
EDUCYRS   -.101202      .1845E-01    -5.484 ( .00000)   2.7563
DCAST      .144277      .1035         1.394 ( .16330)   .60507
RAINMM    -.453985E-02  .2969E-02    -1.529 ( .12625)   17.354
INTRCRP    .608013E-02  .1162E-02     5.234 ( .00000)   44.547
OWNED     -.248319E-01  .8010E-02    -3.100 ( .00193)   7.2639
CHFSZ      .355415      .2595         1.370 ( .17079)   .33138
DVSTG     -.190475      .9182E-01    -2.075 ( .03803)   1.4828
```

TABLE 2

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES
POOLED SAMPLE FOR MALE HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........    LNIDWG
     Number of Observations......        620.
     Mean    Dependent Variable..      -.69272
     Std. Dev. of Dep. Variable..       .36918
     Std. Error of Regression....       .34763
     Sum of Squared Residuals....   73.837
     R - Squared.................       .11191
     Adjusted R - Squared........       .10028
     F-Statistic (  8,  611).....     9.62439
     Significance of F-Test......       .00000
     Log-Likelihood..............  -220.14
     Restricted (Slopes=0) Log-L.  -261.43
     Chi-Squared ( 8)............   82.585
     Significance Level..........   .32173E-13

     Standard Error Corrected for Selection.....     .37566
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......     .19806


   Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
   ------------------------------------------------------------

  ONE        -2.64778     .3653      -7.248 ( .00000)  1.0000
  AGE         .800008E-01 .1475E-01   5.425 ( .00000)  46.547
  AGESQ      -.944918E-03 .1503E-03  -6.289 ( .00000)  2252.8
  EDUCYRS    -.522742E-02 .8891E-02   -.588 ( .55659)  1.8145
  DCAST       .888342E-01 .3435E-01   2.586 ( .00970)   .49032
  DV3         .699791E-01 .5785E-01   1.210 ( .22638)   .40323
  DV5         .127576     .5274E-01   2.419 ( .01556)   .49516
  DVSTG       .246860E-01 .3184E-01    .775 ( .43821)  1.4645
  LAMBDA      .167186     .1035       1.615 ( .10629)  1.1866
```

TABLE 3

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES POOLED SAMPLE FOR MALE HEADS OF HOUSEHOLDS

```
    Ordinary    Least Squares Estimates

    Dependent Variable..........      LNIDWG
    Number of Observations......          620.
    Mean     Dependent Variable..       -.69272
    Std. Dev. of Dep. Variable..        .36918
    Std. Error of Regression....        .32851
    Sum of Squared Residuals....     65.723
    R - Squared.................        .20691
    Adjusted R - Squared........        .19389
    F-Statistic ( 10,  609).....      15.88852
    Significance of F-Test......        .00000
    Log-Likelihood..............    -184.07
    Restricted (Slopes=0) Log-L.    -261.43
    Chi-Squared (10)............     154.73
    Significance Level..........      .32173E-13

    Standard Error Corrected for Selection.....      .34053
    Squared Correlation Between Disturbance in This Equation
    and Selection Criterion (Rho-Squared)......      .95591E-01


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  -----------------------------------------------------------

 ONE        -2.11563      .3501       -6.042 ( .00000)   1.0000
 AGE         .764609E-01  .1393E-01    5.489 ( .00000)   46.547
 AGESQ      -.897940E-03  .1423E-03   -6.310 ( .00000)   2252.8
 EDUCYRS    -.410791E-02  .8570E-02    -.479 ( .63171)   1.8145
 DCAST       .752479E-01  .3271E-01    2.300 ( .02142)   .49032
 LNVWGM      .543919      .6446E-01    8.438 ( .00000)  -.62285
 RAINMM     -.434352E-03  .8296E-03    -.524 ( .60056)   14.080
 DV3         .243345E-01  .5486E-01     .444 ( .65733)   .40323
 DV5         .552420E-01  .5051E-01    1.094 ( .27406)   .49516
 DVSTG       .274059E-01  .3021E-01     .907 ( .36432)   1.4645
 LAMBDA      .105285      .1011        1.042 ( .29759)   1.1866
```

TABLE 4

```
---------------------------------------------------------------------
ESTIMATION OF THE PROBABILITY OF PARTICIPATION IN STAGE 1
                    FOR MALE HEADS OF HOUSEHOLDS
---------------------------------------------------------------------

     Log-Likelihood..............    -271.52
     Restricted (Slopes=0) Log-L.    -324.61
     Chi-Squared ( 7)............     106.19
     Significance Level..........     .32173E-13

  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  -------------------------------------------------------------------

 ONE         1.27163      .4858        2.617 ( .00886)   1.0000
 AGE        -.437884E-01  .8085E-02   -5.416 ( .00000)   50.101
 EDUCYRS    -.112023      .2537E-01   -4.416 ( .00001)   2.7566
 DCAST       .137534      .1425         .965 ( .33433)   .60595
 RAINMM      .456236E-02  .7324E-02     .623 ( .53335)   14.464
 INTRCRP     .675964E-02  .1822E-02    3.711 ( .00021)   44.069
 OWNED      -.158557E-01  .9585E-02   -1.654 ( .09810)   7.1743
 CHFSZ       .287608      .3570         .806 ( .42049)   .32958
```

TABLE 5

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES FOR STAGE 1 FOR MALE HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........     LNIDWG
     Number of Observations......          332.
     Mean    Dependent Variable..        -.71511
     Std. Dev. of Dep. Variable..         .36860
     Std. Error of Regression....         .33508
     Sum of Squared Residuals....    36.378
     R - Squared.................         .17111
     Adjusted R - Squared........         .15320
     F-Statistic (  7,  324).....        9.55479
     Significance of F-Test......         .00000
     Log-Likelihood..............   -104.08
     Restricted (Slopes=0) Log-L.   -139.23
     Chi-Squared ( 7)............    70.307
     Significance Level..........    .32173E-13

     Standard Error Corrected for Selection.....     .33679
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......     .14001E-01


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  ---------------------------------------------------------------

 ONE       -3.11182       .4813       -6.466 ( .00000)   1.0000
 AGE         .102211      .1950E-01    5.242 ( .00000)   46.581
 AGESQ     -.115432E-02   .2022E-03   -5.708 ( .00000)   2256.1
 EDUCYRS     .621231E-02  .1120E-01     .555 ( .57895)   1.8313
 DCAST       .791067E-01  .4387E-01    1.803 ( .07137)   .48795
 DV3         .111947      .7510E-01    1.491 ( .13604)   .40361
 DV5         .193575      .7010E-01    2.761 ( .00576)   .50000
 LAMBDA      .398514E-01  .1089         .366 ( .71445)   1.2031
```

TABLE 6

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES FOR STAGE 1 FOR MALE HEADS OF HOUSEHOLDS

```
    Ordinary    Least Squares Estimates

    Dependent Variable..........     LNIDWG
    Number of Observations......         332.
    Mean    Dependent Variable..      -.71511
    Std. Dev. of Dep. Variable..       .36860
    Std. Error of Regression....       .31750
    Sum of Squared Residuals....    32.459
    R - Squared.................       .25581
    Adjusted R - Squared........       .23501
    F-Statistic (  9,  322).....     12.29862
    Significance of F-Test......       .00000
    Log-Likelihood..............   -85.187
    Restricted (Slopes=0) Log-L.   -139.23
    Chi-Squared ( 9)............    108.10
    Significance Level..........    .32173E-13

    Standard Error Corrected for Selection.....     .31894
    Squared Correlation Between Disturbance in This Equation
    and Selection Criterion (Rho-Squared)......    .12495E-01


 Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
 -------------------------------------------------------------

ONE       -2.62363       .4646       -5.647 ( .00000)   1.0000
AGE         .965640E-01  .1850E-01    5.220 ( .00000)   46.581
AGESQ     -.110199E-02   .1932E-03   -5.705 ( .00000)   2256.1
EDUCYRS    .301704E-02   .1195E-01     .252 ( .80070)   1.8313
DCAST      .747080E-01   .4302E-01    1.737 ( .08248)   .48795
LNVWGM     .444966       .7240E-01    6.146 ( .00000)  -.62772
RAINMM    -.210844E-03   .2097E-02    -.101 ( .91990)   13.707
DV3        .781344E-01   .7216E-01    1.083 ( .27893)   .40361
DV5        .124895       .6948E-01    1.798 ( .07223)   .50000
LAMBDA     .356516E-01   .1269         .281 ( .77871)   1.2031
```

TABLE 7

ESTIMATION OF THE PROBABILITY OF PARTICIPATION IN STAGE 2 FOR MALE HEADS OF HOUSEHOLDS

```
    Log-Likelihood.............   -227.15
    Restricted (Slopes=0) Log-L.   -265.88
    Chi-Squared ( 7)...........    77.457
    Significance Level.........    .32173E-13


 Variable   Coefficient  Std. Error  T-ratio (Sig.Lvl)    Mean
 ---------------------------------------------------------------

ONE          1.32010      .5108        2.584 ( .00976)   1.0000
AGE         -.402816E-01  .8346E-02   -4.826 ( .00000)   50.290
EDUCYRS     -.892540E-01  .2720E-01   -3.281 ( .00103)   2.7561
DCAST        .146876      .1524         .964 ( .33514)   .60413
RAINMM      -.722806E-02  .3354E-02   -2.155 ( .03118)   20.450
INTRCRP      .411492E-02  .1654E-02    2.488 ( .01284)   45.058
OWNED       -.450273E-01  .1425E-01   -3.160 ( .00158)   7.3599
CHFSZ        .340929      .3842         .887 ( .37487)   .33330
```

TABLE 8

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES FOR STAGE 2 FOR MALE HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........     LNIDWG
     Number of Observations......          288.
     Mean     Dependent Variable..       -.66692
     Std. Dev. of Dep. Variable..         .36881
     Std. Error of Regression....         .35784
     Sum of Squared Residuals....     35.854
     R - Squared.................         .05532
     Adjusted R - Squared........         .03170
     F-Statistic (  7,  280).....       2.34225
     Significance of F-Test......         .02440
     Log-Likelihood..............    -108.68
     Restricted (Slopes=0) Log-L.    -120.88
     Chi-Squared ( 7)............     24.391
     Significance Level..........     .97245E-03

     Standard Error Corrected for Selection.....     .37191
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......     .10607


   Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
   ------------------------------------------------------------

  ONE       -2.02103      .5456        -3.704 ( .00021)   1.0000
  AGE         .560955E-01 .2226E-01     2.520 ( .01175)   46.508
  AGESQ     -.654968E-03  .2221E-03    -2.948 ( .00319)   2249.1
  EDUCYRS   -.464028E-02  .1065E-01     -.436 ( .66300)   1.7951
  DCAST       .604351E-01 .4832E-01     1.251 ( .21100)   .49306
  DV3         .649095E-01 .8352E-01      .777 ( .43707)   .40278
  DV5         .817936E-01 .7738E-01     1.057 ( .29052)   .48958
  LAMBDA      .121123     .1125         1.077 ( .28162)   1.0785
```

TABLE 9

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES FOR STAGE 2 FOR MALE HEADS OF HOUSEHOLDS

```
    Ordinary    Least Squares Estimates

    Dependent Variable..........     LNIDWG
    Number of Observations......         288.
    Mean    Dependent Variable..      -.66692
    Std. Dev. of Dep. Variable..       .36881
    Std. Error of Regression....       .33257
    Sum of Squared Residuals....    30.748
    R - Squared.................       .18400
    Adjusted R - Squared........       .15759
    F-Statistic (  9,  278).....      6.96532
    Significance of F-Test......       .00000
    Log-Likelihood..............   -86.597
    Restricted (Slopes=0) Log-L.   -120.88
    Chi-Squared ( 9)............    68.565
    Significance Level..........    .32173E-13

    Standard Error Corrected for Selection.....    .36853
    Squared Correlation Between Disturbance in This Equation
    and Selection Criterion (Rho-Squared)......    .26516


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  -------------------------------------------------------------

 ONE       -1.33077      .5182       -2.568 ( .01023)   1.0000
 AGE         .532344E-01 .2077E-01    2.563 ( .01037)   46.508
 AGESQ      -.658527E-03 .2065E-03   -3.189 ( .00143)   2249.1
 EDUCYRS    -.953808E-02 .1036E-01    -.920 ( .35732)   1.7951
 DCAST       .578133E-01 .4533E-01    1.275 ( .20214)   .49306
 LNVWGM      .818992     .1320        6.204 ( .00000)  -.61724
 RAINMM     -.448000E-03 .1122E-02    -.399 ( .68974)   14.510
 DV3        -.623999E-01 .8008E-01    -.779 ( .43583)   .40278
 DV5        -.200144E-01 .7382E-01    -.271 ( .78629)   .48958
 LAMBDA      .189768     .1180        1.608 ( .10774)   1.0785
```

```
-----------------------------------------
     MEANS OF VARIABLES USED FOR THE
 ESTIMATION OF WAGE FUNCTIONS FOR FEMALES
-----------------------------------------
 VARNAME| OBS          MEAN    STD. DEV.
--------+---------------------------------
   INDWG| 2258  .146416704   .214215918
     CPI| 2258  1.44102746   .216548446
  RLIDWG| 2258  .097977027    .13976567
     AGE| 1986  43.1263341   10.5026345
   DISAB| 1986  1.12789527    .48841212
 EDUCYRS| 1986  .755287009   1.80554275
  RLVWGM| 2258  .491494438   .157859174
  RLVWGF| 2258  .231871938   .089882433
 TWGEARN| 2249  43.1465845   75.8892376
  FAMINC| 2251  280.156053   553.343761
  INC_ID| 2249  237.258607   537.491308
   PLOTV| 1298  114.312789   115.936823
     CLT| 1298  8.65224961   10.7938573
     IRR| 1298  .986533131   1.79059158
   OWNED| 1298  6.65725732   9.08165473
 INTRCRP| 1296  44.0191132   41.2542879
  RAINMM| 2162  15.6491957   17.7773453
 NOMMEMB| 2242  2.03746655    1.1763042
 NOFMEMB| 2242  1.95539697   1.05610984
 FAMSIZE| 2242  6.26494202   2.77077761
  CH_FSZ| 2242  .342074745   .197668079
```

TABLE 10

```
-----------------------------------------------------------------
        ESTIMATION OF THE PROBABILITY OF PARTICIPATION
       POOLED SAMPLE FOR SPOUSES OF HEADS OF HOUSEHOLDS
-----------------------------------------------------------------
    Log-Likelihood.............   -515.57
    Restricted (Slopes=0) Log-L.   -657.63
    Chi-Squared ( 8)............    284.12
    Significance Level..........    .32173E-13


 Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
 ---------------------------------------------------------------

ONE         -.613855      .3134       -1.959 ( .05012)   1.0000
AGE         -.999690E-03  .4716E-02    -.212 ( .83213)   44.095
EDUCYRS     -.984024E-01  .3187E-01   -3.088 ( .00202)   .89842
DCAST       -.289547      .9295E-01   -3.115 ( .00184)   .56305
RAINMM      -.366068E-02  .3029E-02   -1.209 ( .22684)   17.456
INTRCRP      .115765E-01  .1172E-02    9.878 ( .00000)   44.779
OWNED       -.105249      .1323E-01   -7.956 ( .00000)   6.7448
CHFSZ       1.06928       .2538        4.214 ( .00003)   .33164
DVSTG       -.971501E-01  .9124E-01   -1.065 ( .28696)   1.4834
```

TABLE 11

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES POOLED SAMPLE FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........      LNIDWG
     Number of Observations......           709.
     Mean    Dependent Variable..      -1.37822
     Std. Dev. of Dep. Variable..         .27071
     Std. Error of Regression....         .26570
     Sum of Squared Residuals....     49.419
     R - Squared.................         .03532
     Adjusted R - Squared........         .02429
     F-Statistic (  8,   700).....       3.20359
     Significance of F-Test......         .00148
     Log-Likelihood..............    -61.836
     Restricted (Slopes=0) Log-L.    -79.084
     Chi-Squared ( 8)............     34.495
     Significance Level..........     .33036E-04

     Standard Error Corrected for Selection.....     .26594
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......    .46787E-02


   Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)    Mean
   ------------------------------------------------------------

  ONE       -1.66895       .1582       -10.550 ( .00000)   1.0000
  AGE         .606198E-02  .6720E-02      .902 ( .36699)   41.713
  AGESQ     -.675936E-04   .7144E-04     -.946 ( .34405)   1843.7
  EDUCYRS   -.101278E-01   .9413E-02   -1.076 ( .28198)    .32581
  DCAST      .309508E-02   .2556E-01      .121 ( .90361)    .38082
  DV3        .199601E-01   .2895E-01      .689 ( .49060)    .27786
  DV5        .451018E-01   .2923E-01    1.543 ( .12285)    .41326
  DVSTG      .840792E-01   .2003E-01    4.197 ( .00003)   1.4810
  LAMBDA     .181905E-01   .1407E-01    1.293 ( .19602)    .87476
```

TABLE 12

```
------------------------------------------------------------------
 WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES
       POOLED SAMPLE FOR SPOUSES OF HEADS OF HOUSEHOLDS
------------------------------------------------------------------

     Ordinary    Least Squares Estimates

     Dependent Variable..........     LNIDWG
     Number of Observations......          709.
     Mean    Dependent Variable..      -1.37822
     Std. Dev. of Dep. Variable..        .27071
     Std. Error of Regression....        .21254
     Sum of Squared Residuals....    31.532
     R - Squared.................        .38271
     Adjusted R - Squared........        .37386
     F-Statistic ( 10,  698).....      43.27448
     Significance of F-Test......        .00000
     Log-Likelihood..............    97.432
     Restricted (Slopes=0) Log-L.   -79.084
     Chi-Squared (10)............    353.03
     Significance Level..........    .32173E-13

     Standard Error Corrected for Selection.....     .21255
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......     .16423E-03


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  ---------------------------------------------------------------

 ONE       -.190006      .1467        -1.296 ( .19514)   1.0000
 AGE       -.148120E-02  .5391E-02     -.275 ( .78350)   41.713
 AGESQ      .789163E-05  .5730E-04      .138 ( .89047)   1843.7
 EDUCYRS   -.186158E-01  .7553E-02    -2.465 ( .01372)   .32581
 DCAST      .453976E-02  .2046E-01      .222 ( .82437)   .38082
 LNVWGF     .851171      .4268E-01    19.945 ( .00000)  -1.3577
 RAINMM     .758189E-03  .5035E-03     1.506 ( .13214)   14.008
 DV3       -.303734E-02  .2321E-01     -.131 ( .89589)   .27786
 DV5       -.150502E-01  .2369E-01     -.635 ( .52522)   .41326
 DVSTG      .880559E-02  .1650E-01      .534 ( .59352)   1.4810
 LAMBDA     .272387E-02  .1101E-01      .247 ( .80461)   .87476
```

TABLE 13

ESTIMATION OF THE PROBABILITY OF PARTICIPATION IN STAGE 1 FOR SPOUSES OF HEADS OF HOUSEHOLDS

Log-Likelihood..............	-268.77
Restricted (Slopes=0) Log-L.	-347.74
Chi-Squared (7)............	157.95
Significance Level..........	.32173E-13

Variable	Coefficient	Std. Error	T-ratio	(Sig.Lvl)	Mean
ONE	-1.34186	.4090	-3.281	(.00104)	1.0000
AGE	.708432E-02	.6629E-02	1.069	(.28522)	44.025
EDUCYRS	-.745896E-01	.4220E-01	-1.767	(.07716)	.89661
DCAST	-.301830	.1300	-2.321	(.02026)	.56441
RAINMM	.207257E-01	.7785E-02	2.662	(.00776)	14.531
INTRCRP	.878950E-02	.1855E-02	4.739	(.00000)	44.288
OWNED	-.110134	.1856E-01	-5.935	(.00000)	6.6671
CHFSZ	1.21219	.3538	3.426	(.00061)	.32990

TABLE 14

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES FOR STAGE 1 FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........     LNIDWG
     Number of Observations......         368.
     Mean     Dependent Variable..     -1.41968
     Std. Dev. of Dep. Variable..        .24915
     Std. Error of Regression....        .24785
     Sum of Squared Residuals....     22.115
     R - Squared.................        .00767
     Adjusted R - Squared........       -.01163
     F-Statistic (  7,  360).....        .39743
     Significance of F-Test......        .90381
     Log-Likelihood..............    -4.8376
     Restricted (Slopes=0) Log-L.    -10.255
     Chi-Squared ( 7)............     10.834
     Significance Level..........     .14601

     Standard Error Corrected for Selection.....      .24791
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......      .16129E-02


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
  ----------------------------------------------------------------

 ONE        -1.53292      .1997       -7.675 ( .00000)   1.0000
 AGE          .412981E-02 .8557E-02     .483 ( .62935)   41.921
 AGESQ      -.436514E-04  .9051E-04    -.482 ( .62960)   1865.7
 EDUCYRS    -.664675E-02  .1136E-01    -.585 ( .55831)   .34239
 DCAST        .110087E-01 .3328E-01     .331 ( .74082)   .38587
 DV3        -.599176E-02  .3803E-01    -.158 ( .87482)   .26087
 DV5          .308819E-01 .3816E-01     .809 ( .41839)   .42120
 LAMBDA      .995637E-02  .1867E-01     .533 ( .59380)   .81715
```

TABLE 15

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES FOR STAGE 1 FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
Ordinary    Least Squares Estimates

Dependent Variable..........      LNIDWG
Number of Observations......           368.
Mean    Dependent Variable..       -1.41968
Std. Dev. of Dep. Variable..         .24915
Std. Error of Regression....         .20571
Sum of Squared Residuals....     15.150
R - Squared.................         .31640
Adjusted R - Squared........         .29922
F-Statistic (  9,  358).....       18.41132
Significance of F-Test......         .00000
Log-Likelihood..............     64.738
Restricted (Slopes=0) Log-L.    -10.255
Chi-Squared ( 9)............     149.98
Significance Level..........     .32173E-13

Standard Error Corrected for Selection.....     .20572
Squared Correlation Between Disturbance in This Equation
and Selection Criterion (Rho-Squared)......     .27012E-03


Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
-------------------------------------------------------------

ONE       -.234138      .1966       -1.191 ( .23360)   1.0000
AGE       -.206897E-02  .7130E-02    -.290 ( .77169)   41.921
AGESQ      .214568E-04  .7542E-04     .284 ( .77604)   1865.7
EDUCYRS   -.134574E-01  .9462E-02   -1.422 ( .15494)   .34239
DCAST      .914323E-02  .2763E-01     .331 ( .74072)   .38587
LNVWGF     .814853      .6367E-01   12.799 ( .00000)  -1.4000
RAINMM     .372336E-03  .1085E-02     .343 ( .73152)   13.156
DV3       -.121546E-01  .3158E-01    -.385 ( .70036)   .26087
DV5       -.351520E-02  .3264E-01    -.108 ( .91425)   .42120
LAMBDA     .338109E-02  .1537E-01     .220 ( .82587)   .81715
```

TABLE 16

ESTIMATION OF THE PROBABILITY OF PARTICIPATION IN STAGE 2 FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
    Log-Likelihood..............   -239.68
    Restricted (Slopes=0) Log-L.   -309.31
    Chi-Squared ( 7)............    139.26
    Significance Level..........    .32173E-13

 Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)    Mean
 --------------------------------------------------------------

ONE        -.372079      .4219        -.882 ( .37781)   1.0000
AGE        -.611079E-02  .6874E-02    -.889 ( .37401)   44.170
EDUCYRS    -.138299      .5097E-01  -2.714 ( .00666)    .90036
DCAST      -.326793      .1365      -2.394 ( .01667)    .56159
RAINMM     -.859654E-02  .3500E-02  -2.456 ( .01404)    20.581
INTRCRP     .116571E-01  .1672E-02   6.970 ( .00000)    45.304
OWNED      -.106163      .1951E-01  -5.441 ( .00000)    6.8279
CHFSZ       .855233      .3711       2.305 ( .02119)    .33351
```

TABLE 17

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITHOUT DEMAND VARIABLES FOR STAGE 2 FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
     Ordinary    Least Squares Estimates

     Dependent Variable..........     LNIDWG
     Number of Observations......         341.
     Mean     Dependent Variable..      -1.33347
     Std. Dev. of Dep. Variable..         .28589
     Std. Error of Regression....         .28328
     Sum of Squared Residuals....     26.722
     R - Squared.................         .01535
     Adjusted R - Squared........        -.00534
     F-Statistic (  7,  333).....         .74177
     Significance of F-Test......         .63837
     Log-Likelihood..............    -49.743
     Restricted (Slopes=0) Log-L.    -56.381
     Chi-Squared ( 7)............     13.278
     Significance Level..........     .65628E-01

     Standard Error Corrected for Selection.....     .28379
     Squared Correlation Between Disturbance in This Equation
     and Selection Criterion (Rho-Squared)......     .62269E-02


  Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)    Mean
  ---------------------------------------------------------------

 ONE       -1.54372       .2449       -6.304 ( .00000)   1.0000
 AGE         .772503E-02  .1056E-01     .732 ( .46436)   41.489
 AGESQ     -.894795E-04   .1128E-03    -.794 ( .42745)   1819.9
 EDUCYRS   -.149261E-01   .1590E-01    -.939 ( .34777)    .30792
 DCAST     -.237052E-02   .3955E-01    -.060 ( .95221)    .37537
 DV3         .460906E-01  .4394E-01    1.049 ( .29418)    .29619
 DV5         .605569E-01  .4498E-01    1.346 ( .17819)    .40469
 LAMBDA      .223938E-01  .2037E-01    1.099 ( .27167)    .88955
```

TABLE 18

WAGE FUNCTION CORRECTED FOR SELECTIVITY WITH DEMAND VARIABLES FOR STAGE 2 FOR SPOUSES OF HEADS OF HOUSEHOLDS

```
Ordinary    Least Squares Estimates

Dependent Variable..........     LNIDWG
Number of Observations......        341.
Mean    Dependent Variable..    -1.33347
Std. Dev. of Dep. Variable..      .28589
Std. Error of Regression....      .21881
Sum of Squared Residuals....   15.848
R - Squared.................      .41250
Adjusted R - Squared........      .39652
F-Statistic (  9,  331).....    25.82260
Significance of F-Test......      .00000
Log-Likelihood..............   39.304
Restricted (Slopes=0) Log-L.  -56.381
Chi-Squared ( 9)............  191.37
Significance Level..........   .32173E-13

Standard Error Corrected for Selection.....     .21883
Squared Correlation Between Disturbance in This Equation
and Selection Criterion (Rho-Squared)......     .32094E-03


Variable  Coefficient  Std. Error  T-ratio (Sig.Lvl)   Mean
---------------------------------------------------------------

ONE      -.131862      .2114        -.624 ( .53279)   1.0000
AGE      -.417038E-03  .8193E-02    -.051 ( .95940)   41.489
AGESQ    -.122644E-04  .8745E-04    -.140 ( .88847)   1819.9
EDUCYRS  -.258375E-01  .1232E-01   -2.096 ( .03604)   .30792
DCAST     .926407E-03  .3058E-01     .030 ( .97583)   .37537
LNVWGF    .884442      .5880E-01   15.041 ( .00000)  -1.3120
RAINMM    .860346E-03  .6006E-03    1.433 ( .15199)   14.928
DV3       .183147E-02  .3412E-01     .054 ( .95720)   .29619
DV5      -.267453E-01  .3524E-01    -.759 ( .44782)   .40469
LAMBDA    .392037E-02  .1577E-01     .249 ( .80368)   .88955
```

APPENDIX C

EXOGENEITY TESTING

This appendix contains a description of the exogeneity test conducted with respect to the harvesting labor inputs in Chapter V. Several exogeneity tests have been developed by Hausman (1978) and Wu (1973). Nakamura and Nakamura (1981) have shown that Wu's most powerful test and Hausman's computationally more convenient are identical. This test is presented below in the form given by Nakamura and Nakamura.

Assume a structural equation:

(1) $$y_1 = Y_2 B + Z_1 \gamma + u$$

where

$y_1 = N \times 1$, $Y_2 = N \times G$, $B = G \times 1$, $Z_1 = N \times K_1$, $\gamma = K_1 \times 1$, $u = N \times 1$, and G reduced form equations:

(2) $$Y_2 = Z_1 \pi_1 + Z_2 \pi_2 + V$$

with

$\pi_1 = K_1 \times G$, $Z_2 = N \times K_2$, $\pi_2 = K_2 \times G$ and $V = N \times G$.

The covariance matrix $\mathrm{Var}(u|V) = \begin{bmatrix} \sigma_{11} & \delta' \\ \delta & \Sigma_{22} \end{bmatrix}$ and each row of $(u|V)$ assumed to be distributed independently.

We want to test for the exogeneity of the G variables of Y_2. In other words, we want to test H_o: $\delta = 0$. To do this, we use the following equation:

$$(3) \qquad y_1 = Y_2 B + Z_1 \gamma + \hat{e}_2 B_5 + u$$

with $\hat{e}_2 = N \times G$, being the matrix of residuals obtained by running the G regressions of equation (2) by OLS.

Equation (3) was first run by OLS by setting $B_5 = 0$ (which is then equal to equation (1)) and calculating the restricted residual sum of squares (RRSS). It was then run without setting $B_5 = 0$ and calculating the unrestricted residual sum of squares (URSS). Then, the test statistic:

$$L = \frac{(RRSS - URSS)/G}{URSS/(N - 2G - K_1)} \approx F(G, N - 2G - K_1)$$

Applying this test to our case, we first regressed TOUTV on MALE2, FEML2, MALE1, FEML1, CLT, IRR, PESTV, TFERTQ, BULL1, DV77-DV83 (where each one of the variables MALE2-BULL1 are in deviations of the log from the farm mean of the log, and DV77-DV83 are year dummies). This regression yielded RRSS = 134.5626 and had 368 observations since year 1975 was dropped to make it comparable to the unrestricted equation.

Next MALE2 was regressed on WGHM2_1 WGHF2_1 MALE1 FEML1 CLT IRR PESTV TFERTQ BULL1 so as to obtain the residual of this regression (RESM2_1). The exact same regression was ran for FEML2 and the corresponding residual (RESF2_1) was obtained. Note that in these reduced form regressions also, each variable is in deviation of the log from the farm mean of the log, and that WGHM2_1 and WGHF2_1 are the lagged deviations from the farm mean of the village wage rate in the harvesting stage, for males and females respectively. Lagged village wage rates were used as instruments so as to avoid any correlation of the current wage rate with the error term in the production function. Finally, the unrestricted regression was run by including RESM2_1 and RESF2_1 as additional explanatory variables. This yielded URSS = 134.05. Since N = 368, G = 2 and K_1 = 14, the value of the statistic under the null hypothesis was F(2,350) = 0.666 which led to the acceptance of the null hypothesis.

It is worth pointing out however, that the results of the exogeneity test reverse depending on the instrumental variables used. For example, using the current deviations of the harvesting wage rates (for males and females) as instruments for the harvesting stage inputs, leads to the rejection of the null hypothesis. Alternatively, using lagged harvesting inputs as instruments for current harvesting inputs leads to the acceptance of the null hypothesis.

APPENDIX D

DESCRIPTION OF THE VARIABLES USED IN THE STUDY

AGE: The age of the individual in stage i (i=1,2) of crop-cycle j (j=1,2) in year t.

AVHRMO: The average number of hours per month that the individual was available for work in stage i of crop cycle j in year t. This variable was constructed for both males and females in the following manner:
AVHRMO=(TOTAL WORKDAYS*8/(167/30)) for stage 1 in the kharif season
AVHRMO=(TOTAL WORKDAYS*8/(47/30)) for stage 2 in the kharif season
AVHRMO=(TOTAL WORKDAYS*8/(79/30)) for stage 1 in the rabi season
AVHRMO=(TOTAL WORKDAYS*8/(73/30)) for stage 2 in the rabi season
where TOTAL WORKDAYS is the total number of days spent on farm work (working on own farm or in other people's farms), off-farm nongovernment work, off-farm government work and involuntary unemployment in stage i of crop-cycle j in year t. It is assumed that individuals work 8 hours a day.

BULL1: Total bullock labor hours used by the household in the first stage of crop-cycle j in year t. Total bullock labor hours is the sum of labor hours by bullocks owned by the household, bullocks hired, and bullocks hired on an exchange basis.

BWAGE1: The village level hourly wage rate divided by the CPI, paid out to hired bullock labor in the first stage (planting) of crop-cycle j in year t. This variable was constructed by summing the expenditures (in cash and in kind) of all farming households in the village sample on hired bullock labor in the planting stage and dividing this sum by the total hours of work performed by hired bullock labor in the village sample during the planting stage.

CHFSZ: The ratio of the total number of children in the household (15 yrs of age or younger) and the total family size in stage i of crop cycle j in year t.

CLT: The total area cultivated (in acres) by the household in crop-cycle j in year t.

CPI: The consumer price index in year t for each of the three villages. Base year is 1975.

DCAST: A dummy variable for caste. DCAST = 1 if the household belongs to a high ranked caste (see VLS Manual), = 0 otherwise.

DV3 (5): Dummy variables for village. DV3 = 1 for Shirapur and DV5 = 1 for Kanzara.

DVSTG: Dummy variable for stage in the crop-cycle. DVSTG = 1 for the planting stage, DVSTG = 0 for the harvesting stage.

EDUCYRS: The total number of years of education of the individual.

FAMSIZE: Total number of people (adults and children) in the household in crop-cycle j in year t.

FEML1: Total (adult) female labor hours used by the household in the first stage (planting) of crop-cycle j in year t. Total female labor hours is the sum of labor hours by family females, females hired, females working in the household as attached (or permanent) servants and females hired on an exchange basis.

FEML2: Total (adult) female labor hours used by the household in the second stage (harvesting) of crop-cycle j in year t. Total female labor hours is the sum of labor hours by family females, females hired, females working in the household as attached (or permanent) servants and females hired on an exchange basis.

FWAGE1: The village level hourly wage rate divided by the CPI, paid out to hired females in the first stage (planting) of crop-cycle j in year t. This variable was constructed by summing the expenditures (in cash and in kind) of all farming households in the village sample on hired female labor in the planting stage and dividing this sum by the total hours of work performed by hired female labor in the village sample during the planting stage. This variable was used in the estimation of labor demand functions only. The village level wage rates used in the estimation of the wage functions were derived from a different file. (See description of RLVWGF).
Note: This variable has no relation to the variable called FWAGE1 in Tables IV.B.1-IV.B.14.

FWAGE2: The village level hourly wage rate divided by the CPI, paid out to hired females in the second stage (harvesting) of crop-

cycle j in year t. This variable was constructed by summing the expenditures (in cash and in kind) of all farming households in the village sample on hired female labor in the harvesting stage and dividing this sum by the total hours of work performed by hired female labor in the village sample during the harvesting stage.This variable was used in the estimation of labor demand functions only. The village level wage rates used in the estimation of the wage functions were derived from a different file. (See description of RLVWGF).
Note: This variable has no relation to the variable called FWAGE2 in Tables IV.B.1-IV.B.14

FXEFF1: Estimate of the fixed effect present in the labor demand functions for females derived using the coefficients reported in Table IV.C.2

FXEFLSF: Estimate of the Marginal Utility of Wealth for females. Refer to pages 68-70 in the dissertation.

FXEFM1: Estimate of the fixed effect present in the labor demand functions for males derived using the coefficients reported in Table IV.C.3

INC_ID: A measure of the labor income earned (in Rs.) by other household members in stage i in crop-cycle j in year t (excluding the labor income earned by the individual), divided by the CPI.

INTRCRP: Percentage of the land cultivated by the household in crop-cycle j in year t, that was intercropped.

IRR: The total area (in acres) of irrigated land cultivated by the household in crop-cycle j in year t.

MALE1: Total (adult) male labor hours used by the household in the first stage (planting) of crop-cycle j in year t. Total male labor hours is the sum of labor hours by family males, males hired, males working in the household as attached (or permanent) servants and males hired on an exchange basis.

MALE2: Total (adult) male labor hours used by the household in the second stage (harvesting) of crop-cycle j in year t. Total male labor hours is the sum of labor hours by family males, males hired, males working in the household as attached (or permanent) servants and males hired on an exchange basis.

MWAGE1: The <u>village level</u> hourly wage rate divided by the CPI,

paid out to hired males in the first stage (planting) of crop-cycle j in year t. This variable was constructed by summing the expenditures (in cash and in kind) of all farming households in the village sample on hired male labor in the planting stage and dividing this sum by the total hours of work performed by hired male labor in the village sample during the planting stage.This variable was used in the estimation of labor demand functions only. The village level wage rates used in the estimation of the wage functions were derived from a different file. (See description of RLVWGM).
Note: This variable has no relation to the variable called MWAGE1 in Tables IV.B.1-IV.B.14

MWAGE2: The village level hourly wage rate divided by the CPI, paid out to hired males in the second stage (harvesting) of crop-cycle j in year t. This variable was constructed by summing the expenditures (in cash and in kind) of all farming households in the village sample on hired male labor in the harvesting stage and dividing this sum by the total hours of work performed by hired male labor in the village sample during the harvesting stage.This variable was used in the estimation of labor demand functions only. The village level wage rates used in the estimation of the wage functions were derived from a different file. (See description of RLVWGM).
Note: This variable has no relation to the variable called MWAGE2 in Tables IV.B.1-IV.B.14

NOCHILD: The number of children (younger than 16 yrs) residing in the household in stage i in crop-cycle j in year t.

NOFMEMB: The number of adult (older than 16 yrs) females residing in the household in stage i in crop-cycle j in year t.

NOMMEMB: The number of adult (older than 16 yrs) males residing in the household in stage i in crop-cycle j in year t.

OWNED: The area of land (in acres) owned by the household in crop-cycle j in year t

PESTV: The nominal value of all pesticides (in Rs.) divided by the CPI, used by the household in crop-cycle j in year t.

RAINMM: The amount of rainfall (in mm's) in the village in stage i of crop-cycle j in year t.

RLIDWG: A measure of the real wage rate per hour received by the individual in stage i of crop-cycle j in year t. This variable was constructed by taking a weighted sum of the hourly wage rates (in cash and in kind) received by the individual from government, nongovernment and farm work and dividing this weighted average by the CPI. Since the weights used for each individual were the shares of government, nongovernment and farm work hours in the total hours worked by the individual, RLIDWG can also be interpreted as the average real hourly wage rate received by the individual in stage i of crop-cycle j in year t.

RLVWGF: The <u>village level</u> composite hourly wage rate divided by the CPI, paid out to females working in stage i of crop-cycle j in year t. This variable was constructed by taking a weighted sum of the village level hourly wage rates (in cash and in kind) received by females from government, nongovernment and farm work and dividing this weighted average by the CPI. Since the weights used were the shares of government, nongovernment and farm work hours of all females in the village sample in the total hours worked by females in the village sample, RLIDWG can also be interpreted as the average village level real hourly wage rate received by females in stage i of crop-cycle j in year t.

RLVWGM: The <u>village level</u> composite hourly wage rate divided by the CPI, paid out to males working in stage i of crop-cycle j in year t. This variable was constructed by taking a weighted sum of the village level hourly wage rates (in cash and in kind) received by males from government, nongovernment and farm work and dividing this weighted average by the CPI. Since the weights used were the shares of government, nongovernment and farm work hours of all males in the village sample in the total hours worked by males in the village sample, RLIDWG can also be interpreted as the average village level real hourly wage rate received by males in stage i of crop-cycle j in year t.

TASSETR: The value of assets (in Rs.) owned by the household in 1979 divided by the CPI. The value of assets was derived by summing the value of owned land, livestock, implements, buildings, consumer durables, food stocks, financial assets and liabilities.

TFERTQ: Total quantity of organic and inorganic fertilizers (kgs. of nitrogen, phosphorous and potash) used by the household in crop-cycle j in year t.

TOUTV: Total value of output (in Rs.) divided by the CPI, harvested by the household in crop-cycle j in year t.

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