Off-Farm Work and Capital Accumulation Decisions of Farmers over the Life-Cycle: The Role of Heterogeneity and State-Dependence

by

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Abstract

This paper aims to construct an empirical model for the analysis of two principal simultaneous decisions of farm operators: participation in the off-farm labor market, and the amount of resources to invest in farm capital. We first develop a theoretical model analyzing the effects of exogenous shocks on farmers' decisions. Then, we estimate jointly a multinomial probit model of farmers' off-farm labor supply and a switching regression model of farm capital, using a two-period panel data set from Israel. The longitudinal data enables to account for unobserved heterogeneity and structural state dependence. Both state dependence and heterogeneity lead to the same conclusion, that off-farm labor supply and farm capital are negatively associated. However, the heterogeneity model implies that farmers at the higher end of the ability distribution are able to both work off the farm and maintain a capital-intensive farm enterprise. The results show that farm capital investments during the 1970's, which were enhanced by heavily subsidized credit, prevented farmers from seeking off-farm employment opportunities. Holding the capital stock constant would have resulted in a sharp increase, rather than a moderate decline, in farm operators' off-farm participation probabilities. This result demonstrates that a simultaneous analysis of off-farm labor supply and farm capital accumulation has relevant policy implications.

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1. Introduction

Past research has found that off-farm income is critical to the welfare of rural households (Rosenzweig 1988). In many developing countries and economies-in-transition worldwide, between one-third and one-half of farm households derive income from off-farm sources, and off-farm income constitutes between 20 percent and 70 percent of total household income (Adams 2001; Benjamin 1992; Newman and Gertler 1994; Reardon et al. 2001; Rizov et al. 2000; Rosenzweig 1980). The role of capital investments in the development process and in the transition from rural to industrial society has also been emphasized. Mundlak (1993, 2000), for example, claims that capital constraints are a major determinant of the rate of adoption of new technologies.

Moreover, the association between off-farm labor markets and farm capital has important policy implications. Labor market policy tends to spill over to the farm sector, while agricultural policy affects both rural and urban labor markets. Rosenzweig (1988, p. 759) advocated the use of longitudinal data to "provide an essential base for … model formulation aimed at integrating capital accumulation with labor allocation." Yet we are not aware of previous literature that empirically considers the joint determination of these decisions at the farm level, and in a life-cycle setting.

Recognizing the endogeneity of capital stock in empirical analyses of off-farm work is particularly important in developing countries. In those economies, capital markets are less complete and farm capital is more determined by life-cycle accumulation and less by intergenerational transfers. For example, Reardon (1997) noted that off-farm income can increase farm capital accumulation if the family farm is subject to borrowing constraints. The results of Rosenzweig and Wolpin (1993, p. 241) imply that "increasing opportunities for members of farm households to obtain jobs that pay assured salaries may also increase the capital intensity of agricultural investments…" in India. In addition, Kada (1991) found that farm labor and farm capital are substitutes in Japanese rice farms. These results may be specific to land-scarce agricultural societies. Rizov et al. (2001) suggest that off-farm income may be more important than farm assets in reducing capital constraints, in the context of a transitional economy. Reardon et al. (1994) cite cases in which nonfarm income had the opposite effects on farm investments, depending on agro-climatic conditions.

The purpose of this paper is to propose an empirical strategy for the joint analysis of farmers' decisions to participate in the off-farm labor market, and their investment in farm capital. These two significant decisions determine the growth of the farmer's earnings by determining his life-cycle paths in terms of both human and physical capital. At the macro level, the decisions taken by many individual farmers are essential to the overall development of the agricultural sector and the economy as a whole (Timmer 1988), with the resulting major policy implications. We formulate and estimate a finite-horizon life-cycle model that incorporates the major features of those factors influencing these decisions such as returns to ability, experience, and investments, and the effects of farm size and location. We illustrate this strategy with panel data on Israeli farmers from the 1970s. Israeli agriculture recorded a rapid transformation from the 1950s to the 1990s. The situation in the 1970s can be thought of as midway through the development process. Several aspects that were unique to Israel in the 1970s make the illustration useful for developing and transitional economies at the beginning of the 21st century. Moreover, the proposed empirical strategy can be used for a wide range of countries and applications.

In the rest of this introductory section we lay out and explain in detail how the paper is organized. In section 2 we present an intertemporal optimization model for the family farm, in which off-farm labor supply and farm capital accumulation are jointly determined. We treat the two decisions as simultaneous, without assuming any particular causality between them.

On one hand, farm capital and off-farm labor supply can move in the same direction due to the substitution effect (capital deepening releases labor from farm production). On the other hand, the two variables can move in opposite directions because capital increases the marginal productivity of family labor on the farm, and the other way around (expansion effect).

In section 3 we describe the panel data set, and in section 4, the resulting empirical approach. The data include estimates of the value of farm capital stock and discrete realizations of off-farm labor supply, namely whether the farm operator works full-time off the farm, part-time, or not at all. Hence the off-farm labor decision is formulated as a multinomial choice model (McFadden 1984), while the parameters of the capital equation depend on the off-farm labor status, resulting in a switching-regression model for farm capital (Maddala 1986).

The panel structure of the data is somewhat unique. We observe each farmer only twice ten years apart. The main disadvantage of this fact is that we do not have information on the farmer's behavior between the two periods. An important advantage, though, is that we observe the differences in the behavior of the farmer over a relatively long fraction of his life cycle. As a result, we will not try to explicitly model dynamic relationships but rather use the panel properties to control for unobserved heterogeneity among the farmers. This allows for a more accurate interpretation of the estimated parameters and also provides some interesting insights about the joint determination of farm capital and off-farm labor supply, which could not have been obtained in a cross-sectional study.

The results are presented in section 5. We find strong negative association between off-farm labor supply and farm capital stock, indicating that the expansion effect dominates the substitution effect in farm production. The empirical approach and the Israeli data offer some policy implications that could be useful for both developed and developing countries. These are discussed in the concluding section. In particular, farm investments were heavily subsidized during the 1970s, which has lead to significant capital deepening. Our results and simulations show that without this capital deepening, farmers would have increased their off-farm labor supply, which could have made them much less vulnerable to the financial crisis of the mid-1980s.

2. Theoretical Framework

In this section we formulate a dynamic model incorporating farm production and off-farm earnings in order to provide a framework for assessing the interplay between work choices and farm capital investments. For simplicity, we ignore intrahousehold time allocation and assume a single-person household. Skoufias (1996) formulated such a model with more than one family member, but our data include time allocation of heads of households only so this is not necessary.

A farmer is assumed to maximize lifetime income, derived from two sources: farm profits and off-farm labor earnings. He has one unit of time in each period to divide between off-farm work (L) and farm work (1-L). Farm production is a positive function of farm work, intrinsic ability (A), farm-specific human capital (h^f), physical capital (K), fixed inputs (including land), purchased inputs (including hired workers), and a stochastic productivity shock θ. This shock is exogenous to the farm and is revealed at the beginning of each period. The assumption of fixed land is supported by evidence from developing countries (e.g., Rosenzweig 1980), and by the fact that farmland transactions were not allowed in Israel (Kimhi 1998). On the other hand, we assume elastic supply of hired labor, which is not a perfect substitute for own labor. Although several authors (Benjamin 1992; Pitt and Rosenzweig 1986) were not able to reject the perfect substitution hypothesis, others believe that it is unreasonable and find evidence against it (Deolalikar and Vijverberg 1987; Eswaran and Kotwal 1986; Fafchamps and Quisumbing 1999; Frisvold 1994; Jacoby 1993).

Off-farm income is a function of intrinsic ability (A), off-farm (per unit of human capital) wage rate (w^c), off-farm-specific human capital (h^c), and off-farm work time (L). Thus, the maximization problem of the farmer is to choose the values for K_t and L_t for t=1,…,T to:

$$Max \quad E_1 \sum_{t=1}^{T} \left(\frac{1}{1+r} \right)^t (Aw_t^c h_t^c L_t + p_t f(A, h_t^f, K_t, 1-L_t, \theta_t) - p_t^I I_t) \tag{1}$$

subject to the three asset accumulation equations:

$$K_{t+1} = I_t + (1-\delta)K_t \tag{2}$$

$$h_{t+1}^c = L_t + h_t^c \tag{3}$$

$$h_{t+1}^f = (1-L_t) + h_t^f \tag{4}$$

and initial conditions:

$$K(0) = K_0, \quad h^c(0) = h_0^c, \quad and \quad h^f(0) = h_0^f.$$

E_t is the expectation operator conditional on the information set at time t, r is the real interest rate, p_t is the price of farm output, δ is the depreciation rate of physical capital, I_t is capital investments, and p^I_t is a price of investment goods.[1] For simplicity, we assume that the stock of sector-specific human capital is identical to accumulated experience with no depreciation.

To solve the model we insert the three constraints (2)-(4) into (1), and take first-order conditions with respect to the sequences $\{K_1,…,K_T,L_1,…,L_T\}$. Note that we allow for corner solutions with respect to time allocation: some farmers may choose to work only on the farm (L=0) while others -- only off the farm (L=1). The first-order conditions are:

$$p_t f_K(A, h_t^f, K_t, 1-L_t, \theta_t) = p_{t-1}^I(1+r) - p_t^I(1-\delta) \tag{5}$$

and

[1] The price of investment goods includes the difference between the interest rate on farm investment loans and the real interest rate. Note that Israeli farmers obtained investment loans with negative real interest rates throughout most of the 1970s (Kislev et al. 1991).

$$\left(\frac{1}{1+r}\right)^t Aw_t^c h_t^c + E_t \sum_{j=t+1}^{T}\left(\frac{1}{1+r}\right)^j Aw_j^c L_j =$$

$$\left(\frac{1}{1+r}\right)^t p_t f_{1-L}(t) + E_t \sum_{j=t+1}^{T}\left(\frac{1}{1+r}\right)^j p_j f_{h^f}(j) \qquad \text{if } 0<L<1. \qquad (6)$$

Equation (6) is the condition for optimal time allocation. The upper expression represents the marginal contribution to income from working off the farm, and the lower -- from working on farm. Thus, equation (6) shows that the values of the marginal unit of time spent in each activity are equalized. This is of course true only when the solution is interior, whereas, when the farmer goes to a corner and devotes all his time to one activity, it means that even at the corner one activity has a higher value of time than the other. However, these first order conditions are very useful for assessing which exogenous factors increase the likelihood that the farmer chooses to be in one of the two possible corners.

By using a specific production function, it is straightforward to solve analytically the life-cycle earnings path of each farmer. This can be done by using equations (2)-(6), and iterating backwards from the last period. Since analyzing the properties of such analytical solutions is outside the scope of this paper, we continue by perceiving several interesting effects of the exogenous variables on capital investments, on time allocation decisions, and on the interactions between present and future choices from the first order conditions (5) and (6).

Equation (5) indicates how prices and shocks affect the shadow price of farm capital. Holding everything else constant, an increase in either the real interest rate, the depreciation rate, or an overall rise in the schedule of $\{p^I_t\}$, reduces the optimal level of physical capital, while an increase in the price of farm output or the productivity shock increases the optimal level.

Comparative static analysis based on equation (6) yields the following results. First, farmer's ability (A) plays an important role in his time allocation decision. However, since ability is presumed to affect farm and off-farm income in the same direction, its effect on the likelihood of off-farm work is ambiguous. Second, in periods in which off-farm wages are high, more farmers will participate in off-farm work. The opposite will occur when farm profits are high (e.g. high price or technology shock). Third, the model also suggests that past decisions affect present decisions through the accumulation of sector-specific human capital, and thus a person who worked off the farm in the past is more likely to do so in the current period (persistence). Finally, time allocation and capital investments are interrelated, and the sign of the relation is ambiguous. As discussed in the introduction, the input substitution effect in farm production results in a positive association between off-farm work and capital accumulation, while the expansion (or contraction) effect results in a negative association. In the empirical analysis, we plan to investigate both the persistence of off-farm work decisions and the interrelationship between off-farm work and farm capital.

3. Data

The data set used in this research includes matched observations from the two recent censuses of agriculture in Israel, 1971 and 1981. We use only data on family farms from *moshavim* (cooperative villages), accounting for most family farms in Israel.[2] It should be emphasized that despite the cooperative nature of *moshavim*, each *moshav* member makes his own production and consumption decisions. Our working sample includes 6047 observations for each census year. The selection of this sample is described in the Data Appendix.

The primary dependent variable in our research is the farm operator's off-farm work status. In the questionnaire, each person was asked two similar questions, one about farm work and one about off-farm work. The question was qualitative: the person could report no work,

[2] An explanation of the institutional structure of moshavim can be found in Kimhi (1998).

part-time work, or full-time work. The only constraint was that respondents could not report full-time work both on and off the farm. All other possible combinations exist in the data set.

Table 1 – About Here

Table 1 shows the transition between types of off-farm work statuses from 1971 to 1981. About half of all farmers worked exclusively on the farm in 1971. Only 22% of them shifted to work off the farm in 1981, two-thirds of them had turned to work full-time off the farm. Among those who had worked off the farm in 1971, about a third worked part-time; about half of those stopped working off the farm by 1981, and another third worked full-time off the farm in 1981. Among those who had worked full-time off the farm in 1971, more than a half did not change their status, and about a third stopped working off the farm by 1981. The main conclusion is that the part-time off-farm work status is a relatively unstable status, perhaps a temporary one.[3] We also observe a general shift away from off-farm work between 1971 and 1981, but this is mostly due to the fact that we are using the balanced panel. New entrants into farming engaged in off-farm work to a much larger extent in 1981.

The secondary dependent variable is the value of the farm's capital stock. In each census, farmers were asked to report the quantities of many pre-specified capital assets (buildings, machines, equipment, livestock, etc.). These quantities were multiplied by average prices derived from a special survey, and aggregated. The 1971 values were inflated to 1981 prices using the average annual consumer's price index. The capital values were converted to US$ by the average annual 1981 exchange rate.

Figure 1 – About Here

Figure 1 portrays the changes in the farm capital stock between 1971 and 1981 by work status. The nine different categories of off-farm work transitions match those in Table 1. For

[3] On the other hand, overall off-farm labor participation was found by Kimhi (2000) to be a stable situation.

example, the part-full category includes farm operators who worked part-time off the farm in 1971 and full-time in 1981. Overall, it can be seen that farm capital almost doubled in real terms between 1971 and 1981, on average. In both years the levels of farm capital are inversely related to the extent of off-farm work. However, the distribution of farm capital across off-farm work statuses in 1981 was much more unequal than in 1971, which points to the importance of the interrelation between these two variables over the life cycle.

The highest relative rise was in farms in which the operators did not work off the farm in 1981. The lowest relative rise was in farms that moved from no off-farm work in 1971 to positive off-farm work in 1981. This points to a situation in which farm capital is a gross complement to farm labor input. In addition, the 1971 levels of farm capital are inversely related to the extent of off-farm work in 1981, which hints to the existence of life-cycle joint planning of capital investments and off-farm work. In the empirical analysis, we will examine whether these suggestive results hold after controlling for both observable variables and unobservable effects. In addition, the estimates will allow us to quantify the magnitude of the inverse relation between farm capital and off-farm work.

4. Empirical Strategy

In this section we present an empirical strategy to evaluate the implications of the theoretical model. Special attention is given to explain modifications that are imposed by the data available. The two main shortcomings of the data are that the observed time allocation decision is qualitative and that each farmer is observed only twice. To overcome the first, we simply transform the time allocation decision to be discrete. Accordingly, at the beginning of each period the farmer chooses one of three mutually exclusive work alternatives: (1) work only on the farm; (2) work part time off the farm; and (3) work full time off the farm. Our goal is to estimates the likelihood of each farmer to choose one of these states.

Formally, the farmer chooses the work alternative that maximizes the expected present value of the income he attains during his lifetime, i.e., the farmer chooses state m from the set J = {1, 2, 3}, such that

$$V_{it}^{m} = \max\{V_{it}^{1}, V_{it}^{2}, V_{it}^{3}\} \quad , \tag{7}$$

where V_{it}^{j} denotes the expected present value of the income of individual i who chooses state j at time t. Accordingly, the conditional probability of choosing state 2, for example, can be written as:

$$\text{Prob}(V_{it}^{2} = \max(V_{it}^{j})) = \text{Prob}(V_{it}^{2} > V_{it}^{1} \ \& \ V_{it}^{2} > V_{it}^{3}). \tag{8}$$

The sample likelihood function is the product of the individual probabilities in (8) over the N individuals and T years.

Given our focus on analyzing the interrelation between work choices and physical capital accumulation, we adopt a "semi-reduced-form" specification of the above conditional value functions. This approach allows us to address our basic questions without calculating the exact value functions. In other words, we do not impose structural restrictions on the parameters, but rather utilize the econometric strategy to approximate the theoretical model. While several authors do estimate structural dynamic discrete choice models (e.g., Eckstein and Wolpin 1999; Gilleskie 1998; Rosenzweig and Wolpin 1993), most of the empirical applications in the literature employ reduced forms (e.g., Berkovec and Steven 1991; Blau 1994; Hotz and Miller 1993; Hotz et al. 1999; Rust and Phelan 1997; Taber 2000).

The data include observations from two periods with ten years in between. The main advantage of this format is that the behavior of the farmer is observed over a long portion of his life. This, for example, gives a quality perspective on his life-cycle investments, whereas, on the contrary, two observations from consecutive years are not very useful for that purpose. The main disadvantage of this format is that we miss information on changes in state variables that took place during the ten-year interval. Thus, dynamic conclusions obtained from such analysis are not accurate. Hence, our estimated equations do not include explicit dynamic effects, and they are "reduced-form" equations in this sense as well. We denote them as "semi-reduced-form" because the work choice equations explicitly include the endogenous capital variable, and the capital equations explicitly depend on the endogenous work choices.

For simplicity, we consider linear specifications of the V_{it}^{j}'s that depend on: (1) indicators of ethnicity and birth cohort, family background variables, and farm characteristics (X_{it}^{V}); (2) a vector of age-related variables measuring the accumulated amounts of the various work and schooling experiences at the beginning of the period (Z_{it}^{V}); (3) the log of the real value of farm capital (K_{itj}); and (4) a state-specific unobservable variable (ε_{itj}):

$$V_{itj} = X_{it}^{V}\beta_j^{x} + Z_{it}^{V}\beta_j^{z} + K_{itj}\beta_j^{K} + \varepsilon_{itj} \quad , \tag{9}$$

for all $j \in J$, where β_j's are vectors of parameters to be estimated for each work state.

The discrete-choice equations are estimated jointly with the capital equations. The econometric representations of the capital equations take log-linear forms:

$$K_{itj} = X_{it}^{K}\delta_j^{x} + Z_{it}^{K}\delta_j^{z} + u_{itj} \quad , \ j \in \{1,2,3\}. \tag{10}$$

This is a switching regression since the coefficients vary by the work choice. As will be explained bellow, the parameters of the model are identified because the X's and Z's are not identical across Equations (9) and (10).

Estimation of the parameters in (9) and (10), using the data on the observed choices, is complicated by several related problems of endogeneity and selection bias. First, if the stochastic elements of the value functions (the ε_{itj}'s) are correlated over time (that would be the case if they contained person-specific, time-invariant components) the experience variables (Z_{it}) in (9) will not be orthogonal to the ε_{itj}'s. This orthogonality condition is required by the standard estimation methods. Second, the capital variable (K_{itj}) in (9) will not be orthogonal to the ε_{itj}'s if the ε_{itj}'s and the u_{itj}'s are contemporaneously and serially correlated. Finally, if the unobserved determinants of capital (the u_{itj}'s) are correlated with the unobserved components of work choice utilities (the ε_{itj}'s), the use of standard methods to estimate the parameters in (10) are potentially subject to selection bias. Failure to account for these problems may produce inconsistent estimates of the parameters of (9) and (10).

In order to minimize the intrusion of these potential sources of bias, it is necessary to account for the correlation structure of the stochastic elements in (9) and (10) in the estimation. Following Heckman and Singer (1984), we characterize the correlation structure of the ε_{itj}'s and the u_{itj}'s by a common *factor* structure. In particular, we assume that the stochastic elements can be written as the following linear combinations of a (common) person-specific stochastic component and idiosyncratic errors:

$$\begin{aligned} \varepsilon_{itj} &= \alpha_j^V \xi_i + \omega_{itj}^V \quad , \\ u_{itj} &= \alpha_j^K \xi_i + \omega_{itj}^K \quad . \end{aligned} \tag{11}$$

In this set of equations ξ_i denotes a person-specific *unobserved factor,* the α_j's are equation-specific *factor loadings*, and the ω_{itj}'s denote idiosyncratic disturbance terms. These terms are assumed to be uncorrelated with ξ_i. Given the stochastic structure in (11), the ε_{itj}'s and u_{itj}'s will be correlated across time and across states through their dependence on ξ_i, i.e.,

$$\text{Cov}(\varepsilon_{itj}, \varepsilon_{it'm}) = \alpha_j^V \alpha_m^V \text{Var}(\xi_i), \quad \text{for } t \neq t', \ j \neq m$$

$$\text{Cov}(\varepsilon_{itj}, u_{it'j}) = \alpha_j^V \alpha_j^K \text{Var}(\xi_i), \quad \text{for } t \neq t', \text{ and for all } j \tag{12}$$

$$\text{Cov}(u_{itj}, u_{it'm}) = \alpha_j^K \alpha_m^K \text{Var}(\xi_i), \quad \text{for } t \neq t', \ j \neq m.$$

As apparent from (12), the signs of the covariances between the ε_{itj}'s and u_{itj}'s are determined by the products of the corresponding factor loadings. Hence, the distribution of ξ_i (the unobserved factor) is identified from the various correlations of the three work choices and the capital stocks within and across time periods. Therefore, the entire process must be estimated jointly using maximum likelihood methods. We assume that the idiosyncratic disturbance terms (the ω_{itj}'s) are normally distributed with E(ω)=0. Following Heckman and Singer (1984), we use a discrete approximation of the distribution of ξ, and allow the points of support and their associated probabilities to be free parameters that are estimated jointly with the other parameters of the model.

The econometric model is a combination of a multinomial probit model of work choices and a switching-regression model of farm capital, both including random effects.[4] The model is estimated by a conditional maximum likelihood strategy in which the likelihood function is conditional on the estimated distribution of ξ. Hotz et al. (1999) use a similar estimation strategy in their model of discrete schooling choices and continuous wage equations. Note that since the work choice component of our model is a multinomial discrete choice model, the standard requirements for model identification apply. In particular, we normalize the coefficients associated with the choice of working only on-farm to zero, and estimate the relative coefficients associated with working part- and full-time off the farm. In

[4] A switching regression model with random effects was estimated by Meurs (1993).

addition, exclusion restrictions are imposed in order to identify the capital equations and the work-choice equations.

Since the specification is "semi reduced form", structural state dependence may be embodied within the unobserved factors ξ_i. In principle, one would like to allow for both structural state dependence and unobserved heterogeneity (Keane 1997), but this is not feasible in a two-period panel. This may raise a methodological question, namely whether it is legitimate to assume that the unobserved effects (ξ_i) are orthogonal to the included explanatory variables. In life-cycle labor supply models (e.g. Heckman and MaCurdy 1980), the ξ_i's represent the marginal utility of wealth and hence are correlated with the explanatory variables. In this case they should be treated as fixed effects rather than random effects. However, fixed-effect estimation of a discrete choice model of this kind is not feasible.

We believe that our estimation strategy minimizes the potential bias due to the use of random effects rather than fixed effects. This can be justified by the finding of Skoufias (1993), that the random effects specification cannot be rejected against the fixed effects specification. This means lack of correlation between the unobserved factors and the explanatory variables. The explanation is, according to Skoufias (1993), that all the explanatory variables that do not change over time and are included in the random effects model, effectively take care of all possible correlations. Since our model includes many such variables (age, education, ethnicity and location), we believe that the random effects model is reasonably justified.[5]

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[5] Kochar (1999) compared Tobit results of market work equations with fixed effects to those with time-invariant variables, and found the results qualitatively similar. Rose (1999) could not reject a linear probability model of market work participation with random effects and time-invariant variables against a model with fixed effects.

In addition, to verify that our main conclusions are robust to the assumption of unobserved heterogeneity rather than state dependence, we also estimate a model with explicit state dependence (i.e., including lagged dummy dependent variables as explanatory variables), and compare the results with those of the random effects model. Several authors (Gould and Saupe 1989; Weiss 1997) have estimated farmers' off-farm participation equations allowing for state-dependence. However, they could not tell whether the state dependence is "true" or "spurious", due to ignoring unobserved heterogeneity (Heckman 1981). Corsi and Findeis (2000) estimated probit off-farm participation equations with, alternatively, state dependence and heterogeneity, and concluded that the state dependence model is preferred. [6]

5. Results

Table 2 describes the explanatory variables used in this study. Personal characteristics include age, ethnic origin, years since immigration to Israel (equal to age for native Israelis), years of schooling, and family size. Farm attributes, in addition to the capital stock, include land holdings and principal farm enterprise. Village characteristics include geographical region and year of establishment. Table 2 also includes the means of these variables by off-farm work status in each of the census years. The table shows how the off-farm work status is related to each of the explanatory variables. For example, those who work off the farm have more years of schooling, whereas farm size and capital stock are inversely related to the extent of off-farm work.

Table 2 About Here

We estimate two principal models: a model controlling for structural state-dependence, which is estimated using the 1981 data only (Model II), and a model controlling for unobserved

[6] Honore and Kyriazidou (2000) show that both state dependence and heterogeneity can be accommodated with four periods of data using the logistic specification.

heterogeneity, which is estimated using both 1971 and 1981 data (Model IV). In each case we compare the estimates, using the same data, with simple pooled models (Models I and III, respectively). Each model includes the work-choice equations and the capital equations, which are estimated jointly. We will first present the work-choice results of both models (Tables 3a and 3b), and then present the capital results (Tables 4a and 4b).

Work-choice Equations

To estimate the effect of structural state-dependence, we estimate the model using 1981 data, including the off-farm work status in 1971 among the explanatory variables. The results are in Table 3a. We can see that the coefficients of the dummy variables for part-time and full-time off-farm work in 1971 (Model II) are positive and highly statistically significant in both equations. The results with the same data but without the state-dependence control (Model I) are qualitatively similar, but most of the coefficients are larger in absolute value, and in some cases more significant. The reason is that the coefficients of the model with state dependence represent only "short run" effects, i.e. over and above their effect on past off-farm participation. An example is the change in the coefficient of farm size, which became practically zero in the part-time equation and lost more than a third of its magnitude in the full-time equation, after controlling for state-dependence. Similar, although less extreme, changes have occurred in the coefficients of capital stock. Altogether, the hypothesis of no state-dependence can be rejected in all reasonable levels of significance using the likelihood-ratio test.

Table 3a About Here

Focusing on the coefficients estimated with the state-dependence control, we observe that most variables have a stronger effect on the full-time off-farm work choice than on the part-time choice. The establishment-year dummies are significant in the full-time equation only, implying that choosing a full-time off-farm work status is less likely in both the most veteran and the youngest villages than in the intermediate group of villages. Family size has a positive and significant coefficient in the full-time equation. Israeli-born farmers are less likely to work full-time off the farm. Age has a familiar nonlinear effect on both part-time and full-time off-farm work choice, being positive at younger ages and eventually becoming negative at older ages. Years in Israel, which serves as one of the proxies for general human capital, has a significant positive effect on the full-time off-farm work choice only, while schooling has a significant positive effect in both part-time and full-time equations, with a stronger effect in the latter case. Farm size has a significant negative effect on the full-time off-farm work choice only, while capital has a significant negative effect in both part-time and full-time equations, with a stronger effect in the latter case.

We now turn to the work-choice results of the model controlling for unobserved heterogeneity, using data from both census years (Model IV). The results are in Table 3b. We first note that the factor loading is positive and statistically significant in both equations, and the hypothesis of no heterogeneity is rejected by the likelihood-ratio test at all reasonable significance levels. This means that unobserved heterogeneity is important and should be controlled for whenever data availability permits. As opposed to the state-dependence case, many of the coefficients become larger in absolute value after controlling for unobserved heterogeneity. For example, the coefficients of age and schooling in both equations are almost doubled, the coefficients of the capital stock are more than doubled. The 1981-year effect changes even more dramatically, from negative and insignificant to positive and significant in the part-time equation, and from 0.12 to 0.54 in the full-time equation.

Table 3b About Here

As in the model with state-dependence control, most variables have a stronger effect on the full-time off-farm work choice than on the part-time choice. Most of the coefficients have the same sign as in the model with state-dependence, so we will not discuss them explicitly. To evaluate the magnitude of the effect of explanatory variables on the work statuses we conduct simulations. Using the coefficients of the model with unobserved heterogeneity, we simulate the decision to work off the farm in 1981. We find that a ten year increase in the age of farmers reduces the number of farmers that work off the farm by 6% (from 45% as predicted by model III to 39%). However, adding the time trend as if we simulate the changes of the same farmers over calendar time, more than reverses this result. This means that other things equal, no sizeable change in the work patterns of farmers is expected over time.

Adding one person to all farm families increases the number of farmers who work off the farm by 1% only, while an additional year of schooling increases the number of farmers who work off the farm by 2%. A 20% increase in land decreases the number of farmers who work off the farm by 1% only, while a similar increase in the level of capital decreases the number of farmers that work off the farm by 4%. Holding capital constant at the 1971 level, the 1981 off-farm work probabilities rise from 45% to 59%, which means that capital deepening is the exclusive cause to the fall in the probability of working off the farm, from 1971 to 1981.

Figure 2 About Here

Finally, we simulated the age profiles of work-choice probabilities by taking an “average” farmer at age 35, and calculating the changes in probabilities as he ages. This is shown in Figure 2. It is clear that off-farm work probabilities start decreasing after age 47, and it can therefore be concluded that farmers tend to revert to working only on the farm late in the life-cycle.

Capital Equations

Tables 4a and 4b present estimates of the determinants of the value of the farm's capital stock. As with the work-choice equations, we use four specifications. We control for state dependence (Model II), and person-specific unobserved effects (Model IV). In addition, we estimate a separate set of coefficients for each of the three work statutes.[7] As opposed to the work-choice equations, the values of the coefficients in the regression with state dependence are very similar to those of the cross-sectional regression (Model I). Moreover, working full-time off the farm in 1971 has a negative significant effect only on the capital stock of the group of farmers who return to full-time farming. This result confirms what we observed in Figure 1, implies that farms operated by farmers who worked off the farm in the past are less productive, and thus suggests that returning to cultivate a partly-neglected farm is costly.

Tables 4a and 4b About Here

A comparison between Models III and IV shows that the unobserved effects are statistically significant. However, they only alter the results slightly. The 1981 year effect is positive and significant in all equations, pointing to capital deepening during the 1970s regardless of work choice. The main hypothesis that we want to evaluate by estimating a separate set of coefficients for each work choice is how work status affects the capital investment patterns of farmers with statistically comparable characteristics. In other words, we want to compare the capital stock of households that draw all their income from the farm with the capital stock of households that also draw income from working off the farm. A test of imposing a restriction that all parameters in the three equations have the same value is rejected at the $p<0.01$ level. As expected, most of the differences are between the coefficients in the equation for farmers who work only on the farm and the other two equations (those who work

[7] The reader should keep in mind that these coefficients are estimated jointly with those of the work-choice equations.

part-time or full-time off the farm). For example, the ages of the farmer and the farm (Veteran village) have larger positive effects on the capital stock of a farm operator who specializes in farming than on that of a farmer who also works off the farm.

Using our estimates to calculate the value of capital stock over the life cycle, we find that while the value peaks at more or less similar ages across the three statuses (between 42 and 47), the levels and the patterns are very different. As can be seen in Figure 3, the average calculated full-time farmer's capital stock value reaches a maximum of about $121,000, compared to $48,000 for a farmer with a full-time off-farm job. These differences are somewhat more extreme than in the actual data, as can be seen by comparing the two panels of Figure 3. These capital accumulation patterns are consistent with the life cycle investment theory, whereby most investments are made early in the life cycle. However, while full-time farmers invest in the physical capital of their farms, part-time farmers invest relatively more in their own human capital (off-farm work experience). Accordingly, over time, a farm operated by a full-time farmer becomes more productive than a farm operated by a part-time farmer. This implies that the incentive to change work status decreases with age. The decrease in capital late in the life cycle is much stronger for farmers who work only on the farm. This is consistent with the earlier finding that farmers tend to shift away from off-farm work late in the life-cycle.

Figure 3 About Here

We find that more educated farmers have higher capital stocks. Hence, our findings imply that physical capital and general human capital are complements in farm production; they are not substitutes as suggested elsewhere. The schooling coefficient is much smaller for farmers who work full-time off the farm, implying that these farmers invest smaller fractions of their income on the farm (in this regard we interpret schooling as a proxy for off-farm income). The coefficients of farm size are all positive and significant, implying that on average, land and capital are complements. The farm size coefficients in the equations of those who work off the farm are significantly larger than in the equation of those who do not. This indicates that given the work choice, an increase in farm size induces farmers who work off the farm to invest more in capital, probably because they cannot devote more labor to farm work.

However, this result is based on the observed differences among farms. Regarding the unobserved differences, note that the factor loadings are positive in both work choice equations and capital equations, indicating that a farmer who is (unobservably) more likely to participate in off-farm work is also (unobservably) more likely to have a higher level of farm capital. So the observed association between off-farm work and farm capital is opposite in sign to the unobserved association. This is an interesting finding that explains why the results obtained in the literature about the association between farm capital and off-farm work are mixed. This finding also supports our interpretation of the unobserved person-specific effect as an indicator of ability. We learn that more able farmers can work off the farm and still run a capital intensive farm enterprise.

Finally, the capital equations also include controls for the main branch of farming. The omitted category is livestock other than poultry and cattle. We include these controls because each branch requires different combinations of capital assets (livestock for dairy farming, greenhouses for flowers, etc.). One may argue that these variables are endogenous. In Israel, however, it is costly to shift from one branch to the other due to a quota system, so that the choice of major branch preceded the capital investment decision in our model. The results show that farms whose main branch is cattle (mainly dairy farms) are more capital-intensive than other farms, while field-crop farms are the least capital-intensive. When we control for unobserved heterogeneity, the coefficients of flower farms imply that flower-farm operators who work full time off the farm invest more in farm capital relative to full time farmers. This suggests that as opposed to the general pattern, in flower farms capital may be a substitute for family labor.

6. Summary and Conclusions

In this paper we formulate and estimate a model that simultaneously explains off-farm work participation and farm capital investments, two decisions that are closely linked, especially over the life cycle. Despite this fact, and despite the fact that they are very important to the development process, the economic literature did not devote sufficient attention to the joint analysis of these decisions. In particular, the vast empirical literature on farmers' off-farm labor participation and off-farm income of farm households largely ignores the possible endogeneity of farm capital.

We use a two-period Israeli panel data set spanning over ten years. The Israeli example has unique features, which make the results applicable to developing and transition economies. Our empirical model is a combination of multinomial probit for discrete work choices and a switching regression for farm capital. Thus we control for endogeneity of capital in the work choice equations and for selection bias in the capital equations. Using the panel structure, we allow for either structural state dependence or unobserved heterogeneity. In both cases, we find a strong negative association between off-farm work and farm capital accumulation, implying that family labor and farm capital are complements in farm production.

To deal with structural state dependence, we estimate a model that includes past work status among the explanatory variables. We find that state dependence has an important impact on the likelihood of working off the farm, and a relatively small effect on farm capital accumulation. Moreover, comparing this result with cross sectional results reveals that ignoring state dependence leads to over-estimating the effects of personal characteristics and village characteristics on the farm operators' work choices. This is because without the state-dependence control the coefficients represent the long-run effects of these variables on life-cycle work choices.

To deal with unobserved heterogeneity we estimate the model using data from both census years and account for the existence of an unobserved person-specific random effect. Unobserved heterogeneity was found important, and ignoring it caused a considerable bias in several key coefficients of the work-choice equations. We found that the effects of the unobserved factors on capital accumulation and off-farm work participation are similar in sign, meaning that farmers diverge by a common factor (ability?) that allows those at the higher end of the distribution to work off the farm while maintaining a capital-intensive farm enterprise. Note that the unobserved correlation between capital and off-farm work is positive while the observed correlation is negative. This explains why mixed results have been obtained in the literature.

This model enables us to examine the changes in the tendencies of farmers to work off the farm between 1971 and 1981 and decompose these changes into several components. Capital deepening is found to cause most of the overall decline in the rates of off-farm work participation. Thus, holding the capital stock constant at its 1971 level results in an increase rather than a decrease in the off-farm participation probabilities between 1971 and 1981. Since farm capital investments were heavily subsidized in the 1970s, this result demonstrates the policy relevance of the joint analysis of work choices and capital accumulation.

The findings of the capital stock regressions are also quite interesting. Statistically comparable (based on observed and unobserved characteristics) farm operators accumulate different amounts of capital assets, depending on their work status. At the peak (around age 45), the capital stock in farms whose operator holds a full-time job off the farm is less than 40% of that in farms whose operator does not work off the farm. Unlike the case of the work choice decision, we find that the results are not sensitive to either unobserved heterogeneity or state-dependence.

These results highlight the advantage of allowing mutual dependence between work decisions and capital decisions in empirical analyses of farm surveys. Ignoring this dependence may result in incorrect conclusions. Farmers' decision-making is quite sensitive to policy. Our particular example shows that an investment subsidy could lead not only to over-investment in farm capital, but also to distorted labor allocation decisions, that have adverse welfare effects in the long run. This lesson should be of interest to policy makers, especially in developing and transition economies.

Our analytical strategy calls for using a longer panel data set, and even more importantly, to use panel data from other countries. The use of such panels, which we hope to construct in the near future, will increase the effectiveness of our estimation and simulation methods. Hence, it will allow us to continue and explore the unexplained patterns of farmers' behavior over the life cycle. In particular, we are interested in exploring an important methodological question, which is whether the state dependence we find in the data is indeed structural, or simply a reflection of unobserved heterogeneity. This question is extremely important for policy implications, since structural state dependence implies that current policy affects outcomes in future periods as well, while unobserved heterogeneity implies a limited scope for policy interventions.

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Appendix A- Creation of the Working Sample

The 1981 census data set includes 28,566 observations, versus 20,848 in the 1971 census data set, since inclusion criteria were more liberal in 1981. 20,186 observations were identified as representing the same physical farm units in both census years, but only 84% of those (16,908) are recognized as matched observations, i.e., operated by the same household. Of these, 11,777 (70%) observations clearly represent family farms (others are partnerships, private farms, etc.).

Although information was collected about the time allocation of all household members, the file we have includes only information on the farm operator. Hence, we are interested in an even smaller subsample, namely, farms in which the same household member is reported as the farm operator, in both census years. We used an age criterion, using only family farms in which the 1981 operator was exactly ten years older than the 1971 operator. 7,558 farms (64%) satisfied this criterion. We further excluded farms with zero reported land holdings or capital stock, operators who reported in 1981 that they have less than ten years experience in running the farm, and operators who reportedly immigrated to Israel after 1971. The remaining sample includes 7,446 observations. Of these, we selected the 6,047 farm operators who were under 65 years of age (which is the formal age of retirement in Israel) in 1981. Some of these observations still include missing values in several key variables, and these will be dealt with later.

Before proceeding with the estimation, we inspected the data for possible bias resulting from the selection of our working sample. Appendix Table A1 shows the variable means in the various data sets described above, starting from the complete censuses and ending with our working sample. Our sample clearly over-represents younger farmers, by construction. This is also reflected in the over-representation of young and southern villages and the under-representation of veteran and northern villages. Sample families are larger and have larger farms (in terms of land and capital). Some differences also exist in the relative frequencies of the off-farm work status. All these differences are in line with the sample-selection procedure described above.

Table A1. Variable Means in the Different Samples

Variables	Complete census 1971	Complete census 1981	Matched sample 1971	Matched sample 1981	Family farms 1971	Family farms 1981	Matched operators 1971	Matched operators 1981	Working sample 1971	Working sample 1981
Work status										
Work part-time off-farm (share)	0.10	0.07	0.11	0.08	0.12	0.13	0.13	0.09	0.14	0.10
Work full-time off-farm (share)	0.30	0.37	0.31	0.31	0.27	0.26	0.30	0.25	0.33	0.30
Village-related										
Veteran village (share)	0.21	0.21	0.20	0.20	0.21	0.21	0.20	0.20	0.16	0.16
Young village (share)	0.21	0.24	0.21	0.21	0.22	0.22	0.22	0.22	0.25	0.25
Location: North (share)	0.41	0.42	0.44	0.44	0.41	0.41	0.41	0.41	0.39	0.39
Location: South (share)	0.26	0.26	0.19	0.19	0.27	0.27	0.28	0.28	0.31	0.31
Personal-related[a]										
Family size (people)	5.09	4.56	5.39	5.09	5.55	5.32	5.75	5.41	6.08	5.79
Born in Israel (share)	—	0.23	—	0.15	—	0.16	0.12	0.12	0.13	0.13
Born in Africa/Asia (share)	—	0.45	—	0.55	—	0.55	0.56	0.56	0.61	0.61
Age	47.70	47.75	46.56	52.20	45.82	51.79	43.90	53.90	40.09	50.09
Years in Israel (years)	—	32.38	—	33.31	—	33.44	23.97	33.97	23.06	33.06
Schooling (years)	—	8.64	—	7.61	—	7.74	7.55	7.55	7.63	7.63
Farm-characteristics										
Farm size (dunam)	28.30	24.02	27.79	27.71	28.87	29.50	29.20	29.70	29.13	30.30
Capital stock (1981 $'000)	40.27	60.78	40.40	74.84	45.18	(-)	48.10	89.45	47.51	95.02
No. of observations	20,848	28,566	16,908	16,908	11,777	11,777	7,446	7,446	6,047	6,047

[a] The questions on ethnic origin, years in Israel and schooling were asked only in 1981. We constructed them retrospectively after identifying the person.

Table 1. Transition between Work Statuses (percentage)

Origin: Work status in 1971	Percentage in original status (1971)	Destination: Work Status 1981		
		Work only on-farm	Work part-time off-farm	Work full-time off-farm
Work only on-farm	51.5	77.9	7.7	14.4
Work part-time off-farm	14.5	49.2	17.5	33.3
Work full-time off-farm	34.0	34.3	12.1	53.6
Percentage in destination status (1981)		59.0	10.5	30.5

Table 2. Mean Characteristics of Farm Operators, 1971 and 1981

	Worked only on-farm		Worked off-farm			
			Part-time		Full-time	
Variables	1971	1981	1971	1981	1971	1981
Village-related						
Veteran village (share)	0.18	0.17	0.11	0.17	0.14	0.12
Middle-age village (share)	0.54	0.54	0.65	0.55	0.62	0.67
Young village (share)	0.27	0.27	0.22	0.26	0.22	0.20
Location: North (share)	0.44	0.45	0.51	0.38	0.43	0.47
Location: Center (share)	0.19	0.18	0.21	0.23	0.23	0.25
Location: South (share)	0.36	0.36	0.26	0.38	0.33	0.27
Personal-related						
Family size (people)	5.95	5.66	6.45	5.75	6.11	6.05
Born in Israel (share)	0.15	0.15	0.11	0.14	0.12	0.11
Born in Africa/Asia (share)	0.59	0.60	0.70	0.62	0.66	0.68
Age	40.65	50.72	40.31	49.95	39.17	48.96
Years in Israel	22.94	32.82	22.15	32.31	22.65	32.21
Schooling (years)	9.05	9.12	9.07	9.47	9.66	9.48
Farm-characteristics						
Farm size (dunam)	34.29	33.55	24.29	29.84	23.34	24.15
Capital stock (1981 $'000)	58.26	111.65	40.05	81.89	34.36	67.38
Principal farm enterprise:						
Fruit (share)	0.05	0.18	0.13	0.30	0.21	0.31
Vegetables (share)	0.25	0.15	0.16	0.13	0.10	0.08
Field crops (share)	0.01	0.03	0.02	0.05	0.06	0.06
Flowers (share)	0.06	0.13	0.02	0.08	0.01	0.06
Poultry (share)	0.27	0.30	0.41	0.31	0.43	0.41
Cattle (share)	0.27	0.16	0.19	0.08	0.13	0.05
Other livestock (share)	0.01	0.01	0.01	0.01	0.01	0.01
No. of observations	3,118	3,567	879	638	2,050	1,842

Table 3a. Coefficient Estimates of Work Choice Equations: Models I and II

	Model I: Without state dependence		Model II: With state dependence	
	Part-time off-farm work	Full-time off-farm work	Part-time off-farm work	Full-time off-farm work
Constant	**–2.3831**	**–1.6077**	**–2.1747**	–1.1903
	(0.7479)	–(0.6433)	(0.7599)	(0.6339)
Veteran village	0.0361	**–0.1451**	0.0657	**–0.1233**
	(0.0707)	(0.0639)	(0.0738)	(0.0685)
Young village	–0.0605	**–0.2550**	–0.0212	**–0.2204**
	(0.0521)	(0.0464)	(0.0532)	(0.0467)
Family size	0.0110	**0.0310**	0.0021	**0.0198**
	(0.0102)	(0.0082)	(0.0106)	(0.0086)
Born in Israel	–0.0267	**–0.1878**	–0.0038	**–0.1325**
	(0.0946)	(0.0825)	(0.0978)	(0.0835)
Born in Asia/Africa	0.0021	0.0760	–0.0623	–0.0029
	(0.0611)	(0.0545)	(0.0635)	(0.0569)
Age	**0.1055**	**0.1051**	**0.0828**	**0.0704**
	(0.0323)	(0.0266)	(0.0329)	(0.0264)
Age^2	**–0.0011**	**–0.0012**	**–0.0009**	**–0.0009**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Years in Israel	–0.0008	**0.0134**	–0.0042	**0.0079**
	(0.0043)	(0.0036)	(0.0045)	(0.0037)
Schooling (years)	**0.0491**	**0.0684**	**0.0311**	**0.0414**
	(0.0101)	(0.0083)	(0.0105)	(0.0087)
Farm size	**–0.0030**	**–0.0096**	-0.0006	**–0.0060**
	(0.0011)	(0.0010)	(0.0012)	(0.0011)
Log Capital stock	**–0.2809**	**–0.4148**	**-0.2273**	**–0.3522**
	(0.0633)	(0.0490)	(0.0652)	(0.0510)
Part time off-farm in 1971			**0.7036**	**0.6435**
			(0.0600)	(0.0549)
Full time off-farm in 1971			**0.6977**	**1.0891**
			(0.0506)	(0.0426)
No. of observations	6,047		6,047	
No. of parameters	84		94	
Log–likelihood	–11,060		–10,656	

Notes: Standard deviations are in parentheses. **Bold** numerals denote 5% significance level. Included in the estimations (but not reported) are flags indicating missing values for Schooling and Years in Israel. Models I and II use data only for 1981.

Table 3b. Coefficient Estimates of Work Choice Equations: Models III and IV

	Model III: Without heterogeneity control		Model IV: With heterogeneity control	
	Part-time off-farm work	Full-time Off-farm work	Part-time off-farm work	Full-time off-farm work
Constant	**–0.9256**	**–0.5737**	**–1.9218**	**–2.2950**
	(0.2875)	(0.2601)	(0.3225)	(0.3382)
Veteran village	–0.0508	**–0.0912**	0.0585	0.0682
	(0.0473)	(0.0391)	(0.0580)	(0.0662)
Young village	**–0.1338**	**–0.2130**	**–0.1911**	**–0.2976**
	(0.0344)	(0.0293)	(0.0428)	(0.0482)
Family size	**0.0226**	**0.0334**	**0.0221**	**0.0362**
	(0.0064)	(0.0054)	(0.0075)	(0.0079)
Born in Israel	–0.0086	**–0.2236**	–0.0141	**–0.2262**
	(0.0606)	(0.0525)	(0.0744)	(0.0857)
Born in Asia/Africa	0.0480	**0.0745**	**0.1397**	**0.2363**
	(0.0412)	(0.0340)	(0.0505)	(0.0564)
Age	**0.0484**	**0.0631**	**0.0919**	**0.1303**
	(0.0139)	(0.0123)	(0.0155)	(0.0154)
Age^2	**–0.0006**	**–0.0008**	**–0.0011**	**–0.0016**
	(0.0002)	(0.0001)	(0.0002)	(0.0002)
Years in Israel	**0.0053**	**0.0173**	0.0026	**0.0138**
	(0.0026)	(0.0023)	(0.0033)	(0.0038)
Schooling (years)	**0.0417**	**0.0751**	**0.0744**	**0.1310**
	(0.0066)	(0.0051)	(0.0084)	(0.0088)
Farm size	**–0.0068**	**–0.0111**	**–0.0048**	**–0.0091**
	(0.0007)	(0.0006)	(0.0008)	(0.0008)
1981 dummy	–0.0504	**0.1202**	**0.2008**	**0.5363**
	(0.0503)	(0.0450)	(0.0601)	(0.0627)
Log Capital stock	**–0.2991**	**–0.4654**	**–0.7166**	**–1.1560**
	(0.0439)	(0.0351)	(0.0583)	(0.0556)
α^v (factor loading)			**2.2007**	**3.6406**
			(0.1205)	(0.1244)
No. of observations	12,094		12,094	
No. of parameters	89		97	
Log likelihood	–21,891		–20,913	

Notes: Standard deviations are in parentheses. **Bold** numerals denote 5% significance level. Included in the estimations (but not reported) are flags indicating missing values for Schooling and Years in Israel. Models III and IV use data for 1971 and 1981. The factor loading corresponds to the coefficient of the unobserved heterogeneity. A three-point heterogeneity distribution is fitted.

Table 4a. Coefficient Estimates for Determinants of Capital Stock: Models I and II

	Model I: Without state-dependence			Model II: With state-dependence		
	Work only on-farm	Part-time off-farm	Full-time off-farm	Work only on-farm	Part-time off-farm	Full-time off-farm
Constant	**1.9304**	1.2735	**1.9688**	**1.9554**	1.3566	**1.9367**
	(0.3880)	(0.9587)	(0.5405)	(0.3854)	(0.9563)	(0.5439)
Veteran village	**0.1421**	0.0130	–0.0425	**0.1276**	0.0084	–0.0419
	(0.0371)	(0.0838)	(0.0541)	(0.0372)	(0.0851)	(0.0540)
Young village	**0.0719**	–0.1117	**0.1073**	**0.0660**	–0.1077	**0.1054**
	(0.0285)	(0.0617)	(0.0420)	(0.0283)	(0.0627)	(0.0418)
North	**0.1912**	**0.2053**	**0.1361**	**0.1921**	**0.2055**	**0.1367**
	(0.0332)	(0.0774)	(0.0378)	(0.0331)	(0.0789)	(0.0378)
South	**0.2193**	**0.1698**	**0.2938**	**0.2223**	**0.1781**	**0.2936**
	(0.0340)	(0.0788)	(0.0446)	(0.0341)	(0.0807)	(0.0447)
Age	**0.0820**	**0.1125**	**0.0643**	**0.0826**	**0.1096**	**0.0661**
	(0.0153)	(0.0366)	(0.0214)	(0.0152)	(0.0367)	(0.0216)
Age^2	**–0.0009**	**–0.0012**	**–0.0007**	**–0.0009**	**–0.0012**	**–0.0007**
	(0.0002)	(0.0004)	(0.0002)	(0.0002)	(0.0004)	(0.0002)
Schooling	**0.0483**	**0.0491**	**0.0344**	**0.0499**	**0.0502**	**0.0348**
	(0.0052)	(0.0107)	(0.0056)	(0.0052)	(0.0109)	(0.0056)
Farm size	**0.0092**	**0.0108**	**0.0137**	**0.0089**	**0.0108**	**0.0137**
	(0.0002)	(0.0014)	(0.0007)	(0.0002)	(0.0014)	(0.0007)
Fruit	**–0.4831**	**–0.5463**	**–0.4583**	**–0.4625**	–0.5594	**–0.4469**
	(0.0702)	(0.3044)	(0.1242)	(0.0704)	(0.2963)	(0.1257)
Vegetables	**–0.6619**	**–0.7696**	**–0.7644**	**–0.6595**	**–0.7864**	**–0.7558**
	(0.0701)	(0.3078)	(0.1274)	(0.0702)	(0.3000)	(0.1281)
Field crops	**–1.2212**	**–1.3006**	**–1.1979**	**–1.2099**	**–1.3147**	**–1.1890**
	(0.0765)	(0.3081)	(0.1276)	(0.0764)	(0.2994)	(0.1289)
Flowers	–0.0150	–0.0850	0.1067	–0.0034	–0.1027	0.1153
	(0.0750)	(0.3200)	(0.1375)	(0.0751)	(0.3123)	(0.1392)
Poultry	–0.1387	–0.2516	–0.0670	–0.1265	–0.2744	–0.0573
	(0.0694)	(0.3053)	(0.1243)	(0.0696)	(0.2975)	(0.1258)
Cattle	**0.2426**	0.0924	0.2118	**0.2339**	0.0652	0.2194
	(0.0744)	(0.3176)	(0.1451)	(0.0744)	(0.3105)	(0.1465)
Part time off-				**–0.0910**	0.0780	–0.0247
farm in 1971				(0.0383)	(0.0749)	(0.0493)
Full time off-				**–0.1392**	–0.0327	–0.0323
farm in 1971				(0.0315)	(0.0615)	(0.0394)
S^2_w	0.4365	0.3869	0.3900	0.4334	0.3851	0.3898

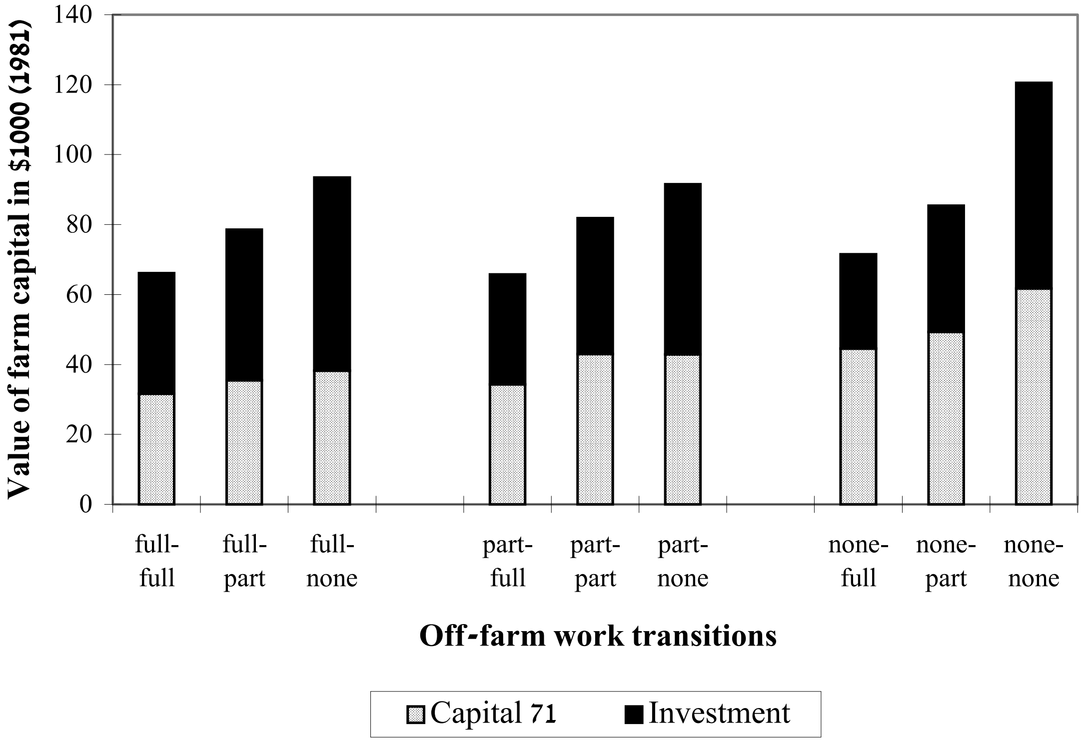
Notes: Standard deviations are in parentheses. **Bold** numerals denote 5% significance level. Included in the estimations (but not reported) are flags indicating missing values for Schooling. Models I and II use data only for 1981.

Table 4b. Coefficient Estimates for Determinants of Capital Stock: Models III and IV

	Model III: Without heterogeneity control			Model IV: With heterogeneity control		
	Work only on-farm	Part-time off-farm	Full-time off-farm	Work only on-farm	Part-time off-farm	Full-time off-farm
Constant	**1.0743**	**1.1047**	**1.3537**	**0.3684**	0.4033	**0.5112**
	(0.1623)	(0.3499)	(0.1981)	(0.1541)	(0.3216)	(0.1928)
Veteran village	**0.1986**	0.0669	0.0353	**0.1962**	0.0333	0.0101
	(0.0222)	(0.0511)	(0.0321)	(0.0253)	(0.0506)	(0.0333)
Young village	**0.0503**	–0.0678	**0.0708**	0.0027	**–0.0935**	0.0432
	(0.0180)	(0.0394)	(0.0258)	(0.0202)	(0.0377)	(0.0265)
North	**0.1193**	0.0782	0.0361	**0.1059**	0.0740	0.0379
	(0.0206)	(0.0445)	(0.0247)	(0.0229)	(0.0429)	(0.0261)
South	**0.1780**	**0.1729**	**0.1857**	**0.1457**	**0.1671**	**0.1888**
	(0.0208)	(0.0462)	(0.0274)	(0.0230)	(0.0450)	(0.0288)
Age	**0.0956**	**0.0830**	**0.0623**	**0.1013**	**0.0798**	**0.0641**
	(0.0068)	(0.0142)	(0.0085)	(0.0061)	(0.0129)	(0.0078)
Age^2	**–0.0010**	**–0.0010**	**–0.0007**	**–0.0011**	**–0.0009**	**–0.0007**
	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Schooling	**0.0444**	**0.0384**	**0.0282**	**0.0487**	**0.0464**	**0.0372**
	(0.0032)	(0.0063)	(0.0036)	(0.0035)	(0.0061)	(0.0039)
Farm size	**0.0088**	**0.0120**	**0.0126**	**0.0077**	**0.0099**	**0.0102**
	(0.0002)	(0.0008)	(0.0005)	(0.0002)	(0.0007)	(0.0005)
1981 dummy	**0.6368**	**0.6995**	**0.6248**	**0.6261**	**0.6860**	**0.6282**
	(0.0215)	(0.0416)	(0.0267)	(0.0193)	(0.0376)	(0.0250)
Fruit	**–0.4338**	–0.1750	**–0.2054**	**–0.3743**	–0.1809	**–0.2192**
	(0.0415)	(0.1084)	(0.0622)	(0.0403)	(0.1085)	(0.0593)
Vegetables	**–0.6984**	**–0.5761**	**–0.7022**	**–0.5432**	**–0.4730**	**–0.6167**
	(0.0396)	(0.1078)	(0.0648)	(0.0388)	(0.1074)	(0.0613)
Field crops	**–1.0751**	**–1.0448**	**–0.8610**	**–0.8605**	**–0.9144**	**–0.7922**
	(0.0487)	(0.1150)	(0.0648)	(0.0486)	(0.1149)	(0.0618)
Flowers	0.0572	0.0995	**0.2704**	**0.0942**	0.0791	**0.2441**
	(0.0422)	(0.1182)	(0.0767)	(0.0409)	(0.1174)	(0.0711)
Poultry	–0.0649	0.1396	**0.1608**	–0.0434	0.0996	0.1048
	(0.0392)	(0.1067)	(0.0623)	(0.0383)	(0.1069)	(0.0590)
Cattle	**0.1950**	0.1662	0.1236	**0.1955**	0.1524	0.0831
	(0.0411)	(0.1100)	(0.0669)	(0.0405)	(0.1102)	(0.0637)
α^y (factor loading)				**1.2081**	**1.2436**	**1.1855**
				(0.0375)	(0.0724)	(0.0534)
S^2_w	0.3872	0.3584	0.3714	0.2739	0.2523	0.2777

Notes: Standard deviations are in parentheses. **Bold** numerals denote 5% significance level. Included in the estimations (but not reported) are flags indicating missing values for Schooling. Models III and IV use data for 1971 and 1981. The factor loading corresponds to the coefficient of the unobserved heterogeneity. A three-point heterogeneity distribution is fitted.

Figure 1. Farm Capital and Off-Farm Work Status Interrelations and Transitions



Note: the height of the lighter bar is the 1971 capital stock, while the whole height of the bar represents the 1981 capital stock. Hence, what we call "investment" is simply the difference.

Figure 2. Calculated Age Profiles of Work Choice Probabilities

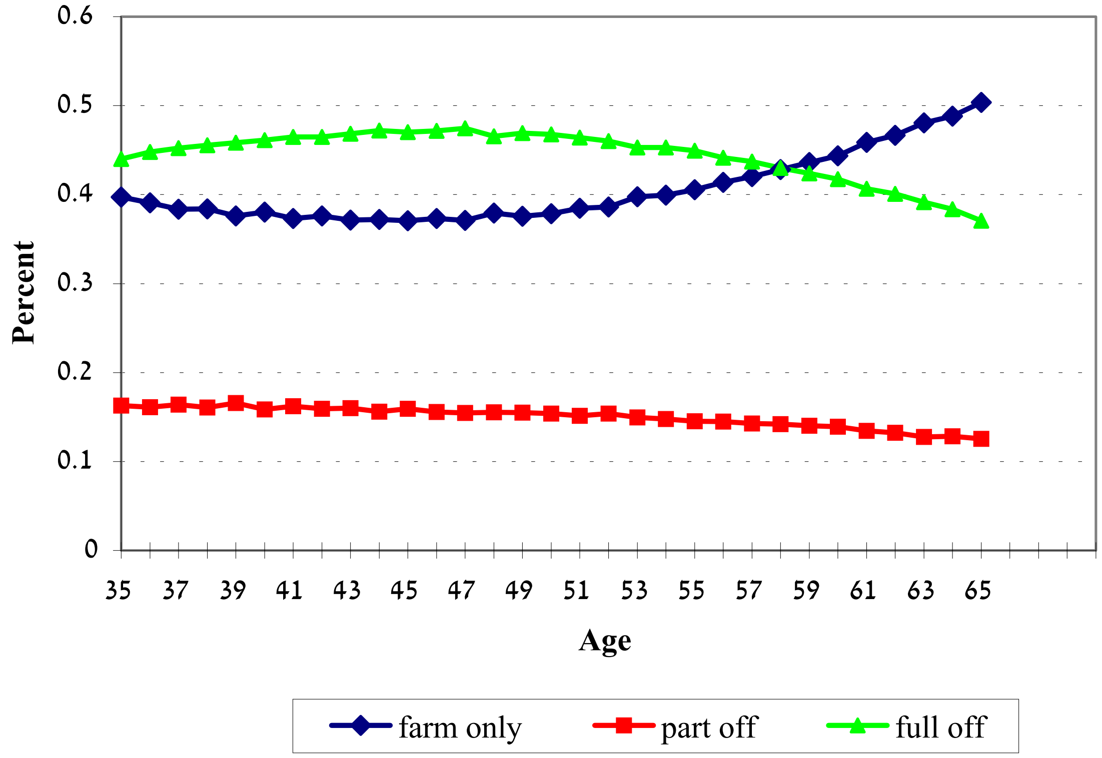


Figure 3. Calculated versus Actual Age Profiles of Capital Stock