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Off-Farm Labour Decisions of Norwegian Farm Households

Conference paper for the 39th congress of the European Regional Science Association
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Abstract

In this paper we discuss the off-farm labour decisions of Norwegian farm households using household production theory. The off-farm participation decision rule is modelled by a binary probit model estimated by general maximum likelihood estimation on a panel data set of Norwegian farm households. The households' labour supply equations are estimated using the least squares dummy variable (LSDV) model. In the modelling of labour market data, we often detect persistence in state due to either *true state dependence*, where present state is modified by earlier states, or *heterogeneity* (unobservable permanent individual characteristics), or both. Despite convincing evidence of state dependence, we have not accounted for heterogeneity in the participation model since the loss of consistency would be negligible due to lacking personal characteristics variables, but in estimating off-farm labour supply, the heterogeneity is well accounted for. The results show that both the participation decision and off-farm labour supply follow a concave life-cycle pattern and that additional work hours on the farm reduce off-farm labour supply, but not participation. We also find that taking on off-farm work is more probable in densely populated regions.

Introduction

The problem of farmers' time-allocation attract researchers since many farmers divide their time between two major occupations, farm work and off-farm work (Kimhi, 1996). Off-farm employment of farmers has increased throughout the post-war period and has become an important phenomenon all over the world. Off-farm participation is connected with factors such as economic growth through prospects of higher incomes in the non-farm sector (Huffman 1980), risk diversification, productivity gains due to technological changes, and declining prices on farm products. A large proportion of farm families have chosen to quit farming to take on off-farm jobs, while others prefer to divide their time between farming and off-farm employment. In the US about six percent of all farm operators worked 200 or more days each year off the farm before World War II (Huffman 1997). In 1994 the proportion of farmers working at least 200 days off the farm had risen to thirty percent (Huffman 1997). An equivalent development can be found in the Norwegian agricultural sector as total farm units decrease while the off-farm participation of farm household members increase (NILF 1996). In conjunction with the increasing number of farmers working off the farm is the increased importance of income earned in the off-farm sector (Weersink 1992). The share of total income coming from off-farm work has risen significantly and is on average above fifty percent of the smaller and medium-sized Norwegian farms total household income (NILF 1996).

The purpose of this paper is to examine the off-farm labour decisions of Norwegian farm households. We start by presenting a household production model based on neo-classical labour supply theory. The next parts of the paper presents the econometric models and the available data used to estimate off-farm participation and labour supply. The participation decision is a binary choice problem requiring the use of qualitative dependent variable methods. The households' off-farm labour supply are modelled by a least squares dummy variable (LSDV) model, taking account of individual specific characteristics. As the off-farm labour

decisions are estimated on panel data, we discuss problems of state dependence, due to both adaptive persistence in state and individual specific preferences (heterogeneity). Panel data sets possess several major advantages over conventional cross-sectional or time-series data sets, for instance by improving efficiency by increasing the degrees of freedom and reducing the collinearity among explanatory variables (Hsiao 1996). One of the advantages of using longitudinal data is the possibility of taking account of individual specific characteristics instead of considering the aggregate of the individual effects and the omitted-variable effects as pure chance effects (as in the cross-sectional setting), but this possibility also complicate the estimation problem. Finally, the results are presented, followed by the implications the findings may have for future work.

Theoretical model

Following the extensive literature on the off-farm behaviour in a pure cross-sectional setting, the decision to work off the farm can be modelled using household production theory (Huffman 1980, Weersink 1992). The household production function considers both technical factors of production and time costs, and the labour supply decisions of the farm household members are derived from the household maximizing utility subject to constraints on time, income and farm production. Utility, U , can be derived from purchased goods, G , and the household members' leisure time, S , and is affected by environmental factors, E , such as personal, household and farm characteristics, which are assumed to be exogenous to current consumption decisions:

$$(1) \quad U = U(G, S; E), \quad \partial U / \partial G > 0, \quad \partial U / \partial L > 0$$

Utility is assumed to be ordinal and strictly concave and is maximized subject to constraints on time, income and farm productivity. As we consider the farm households joint labour decisions, the farmer's and the spouse's time are assumed to be homogeneous. The farm households have a fixed amount of time, T , each year which can be allocated between leisure time, farm work, F , and off-farm work, OF .

$$(2) \quad T = S + F + OF, \quad OF \geq 0$$

Optimal hours of off-farm work may be zero in any given year, but it can be argued that existence of search costs or individual preferences may cause asymmetries and non-reversibilities in off-farm labour supply. The consumption of market goods at the price P_G will be limited by the available income earned from farm profits, net income from off-farm work, and other household income, V . The farm households are assumed to be competitive in input and output markets and farm profit is set equal to the price of farm output, Q , less the variable costs of production, $R \cdot X$, where R is the input price vector and X is the quantity of inputs used. Off-farm work is paid at the market wage rate W .

$$(3) \quad P \cdot Q - R \cdot X + W \cdot OF + V = P_G \cdot G$$

Following the literature, we assume flexible work schedules in off-farm employment so that the farm household members can maximize utility by offering an optimal number of off-farm work hours. The properties of the farm production function represent the third and final constraint to

the household's consumption abilities. Farm output is a function of the household members' farm work hours and a vector of input factors, and is dependent on a vector of fixed farm inputs, K , and of human capital characteristics, H , such as education and agricultural training.

$$(4) \quad Q = f(F, X; K, H)$$

where $f(\cdot)$ is assumed to be a strictly concave production function.

Conditions for optimal quantities of off-farm work (OF), of the two input variables in household consumption (G and S), and of the two variable inputs in production (F and X) are obtained by maximizing equation (1) subject to equations (2) - (4). The Lagrange function can be expressed like

$$(5) \quad L = U(G, S; E) + I(T - S - F - OF) + g(P * Q - R * X + W * OF + V - P_G G) + d(f(F, X; K, H) - Q)$$

and the maximization problem gives the following first order conditions for an interior solution:

$$(6) \quad \frac{\partial L}{\partial S} = U'_S - I = 0$$

$$(7) \quad \frac{\partial L}{\partial G} = U'_G - g = 0$$

$$(8) \quad \frac{\partial L}{\partial F} = -I + df'_F(\cdot) = 0$$

$$(9) \quad \frac{\partial L}{\partial OF} = -I + gW = 0$$

$$(10) \quad \frac{\partial L}{\partial X} = -gR + df'_X(\cdot) = 0$$

$$(11) \quad \frac{\partial L}{\partial Q} = gP - d = 0$$

$$(12) \quad \frac{\partial L}{\partial I} = T - S - F - OF = 0$$

$$(13) \quad \frac{\partial L}{\partial g} = P * Q - R * X + W * OF + V - P_G G = 0$$

$$(14) \quad \frac{\partial L}{\partial d} = f(F, X; K, H) - Q = 0$$

From equations (10) and (11) we find that variable inputs should be used to the point at which their marginal value product is equal to their marginal cost. Equations (6) - (8) and (11) states that the marginal value of farm work should equal the marginal rate of substitution between leisure and consumption. This holds as an equality when we assume that the farm households offer a positive amount of farm labour hours ($F > 0$). Equations (6), (7) and (9) states that the household members' will offer a positive amount of off-farm work hours if the marginal return to off-farm labour is equal to the marginal rate of substitution between leisure and consumption. Assuming an interior solution the producer's off-farm wage will equal the marginal value of farm labour, i.e. the marginal value of time should be equal in all employments.

$$(15) \quad \frac{U_s}{U_G} = P * f_F(K, H) = W$$

The decision to work off-farm can be summarized through the following participation rule which states that the farm household will work off the farm only when the wage rate exceeds the marginal value of farm work, when off-farm hours are zero.

$$(16) \quad D = \begin{cases} 1 & \text{if } W > Pf_F(K, H)|_{OF=0} \\ 0 & \text{if } W \leq Pf_F(K, H)|_{OF=0} \end{cases}$$

According to equation (16) the households will work off the farm if the offered market wage exceeds the marginal value of farm work evaluated at the point of optimal allocation of time between farm work and leisure. The binary decision rule is a function of all the exogenous variables in the model since the optimal off-farm work hours, OF^* , is determined jointly with farm labour allocation, F^* . If we account for the existence of asymmetries and non-reversibilities in off-farm labour supply due to either true state dependence (e.g. search costs) or individual preferences, it is not given that a fall in the market wage rate below the marginal value of farm work will cause an exit from the labour force. We discuss the problems of state dependence more closely below.

Empirical model

To estimate the decision rule for the households' off-farm labour participation we specify a binary choice model based on the method of maximum likelihood, where each observation is treated as a single draw from a Bernoulli distribution (Greene 1997). The dependent variable is set up as a 0-1 dummy taking the value 1 for the households that participate in off-farm work and 0 for the households that don't, just like in equation (16) above. The predicted value of the dependent variable can be interpreted as the probability of participating in off-farm work, given the values of the explanatory variables (Kennedy 1996).

We specify the probit model as follows:

$$(17) \quad \begin{aligned} y_{it}^* &= \mathbf{b}'x_{it} + \mathbf{e}_{it}, \quad \mathbf{e}_{it} \sim N[0,1], \quad i = 1, \dots, n, \quad t = 1, \dots, T_i, \\ y_{it} &= \begin{cases} 1 & \text{if } y_{it}^* > 0 \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

where y_{it}^* is the dependent variable in a linear regression giving the farm households off-farm labour hours. x_{it} is a matrix of the explanatory variables and β is the parameter vector to be estimated. The probit model correspond to the cumulative normal distribution where the disturbance term has a two-point distribution $(1 - \mathbf{b}'x)$ and $(-\mathbf{b}'x)$, with the probabilities $(\mathbf{b}'x)$ and $(1 - \mathbf{b}'x)$, respectively.

We assume that the \mathbf{e}_{it} 's are independently distributed standard normal variables. This will make the panel nature of the data irrelevant and the methods for the cross-sectional probit model can be applied (Greene 1997). As already mentioned, due to heterogeneity it is not given that the residuals can be taken as independent standard normal variables. When using panel data, a persistence in state is often observed, and individuals who have experienced an event or state are found to have a higher probability of experiencing that state in the future than those who have not (Corsi & Findeis 1998). We can distinguish between *true state dependence*, in which the probability of being in a state depends on the previous state, and *spurious state dependency* or *heterogeneity*, which may be caused by the households' having different preferences towards e.g. off-farm work. In the case of true state dependence, cross-sectional approaches will wrongly assume that all individuals have the same behaviour while they are actually different according to their previous state, and in the case of state dependence due to heterogeneity, the cross-sectional results will tend to be biased as they fail to consider individual time-invariant characteristics. When intertemporal correlation in the unobservables is ignored, we will generally find that too much credit is attributed to past experience as a determinant of employment (Hsiao 1996), and ignoring heterogeneity may also induce the problem of underpredicting households who work off-farm all the time, while overpredicting households that don't work off-farm.

Presence of heterogeneity requires the use of a random effects probit model to get consistent estimates as the models developed for analyzing cross-sectional data ignore individual differences and treat the aggregate of the individual effect and the omitted variable effect as a pure chance events (Hsiao 1996). The error term of the random effects probit model is specified as $\mathbf{e}_{it} = \mathbf{u}_{it} + u_i$ with both components normally distributed with zero means and independently of one another. The time-invariant individual-specific effects are represented by the term u_i . Instead of having a probability function for y_{it} conditional on u_i as in the cross-sectional setting, we get a probability function that is marginal on u_i (Hsiao 1996).

In the problem of estimating the households' labour supply equations, it is simpler to account for individual effects either by using a least squares dummy variable (LSDV) model or generalized least squares (GLS) depending on whether the individual effects are correlated with the explanatory variables or not. The LSDV model models the fixed effects approach, where the individual effects can be captured as differences in the constant term. We can write the fixed effects model as

$$(18) \quad y_{it} = \mathbf{a}_i^* + \mathbf{b}'x_{it} + \mathbf{e}_{it}, \quad \begin{matrix} i = 1, \dots, N, \\ t = 1, \dots, T, \end{matrix}$$

where \mathbf{b}' is a $1 \times K$ vector of constants to be estimated, \mathbf{x}_{it} is a $K \times 1$ vector of explanatory variables and \mathbf{a}_i^* is a 1×1 scalar constant representing the effects of those variables peculiar to the i th individual in more or less the same fashion over time (Hsiao 1996). The error term, \mathbf{e}_{it} , represents the effect of the omitted variables that are peculiar to both individuals and time-periods and can be assumed to have zero mean and variance \mathbf{s}_e^2 . The fixed effects estimator, \mathbf{b} , is also called the within-group estimator, since only the variation within each group is utilized in forming this estimator.

In the random effects approach, modelled by GLS, the individual effect are treated as random variables that are uncorrelated with the explanatory variables. The model can be written like

$$(19) \quad y_{it} = \mathbf{b}' \mathbf{x}_{it} + \mathbf{e}_{it}, \quad \text{where } \mathbf{e}_{it} = \mathbf{a}_i + u_{it}$$

$$\left. \begin{aligned} E\mathbf{a}_i &= E u_{it} = 0, \quad E\mathbf{a}_i u_{it} = 0, \\ E\mathbf{a}_i \mathbf{a}_j &= \begin{cases} \mathbf{s}_a^2 & \text{if } i = j, \\ 0 & \text{if } i \neq j, \end{cases} \\ E u_{it} u_{js} &= \begin{cases} \mathbf{s}_u^2 & \text{if } i = j, t = s, \\ 0 & \text{if } i \neq j, t \neq s \end{cases} \end{aligned} \right\}$$

The random effects model is also called the variance-components model. The time invariant random disturbance, \mathbf{a}_i , represents all individual specific factors that affect the value of the dependent variable but that have not been explicitly included among the explanatory variables (Hsiao 1996). While the individual effects could be expressed through the constant term in the fixed effects model, the differences between the individuals are treated as parametric shifts of the regression function in the random effects model.

It is not always obvious whether one should treat the individual effects as fixed or as random. When the number of time-periods is small and the number of individuals large, one may get surprisingly large differences in the parameter estimates by the two approaches. Which model is the better depends on the context of the data and what the economic relationship the model is meant to explain. When estimating farm households' off-farm labour supply it is reasonable to assume that the individual effects are correlated with the explanatory variables. Suppose we are regressing labour supply on education. Then missing variables like e.g. ability are likely to be correlated with the regressor, and the fixed effects model would be preferable. When individual effects that are correlated with the other regressors are treated as random, the coefficient estimates will be biased (whereas modelling them as fixed effects will not cause bias). We can use a Hausman test for correlation between the error and the regressors to check whether the random effects approach is appropriate. Under the null hypothesis of no correlation, the random effects model is applicable and the GLS estimator will be consistent and efficient, while under the alternative hypothesis it is inconsistent. The OLS estimator of the fixed effects model is consistent under both the null and the alternative.

Data

The data used in the analysis are obtained from a yearly survey of Norwegian farm households (Account Results in Agriculture and Forestry) by the Norwegian Agricultural Economics Research Institute (NILF). The survey dates back to the beginning of the 20th century and has since 1950 included approximately 1000 farm households representing different regions and principal productions (grain, dairy, livestock etc.). Participation in the survey is voluntary but restricted to farmers younger than the age of 67 (retirement age) and to farm households working at least 400 on-farm hours yearly. Farms that produce both grain and swine products, and dairy farms (pure dairy farms or dairy in combination with livestock production) have the highest representation both in absolute numbers and as share of the total population. Most farm households in the survey report between 1800 and 6000 on-farm work hours yearly, while a standard man-labour year in the agricultural sector is set like 1875 hours. There is no specific decision rule used when entering new households, but one aim to enter farm households with more or less the same characteristics (region/size/production) as the exiting farms. Somewhere between five and ten percent of the farm households are replaced each year, most commonly because the exiting households don't wish to continue being part of the survey.

The Account Results in Agriculture and Forestry by NILF is the most elaborate source of information on Norwegian farm households financial matters both in a regional and a production type of context (Hegrenes 1998). The survey includes data on daily or weekly labour hours for all household members, family members, and hired help and in all employments. On-farm labour compensation is calculated using the cost of hired help added holiday allowances and social security payments, and off-farm income is divided between wage work and other income. The survey also includes data on total area of cultivated land and the division of land into different uses and the yield of and income from different agricultural crops, fruit, garden berries and vegetables. To allow for calculation of obtained prices from farm sales, the turnover from all farm products are registered. Also the household's consumption of own production is registered. All costs of production are reported in total figures for each and every production input. Finally, the survey includes detailed balance sheets information and profit and loss accounts for all households, including information on production grants, interest payments, tax payments, and investment grants.

Another extensive data source is the Agricultural Statistics published by Statistics Norway, including data from censuses of agriculture held with intervals of ten years, annual sample surveys, and statistics based on registers collected by other institutions and from the tax assignment register. The Agricultural Statistics includes information on agricultural structure, yield, livestock and dairy production, national food consumption, means of production, agriculture and environment, farmers age, income basis and labour input, and certain economy variables (Statistics Norway 1998a).

Neither of the two main available data sources on the Norwegian agricultural sector include information on personal and family characteristics besides the farmers' age. This is rather unfortunate as variables such as family size, marital status, number of pre-school aged children and the farm operator's and spouse's level of education are important explanatory variables when estimating off-farm labour decisions. In choosing between the two data sources, we have focused on the more extensive amount of economic and accounting data supplied by NILF in

their Account Results in Agriculture and Forestry, combined with a general desire for more widespread use of these surveys in applied research.

Our sample consists of a longitudinal data set of 586 farm households (operator, spouse and children younger than 17 years) over a period of ten years (1988-1997). This is approximately sixty percent of the total number of farms included in «driftsgranskningene» as households which are taken out of, or have been included, in the survey during the ten year period are excluded from the sample. The panel data set is unbalanced as some farm households lack information on some explanatory variables for one or more years. As a consequence, the number of observations will be less than 5860.

The data set does not contain information on personal and family characteristics such as education, marital status, and family size which are found to be important explanatory variables in estimating farmers' off-farm work participation and off-farm labour supply (see e.g. Huffman 1980 and Weersink 1992). The number of children (Sumner 1992) and especially the number of pre-school aged children (Lass & Gempesaw 1992) have been found to have a negative effect on off-farm labour decisions, while marital status have a positive effect on farmers off-farm labour participation (Weiss 1996). Education is generally found to have a positive effect on both participation (Weersink 1992) and on off-farm labour supply (Huffman 1980, Lass & Gempesaw 1992). Omission of explanatory variables may lead to serious problems in the probit estimation of off-farm work participation even if the omitted variables are uncorrelated with the other explanatory variables of the model (Lechner 1995) because the error terms may become non-normal and heteroscedastic. If the error terms are non-normal or heteroscedastic, we are left with inconsistent estimates.

Among the included variables that are assumed to influence on the decision to participate in off-farm work is the farmers' birth year or age (AGE). The farmers' age indicates a stage in the life-cycle, and off-farm labour participation generally exhibits concave, hump-shaped age profiles in which participation is first increasing and then decreasing (Lass, Findeis, and Hallberg 1991). We include age squared (AGESQ) as a regressor to account for the non-linear effect age has on labour supply. Age can be used to represent general experience and is thus expected to increase the marginal value of time in both farm and off-farm work. The amount of land under cultivation and the output composition affect the amount of work hours required in farm production as e.g. dairy farms have a higher labour intensity in production than field crop farms. We have included the farm size (AREA) and dummies for dairy production (DAIRY), livestock production (LIVESTOCK) and mixed production (MIXED), as regressors in the estimation problem. Farms producing more than two main products are categorized as having mixed production. We have also included regional dummies (EAST, SOUTH and NORTH) to account for regional differences in growing season, type of farm production, and differences in the labour market, and one regressor to account for differences in population density (DENS) in different regions. The density variable was not included among the survey data from NILF, but as it has been found to be an important labour market characteristic, we have implemented the variable on the regional level used by NILF. The figures for the population density in the different regions are obtained from Statistics Norway (1998b). We expect that the amount of hours devoted to farm work (TJOR) and (TSKO) will affect the decision to participate in off-farm activities. One could a priori expect the signs of these parameters to be negative as an increase in time devoted to farm work reduces the time available for off-farm labour, but since we are examining the time allocation of households (farm operator and spouse) the signs may be more ambiguous. The economic variables included in the regression are the farm

households' debt to assets ratio (DAR), and the households ratio of off-farm to farm income (INCRATIO).

Off-farm work is defined as the sum of wage work and non-farm self-employment. The off-farm wage rate is accordingly the sum of the individual market wage and compensation for self-employment which causes both exceedingly small (negative) and exceedingly large values in the wage rate variable. We have chosen to consider the annual compensation for off-farm work and farm work instead of the hourly wage rate so as not to get missing values for households who are not engaged in off-farm work. The summary statistics of the explanatory variables are given in table 1.

Table 1. Descriptive statistics

Variable	Symbol	Mean	Std Dev	Minimum	Maximum
Off-farm labour participation (yes=1)	PART	0.9388	0.2397	0.0000	1.0000
Age (years)	AGE	46.6005	9.8697	19.0000	73.0000
Compensation paid to former owner (NOK)	KAR	-3535.4483	5384.2909	-48188.4805	0.0000
Area under cultivation (dekar ¹)	AREA	184.6714	103.8593	32.0000	1000.0999
Debt to asset ratio	DAR	5.2268	43.6367	0.0000	2524.5432
Population density (Inhab./ km ²)	DENS	15.7321	6.6704	4.0000	26.0000
Reginal dummy:	EAST	0.3674	0.4821	0.0000	1.0000
	SOUTH	0.1424	0.3495	0.0000	1.0000
	NORTH	0.1424	0.3495	0.0000	1.0000
Principal farm enterprise:	DAIRY	0.6363	0.4811	0.0000	1.0000
	LIVESTOCK	0.1172	0.3217	0.0000	1.0000
	MIXED	0.0410	0.1982	0.0000	1.0000
Hours of farm work	TJOR	2459.7395	862.3301	50.0000	5579.0000
Hours of forestry work	TSKO	103.2600	149.9052	0.0000	1287.0000
Ratio of off-farm to farm income	INCRATIO	0.6332	1.4263	-0.4274	23.2935

The table gives evidence of large variance in the variables KAR, DAR, TJOR, TSKO, and AREA that are due to differences in the farm households obligations towards the previous owner, their debt burden, the amount of work hours devoted to farm and forestry work, and the size of the area under cultivation. Less than half of the farm households have financial obligations towards the previous owner and the range of this variable is close to NOK 50 000. About twenty percent of the households in the survey either don't own forestland or they do not utilize it commercially. Another thirty percent of the sample spend less than fifty hours a

¹ Dekar is a commonly used measure for area of land in Norway and approximates 0,247 acres.

year doing forest work. We also find that there are substantial differences in farm size and hours devoted to farm work in the sample. The households annually supply a minimum of fifty and a maximum of 5579 hours to farm work. Approximately 94 percent of the households work off the farm, which is a high percentage even when we are considering the farm households' joint labour supply. The mean of the households' income ratio between off-farm and farm work is less than one, which means that on average, the households have farm production as their main source of income. 37 percent of the farm households in the sample live in the eastern part of southern Norway, which is the most densely populated area. As much as 64 percent of the farms are mainly involved in dairy production and another twelve percent have livestock production as their most important occupancy. These are both labour-intensive occupations.

Empirical results

Off-farm labour participation

Like Nakamura & Nakamura (1985) and Corsi & Findeis (1998), we have used a dummy variable approach to detect existence of state dependence by including a lag of the dependent variable among the regressors. The calculations are shown in appendix 1. In order to determine whether state dependence is due to heterogeneity or due to true state dependence, we examine the interrelationships over time between the states in the same manner as Corsi & Findeis (1998). Both types of state dependence create a correlation between past and present states, which we may think of as «backward state dependence». In addition, what may be thought of as «forward state dependence» can be tested with the same approach as indicated above, conditioning *present* outcome on *future* states. If «backward state dependence» but no «forward state dependence» is detected, we can conclude that only true state dependence exists, but if both backward and forward state dependence exists, this will give strong evidence for heterogeneity since future outcomes can't possibly have an impact on present outcomes (Corsi & Findeis 1998). When only true state dependence exists, the participation decision can be estimated using the dummy variable approach, and observations from previous periods are useful to condition present period observations according to the previous state of the households. The bias from considering equal behaviour for all households irrespective of their previous off-farm work status, is avoided, and unobservable personal characteristics will be included in the random term, thus not causing biased estimates (Corsi & Findeis 1998). If we find evidence of heterogeneity, the dummy variable approach applied will no longer secure consistent estimates and we should make use of a random effects probit model. As the random effects model doesn't address the problem of true state dependence, the estimates obtained from using this model might still be biased if true state dependence is also present.

When we condition present outcome on respectively past and future states we get better predictions than in the simple cross-sectional setting. The likelihood ratio test rejects the cross-sectional model in favour of the dummy variable models at a one percent level or better. In addition, t-tests of the parameters of both the previous and the future states show that the parameters are statistically different from zero and also, we find that the fraction of correct predictions are higher in the dummy variable models. These results give evidence of both forward and backward state dependence, indicating presence of heterogeneity. We are not able to determine whether all backward state dependence can be explained by heterogeneity or if true state dependence also exists.

Despite the evidence of heterogeneity detected in the dummy variable approach, we have decided not to include individual effects in the probit estimation of the households' off-farm labour participation. To gain efficiency by accounting for heterogeneity, we need to include more individual specific explanatory variables. Other studies have shown that particularly the household members' level of education, but also farm training, previous work experience, and number of children are important variables if we are to gain efficiency from taking account of individual effects. As we lack information on such variables we will not suffer any great efficiency loss by holding on to the more simplistic cross-sectional methods.

The results from the cross-sectional methods probit estimation of the households' off-farm labour participation are presented in table 2. The model is estimated under the assumption that the disturbances are normally distributed and homoscedastic and the starting values are set like zero. Convergence was achieved after eleven iterations.

Table 2. Probit estimates of off-farm labour participation

Variable	Estimate	Standard error	t-statistic	P-value
C	-2.79920	0.643352	4.35096	[.000]
AGE	0.045087	0.025485	1.76913	[.077]
AGESQ	-0.567829E-03	0.0267712E-03	-2.12104	[.034]
KAR	-0.249018E-05	0.908890E-05	-0.273981	[.784]
AREA	-0.298584E-03	0.324855E-03	-0.919130	[.358]
DAR	-0.249794E-02	0.102895E-02	-2.42767	[.015]
DENS	0.190541	0.022472	8.47911	[.000]
EAST	-1.05128	0.198705	-5.29068	[.000]
SOUTH	-2.59906	0.346352	-7.50408	[.000]
NORTH	1.80180	0.199949	9.01130	[.000]
DAIRY	-0.253079E-02	0.102620	-0.024662	[.980]
LIVESTOCK	-0.067660	0.158328	-0.427340	[.669]
MIXED	0.517196	0.260788	1.98320	[.047]
TJOR	0.159118E-03	0.454214E-04	3.50316	[.000]
TSKO	0.562605E-03	0.249703E-03	2.25310	[.024]
INCRATIO	14.1060	0.967885	14.5741	[.000]
Observations:	5689			
Log likelihood:	-808.498			
LL (slopes=0):	-1309.47			
LR test of the model:				
χ^2 (15 D.F)	1001.954			
Fraction of correct predictions:	93.8%			

Participation in off-farm work seem to follow a quadratic age pattern peaking at forty years, which is below the average age of farmers. This result is consistent with life-cycle theory and off-farm labour participation has generally been found to exhibit concave age profiles, as participation first increases and then decreases with age. A priori, age could be thought of as having an ambiguous effect on the probability of off-farm employment, as it affects both farm

labour productivity and the market wage. Sumner (1992) and Lass and Gempesaw (1992) have found off-farm participation to peak at the age of forty-three for their respective samples, Lass & Findeis (1998) found a peaking age of forty-one, while Huffman (1980) found participation peaking at the age of fifty-six in his North-American 1964 study. Age was the only variable available in the survey to account for personal, or human capital characteristics.

Among the farm characteristics included in the model we find that compensation paid to former owner (KAR), and farm size (AREA) are insignificant variables in the estimation. A priori, we would expect farm size to have a negative impact on off-farm labour participation as farm size may affect work hours, farm output, and farm productivity, and thus the marginal value of time in farm production. In table 2 we find that this variable affects participation negatively, as is the usual finding in similar studies (Weersink 1992, Corsi & Findeis 1998), but the parameter is not statistically significant. The KAR variable is highly insignificant and the expected sign of the parameter is ambiguous. A negative sign might be explained by a closer and more traditional binding to farm production among farmers' who compensate former owner, whom in most respects are the farmers' (or the spouse's) parents. As we discussed above, payments to former owner are not very common as less than half of the households have such obligations.

Dairy and livestock production are found to be statistically insignificant and influence off-farm participation in a negative manner. Both dairy and livestock production are labour intensive and need daily attendance and it is thus expected that dairy and livestock farmers have a low propensity to work off the farm as have been found by Sumner (1982), Lass & Gempesaw (1992), and Corsi & Findeis (1998). Mixed production is found to have a significantly positive effect on off-farm participation and increase the probability of working off-farm by four percent. We have not included a dummy for grain production in the model due to it being highly correlated with the dependent variable. Grain production is generally seasonally labour intensive and is most often found to have a negative impact on off-farm participation (Sumner 1982, Lass & Gempesaw 1992, Corsi & Findeis 1998).

The amount of labour hours devoted to both farm and forestry work are found to have a small, but significantly positive effect on the households' off-farm participation.

The debt to assets ratio was expected to have a positive influence on off-farm participation as higher financial obligations increases the probability of taking on off-farm work (Weersink 1992). We find that the DAR-variable has a significantly negative effect on off-farm labour participation. This may be explained by increased farm labour devotion as farm investments increase, but the result stands in contradiction to what has been found in similar studies. The mean of the households' ratio of off-farm to farm income has a substantial and positive effect on off-farm participation and the higher off-farm income relative to farm income, the more likely are the households to participate in off-farm work. Higher population density seems to affect off-farm participation positively. This may be due to better labour market conditions in more densely populated regions. Still, we find that living in the southern and eastern parts of Norway decreases the propensity to participate in off-farm work by twenty-one and eight percent, respectively, which seems somewhat contradictory as the southern and eastern parts are the more densely populated. Living in northern Norway, which is the least densely populated area, increases the probability of off-farm work by fourteen percent.

Supply functions

Table 3 presents the within estimates of the households' off-farm labour supply functions. The total, between and variance components estimates are given in appendix 2. To decide whether individual effect should be accounted for we tested the significance of group effects by using an F-test under the null hypothesis that all constant terms were equal. This made us able to reject the OLS (total) model in favour of the within model with individual constant terms at a one percent significance level. After having established the existence of individual effects we made use of a Hausman test to decide whether the individual effects should be treated as fixed or random. The Hausman test rejected the null hypothesis that the individual effects were uncorrelated with the explanatory variables at a one percent significance level. This tells us that the fixed effects model gives more consistent estimates than the random effects model and that the individual effect should be treated as differences in the households' constant terms. The within model also had higher explanatory power and less variance in the residuals than the other models, as well as less problems with heteroscedasticity and autocorrelation.

Table 3. Within (fixed effects) estimates of off-farm labour supply

Variable	Estimate	Standard error	t-statistic	P-value
AGE	107.014	7.22550	14.8106	[.000]
AGESQ	-1.18867	0.076471	-15.5441	[.000]
KAR	-0.012653	0.165411E-02	-7.64961	[.000]
AREA	0.157893	0.058067	2.71915	[.007]
DAR	-0.251895	0.142379	-1.76920	[.077]
DENS	8.54589	8.62345	0.991005	[.322]
EAST	-287.296	63.2232	-4.54415	[.000]
SOUTH	12.9184	114.533	0.112792	[.910]
NORTH	36.9834	93.6857	0.394760	[.693]
DAIRY	-81.0295	34.8765	-2.32332	[.020]
LIVESTOCK	190.190	45.5394	4.17638	[.000]
MIXED	142.566	48.0907	2.96452	[.003]
TJOR	-0.113031	0.012612	-8.96217	[.000]
TSKO	-0.198277	0.059454	-3.33496	[.001]
INCRATIO	288.157	6.61803	43.5411	[.000]

Unbalanced data: NI= 586, TMIN= 1 TMAX= 10, NOB= 5689

F test of A,B=Ai,B: F(585,5088) = 11.524, P-value = [.0000]

Hausman test of H0: RE vs. FE:

$\chi^2(15 \text{ D.F.}) = 72.563$

P-value = [.000]

LM het. test = 837.256

P-value = [.000]

Durbin-Watson = 1.14026

P-value = [.000,.000]

Variance of residuals = 182153.

R-squared = .785836

As for the participation decision, we find that hours devoted to off-farm work follow a life-cycle pattern, as off-farm hours first increase and then decrease with age. This result is in

accordance with earlier findings, e.g. Huffman (1980), Sumner (1982), and Huffman & Lange (1989). Age is the only variable that may represent general experience and is supposed to increase the marginal value of time in both farm and off-farm work. The interpretation of the coefficient of age squared is that the age elasticity of farmers' off-farm workdays declines as the average age of farmers increases.

For the farm characteristics included in the model there are some discrepancies between how they affect the participation decision and the amount of off-farm work hours. Financial obligations towards previous owner (KAR) affect off-farm hours negatively as it affected participation negatively and we assumed this could be explained by a strong binding towards the farm estate and family traditions. As already mentioned, compensation paid to previous owner is neither particularly common nor substantial, and less than two percent of the households have such obligations exceeding NOK 20.000,-.

While the size of the area under cultivation had an insignificantly negative effect on participation, it affects hours of off-farm work in a positive manner. Since hours of farm and forestry work have a negative impact on off-farm hours, the explanation must be sought in e.g. efficiency gains. Weersink et.al. (1998) found tillable acres to have a positive effect on the labour supply of dairy farm spouses, while Mishra & Goodwin (1997) found total acres to have a negative effect on farmers' labour supply, and a positive effect on spouses'. As we are treating the farm couples' joint labour decisions, we don't get to separate the possibly opposite effects AREA has on the labour supply of operators and spouses, respectively. We find it reasonable that more hours devoted to farm and forestry work reduce the amount of off-farm work hours as leisure has a positive effect on utility, and we see that both variables have a significantly negative effect on off-farm labour supply.

Dairy production is found to affect off-farm hours negatively, while livestock production, which affected participation negatively, has a positive impact on off-farm hours. This result is somewhat surprising since livestock production is rather labour intensive. Mishra & Goodwin (1997) found that revenues from livestock production had a positive effect on farmers off-farm labour supply and a negative effect on spouses'. Mixed production has a significantly positive effect on off-farm hours as it had on the participation decision.

The ratio of off-farm to farm income has, not surprisingly, a highly significant effect on off-farm hours. The variables are highly correlated as extensive off-farm work increases the ratio. The households' debt to assets ratio is found to have a negative effect on labour supply as well as on the participation decision. The result contradicts the findings of Weersink (1992) and Mishra & Goodwin (1997). One possible explanation may be that farm investments/production extensions that increase the debt to assets ratio create a greater need of farm work hours.

The population density has a positive effect on off-farm work hours, but the estimate is not a significant one. As we expect to find better labour market conditions in more densely populated areas this results in accordance with our assumptions and is supported by earlier findings. The regional dummies SOUTH and NORTH are not statistically significant in the labour supply model and are found to affect off-farm hours in a positive manner. The regional dummy EAST is statistically significant as in the participation model, and has a negative effect on labour supply. The results for the regional dummies somewhat contradicts the density variable, as the eastern part of Norway, together with the southern part are the more populated

regions in the country. The dummy NORTH that is found to have a positive effect on labour supply represents the least densely populated region.

Concluding remarks

This paper examines the off-farm labour decisions of Norwegian farm households using household production theory. We have determined that both participation and labour supply follow a quadratic age pattern, first increasing and then decreasing with age. Age is the only personal characteristic included in the data set which is unfortunate since personal, together with farm characteristics, generally are found to have the largest impact on off-farm labour decisions (Weersink 1992). Dairy production and tillable acres are found to have a negative impact on participation, and on-farm work decreases off-farm hours, but not the participation decision. Somewhat surprisingly, we have found financial obligations to have a negative effect on off-farm labour decisions. We would have expected that increases in the farm households' debt to assets ratio would give an incentive to supply more off-farm hours as has been found by both Weersink (1992) and Mishra & Goodwin (1997), and the most striking explanation for our finding may be that increases in the debt to assets ratio is connected with investments expanding farm operations. The variables AREA (cultivated land), LIVESTOCK (livestock production), TJOR and TSKO (work hours devoted to farm and forestry work, respectively), and SOUTH (regional dummy) was found to have opposite effects on participation and off-farm labour supply.

Approximately 94 percent of the households in the sample work off the farm and the households' total number of off-farm hours have risen by more than 50 percent during the ten year period. During the same period, the households' total hours devoted to farm work have been reduced by less than three percent, which tells us that the increase in off-farm hours is accompanied by an increase in total hours worked. This increase can probably to some extent be explained by women's increasing participation in the labour market, and it also gives an indication of Norwegian farm households' being on an upward sloping labour supply curve. Measured in total (off-farm, farm and forestry) work hours, the households worked approximately 7,5 percent more in 1997 than they did in 1988.

A survey concerning Norwegian farm households' living conditions (Strøm et. al. 1996) show that a higher share of Norwegian farmers have taken education exceeding primary and lower secondary school compared with the total Norwegian population. More than one forth of the farmers reported at least five years of education after lower secondary school and younger farmers was found to have higher education than the elder. As already mentioned, the level of education is generally found to be one of the most important variables in explaining the increase in off-farm labour decisions, and the results from the living conditions survey combined with the increase in off-farm hours give an indication of this variable being of importance in determining Norwegian farm households' labour decisions as well.

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Appendix 1. Dummy variable probit models

Dependent variable: PART

Parameter	Cross-sectional model I		Dummy variable models			
	Estimate	t-stat.	(-1) Estimate	(-1) t-stat.	(+1) Estimate	(+1) t-stat.
C	-2.7992	-4.3510*	-3.0869	-4.3115*	-3.0191	-4.1908*
AGE	0.0451	1.7691*	0.0360	1.2679	0.0927	1.0332
AGESQ	-0.0006	-2.1210 *	-0.0004	-1.4503	-0.0003	-1.2135
KAR	-0.0000	-0.2740	-0.0000	-0.2688	-0.0000	-0.0972
AREA	-0.0003	-0.9191	-0.0002	-0.5575	-0.0005	-1.1445
DAR	-0.0025	-2.4277*	-0.0025	-2.1544*	-0.0029	-2.7601*
DENS	0.1905	8.4791*	0.1471	5.9064*	0.1427	5.6476*
EAST	-1.0513	-5.2907*	-0.7612	-3.4949*	-0.8396	-3.8079*
SOUTH	-2.5991	-7.5041*	-2.0071	-5.2700*	-1.9598	-5.0693*
NORTH	1.8018	9.0113*	1.3029	5.7406*	1.4613	6.3582*
DAIRY	-0.0025	-0.2466	-0.0440	-0.3758	-0.0584	0.5025
LIVESTOCK	-0.0677	-0.4273	-0.2414	-1.3230	-0.0393	-0.2153
MIXED	0.5172	1.9832*	0.4515	1.4867	0.3417	1.1609
TJOR	0.0002	3.5032*	0.0002	3.0437*	0.0002	3.9733*
TSKO	0.0006	2.2531*	0.0005	1.7681*	0.0005	1.7798*
INCRATIO	14.1060	14.5741*	17.5660	2.1549*	15.6848	
12.7465*						
PART(-1)			1.1608	12.4482*		
PART(+1)					1.3190	
14.0291*						
Observations:	5689		4967		5101	
Log likelihood:	-808.498		-619.665		-621.403	
LL (slopes=0):	-1309.47					
LR test of the model:						
χ^2 (15 D.F)	1001.9543					
χ^2 (16 D.F)			1379.6188		1376.143	
Correct predictions:	93.8%		95.2%		95.1%	
LR test of model I against model II:						
χ^2 (1 D.F)			377.6645			
LR test of model I against model III:						
χ^2 (1 D.F)					374.1883	

Appendix 2. Panel data estimation of off-farm labour supply.

Unbalanced data: NI= 586, TMIN= 1 TMAX= 10, NOB= 5689

Dependent variable: TLON

TOTAL (plain OLS) Estimates:

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
AGE	108.058	6.88786	15.6882	[.000]
AGESQ	-1.22535	.073234	-16.7319	[.000]
KAR	-.844977E-02	.166405E-02	-5.07782	[.000]
AREA	.101900	.078925	1.29110	[.197]
DAR	-.441562	.188535	-2.34208	[.019]
DENS	28.4570	4.68540	6.07355	[.000]
EAST	-161.341	36.8177	-4.38217	[.000]
SOUTH	-301.222	66.6045	-4.52255	[.000]
NORTH	216.535	49.6948	4.35730	[.000]
DAIRY	29.4901	25.6456	1.14991	[.250]
LIVESTOCK	302.696	32.2955	9.37270	[.000]
MIXED	178.130	45.1987	3.94104	[.000]
TJOR	-.163060	.011795	-13.8244	[.000]
TSKO	-.400574	.056433	-7.09820	[.000]
INCRATIO	331.532	6.92745	47.8577	[.000]
C	-1664.41	171.117	-9.72669	[.000]

R-squared = .7858

Variance of residuals = 379840.

LM het. test = 2795.67 [.000]

Durbin-Watson = .513228 [.000,.000]

BETWEEN (OLS on means) Estimates:

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
AGE	99.2648	21.6111	4.59324	[.000]
AGESQ	-1.15872	.230273	-5.03196	[.000]
KAR	-.173532E-02	.533899E-02	-.325028	[.745]
AREA	-.183139	.489454	-.374169	[.708]
DAR	-1.30893	1.12850	-1.15988	[.247]
DENS	24.1427	12.0162	2.00918	[.045]
EAST	-77.5786	95.6710	-.810890	[.418]
SOUTH	-224.843	172.924	-1.30024	[.194]
NORTH	185.281	127.383	1.45452	[.146]
DAIRY	97.4432	71.2409	1.36780	[.172]
LIVESTOCK	316.697	86.9339	3.64297	[.000]
MIXED	166.794	138.151	1.20733	[.228]
TJOR	-.183768	.036693	-5.00822	[.000]
TSKO	-.579671	.176017	-3.29328	[.001]
INCRATIO	385.745	23.8874	16.1484	[.000]
C	-1299.36	527.876	-2.46149	[.014]

R-squared = .569591
Adjusted R-squared = .558265
LM het. test = 190.839 [.000]

Variance Components (random effects) Estimates:

VWITH (variance of U_{it}) = 0.18215E+06
VBET (variance of A_i) = 0.19769E+06
(computed from small sample formula)
THETA (0=WITHIN, 1=TOTAL) = 0.84368E-01
(evaluated at TMAX = 10)

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
AGE	108.150	6.84065	15.8099	[.000]
AGESQ	-1.20407	.072465	-16.6159	[.000]
KAR	-.011774	.158000E-02	-7.45184	[.000]
AREA	.153833	.057684	2.66683	[.008]
DAR	-.271658	.141231	-1.92350	[.054]
DENS	16.3226	6.94813	2.34920	[.019]
EAST	-226.055	52.0697	-4.34139	[.000]
SOUTH	-117.698	94.8432	-1.24097	[.215]
NORTH	99.0228	74.6206	1.32702	[.185]
DAIRY	-50.5087	31.0290	-1.62779	[.104]
LIVESTOCK	225.306	40.2189	5.60200	[.000]
MIXED	140.577	45.3960	3.09668	[.002]
TJOR	-.123611	.011887	-10.3984	[.000]
TSKO	-.230927	.056308	-4.10117	[.000]
INCRATIO	294.000	6.36856	46.1643	[.000]
C	-1561.05	186.804	-8.35662	[.000]

Variance of residuals = 391121.
R-squared = .493650
LM het. test = 1815.65 [.000]
Durbin-Watson = .478102 [.000,.000]
