ON- AND OFF-FARM LABOUR SUPPLY OF DUTCH DAIRY FARMERS: ESTIMATION AND POLICY SIMULATIONS

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Abstract

This research focuses on the effect of decoupled payments on labour supply of Dutch dairy farmers. Data availability leads to the fact that we can not estimate structural labour supply equations. We show how to derive reduced form equations suitable for policy simulations. We use the panel data sample selection estimation approach Wooldridge (1995) to estimate the off-farm labour supply equation. This method is based on Mundlak's (1978) linear panel data estimation approach, which we us to estimate the on-farm labour supply equations. Even though, simulations show a significant negative effect of decoupled payments on labour supply, the economic significance of this effect is very limited.
Keywords: Decoupled Payments, Labour Supply, Panel Data, Sample Selection, Policy Simulation.
JEL: C23, C24, C51, C53, D13, J22, Q12, Q18.

1. Introduction

Decoupled payments are lump-sum payments that are financed by the government, are not related to current production, factor use and factor prices and for which eligibility criteria are defined by a fixed, historical base period. Decoupled payments are advocated by the World Trade Organisation (WTO) as a way to transfer income to farmers with minimal potential to distort production and trade. This is based on the fact that decoupled payments do not alter relative prices and therefore do not attract additional resources into agriculture. However, there are many conditions under which lump-sum payments can have impact on production (USDA, 2005). With respect to labour, Findeis (2002) shows in a theoretical household production model that income transfers reduce total working time, caused by an increase in affordability of leisure. This can lead to a reduction in farm output. On the other hand farmers are often perceived to consider farming a lifestyle. This might lead to an increase in on-farm labour as a result of the lump-sum payment. Dewbre and Mishra (2002) and Goodwin and Mishra (2004) find evidence for the findings of Findeis (2002) for U.S. agriculture. However, the economic significance of the effect of decoupled payments on labour supply is very limited (Dewbre and Mishra, 2002). On the other hand, Woldehanna et al. (2000) does not find an effect of external income on off-farm labour supply of Dutch cash crop farmers. The period we are investigating in this research is 1987 till 1999. The fraction of off-farm labour income in total income of Dutch dairy farmers rose from 5.5% to 20% in this period. Even though this is a sharp increase, it is not comparable with the situation in the U.S., where 92% of farm income came from non-farm sources. This could be caused by the fact that the lifestyle argument is more important for Dutch dairy farmers. Given all these considerations, the qualitative effect of decoupled income payments on time allocation can not be predicted beforehand and estimation of this effect is needed.

Decoupled payments are introduced in the Dutch dairy sector as part of the reform of the Common Agricultural Policy (CAP) of the European Union (EU) (European Commission, 2003). Decoupled payments are introduced in this policy reform as a compensation of the reduction in guaranteed milk prices. Next to that, dairy farmers receive a small increase in milk quota amount. The impact of decoupled payments on labour should be investigated together with these other policy changes.

In The Netherlands, the Dutch Agricultural Research Institute (LEI) creates an extensive farm level panel data set. Unfortunately the data set does not contain individual off-farm hourly wage. For this reason we can not estimate structural on- and off-farm labour supply equations. We will show that we can estimate reduced form labour supply equations that are suitable for 2003 CAP reform simulations.

A large part of Dutch dairy farm households does not supply off-farm labour. This has to be taken into account in estimation (Heckman, 1979). Wooldridge (1995), amongst others, introduces a panel data sample selection model estimation approach. To the best of our knowledge panel data sample selection model estimation approaches have not been used in agricultural labour economics.

The purpose of this paper is to determine the effect on on-farm and off-farm labour of proposed decoupled payments as part of a package of policy changes. To this end we estimate reduced form on-farm and off-farm labour supply equation for Dutch dairy farmers using a panel data estimation techniques and taking possible sample selection in the off-farm labour supply equation into account. These reduced form equations are used for policy simulations.

An outline of the remainder of the paper is as follows. In section 2, a theoretical derivation of on- and off-farm labour supply equations is given. In section 3, we derive reduced form labour supply equations suitable for policy simulations. Section 4 describes the data used for estimation and simulation. Section 5 gives descriptions of a linear panel data estimation approach used and Section 6 gives a description of a panel data sample selection estimation approaches used. Section 7 describes the estimation results. Section 8 describes the policy simulations of which the results are described in Section 9. Finally, section 10 gives a brief summary and conclusions.

2. Theoretical model

Labour supply decisions of dairy farm household i at time t are assumed to be the result of maximising utility (u_{it}) received from consuming goods and services (c_{it}) and home time ($h_{h,it}$) given a vector of utility shifting household characteristics ($\mathbf{z}_{u,it}$) and a vector of other variables influencing the households' decision making environment ($\mathbf{o}_{it}$),

$$u_{it} = u(c_{it}, h_{h,it}; \mathbf{z}_{\mathbf{u},it}, \mathbf{o}_{it}) \tag{1}$$

where $u(\ )$ is a utility function that is the same for all households. Differences between the utility levels of households come from the different choices made with respect to the elements of the utility function. Total time endowment (h_{it}^0) is allocated between farm labour ($h_{f,it}$), off-farm labour ($h_{of,it}$) and home time, and so:

$$h_{it}^0 = h_{f,it} + h_{of,it} + h_{h,it}, \quad h_{of,it} \geq 0\,. \tag{2}$$

The time constraint is a strict equality because home time is defined to be the difference between total time and labour time. Home time consists of leisure, household work, etc. About half of the farmers in our data set have zero income from farming, whereas all farmers have positive on-farm labour and leisure. Therefore we only restrict off-farm labour hours to be larger or equal to zero in this theoretical model.

A non-negativity constraint is imposed on off-farm labour because it may be zero. Throughout, we assume all prices to be the same for all households and only differ between time periods. Dairy farmers in The Netherlands produce milk ($q_{m,it}$) and one or more other output ($q_{o,it}$). For this production the farmer uses variable input (g_{it}), cattle (m_{it}), farm labour and factor inputs ($\mathbf{z}_{\mathbf{q},it}$). Since milk output is produced under a quota system it is assumed fixed on the short term. We assume farm households minimise short-term costs given the price of a composite of variable inputs (v_t), the price of cattle ($v_{m,t}$), prices of other outputs ($p_{o,t}$), farm labour, factor inputs and milk output. Other outputs generate revenue and are therefore seen as negative costs in the following short-term cost function $k(\ )$:

$$\begin{aligned} &k(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}) = \\ &\qquad \min_{g_{it}, m_{it}, q_{o,it}} \{g_{it} v_t' + m_{it} v_{m,t} - q_{o,it} p_{o,t}' \mid h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}\} \end{aligned} \tag{3}$$

This cost function is assumed to be continuous, non-decreasing and concave in input prices and the price of cattle, non-increasing and convex in other output prices and linear homogeneous in all prices. The shadow price of farm labour $s_{f,it}(\ )$ is:

$$\frac{\partial k(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it})}{\partial h_{f,it}} = s_{f,it}(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}) \tag{4}$$

The shadow price of farm labour is the marginal cost of using an extra unit of labour in production. Since farm labour is owned by the farm this marginal cost for production is equal to the marginal revenue of labour for the farm household. The shadow price of labour is the price at which the internal market of farm labour supply clears. The equations for the shadow prices of factor inputs and milk output are similar to equation (4). Because we are mainly interested in labour in this paper we omit the explicit equations for these other shadow prices. Farm income ($y_{f,it}$) equals milk revenue minus costs:

$$y_{f,it} = p_{m,t}q_{m,t} - k(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}) \tag{5}$$

Off-farm labour income is defined as off-farm labour time times off-farm wage ($w_{of,it}$):

$$y_{of,it} = w_{of,it}h_{of,it} \tag{6}$$

Notice that wages are farm and time specific. The value of household consumption is defined as the product of consumption goods and services with the price of consumption goods and services ($p_{c,t}$). Consumption is constrained by total income. Total income consists of farm income, off-farm labour income and other income ($y_{o,it}$):

$$y_{f,it} + y_{of,it} + y_{o,it} = c_{it}\,p_{c,t}{}' \tag{7}$$

Notice that subsidies in the form of income transfers are included as part of the other income variable, but the EU milk price support impacts on farm income via the milk price variable. Combining equations (5) to (7) results in:

$$p_{m,t}q_{m,t} - k(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}) + w_{of,it}h_{of,it} + y_{o,it} = c_{it}\,p_{c,t}{}' \tag{8}$$

We assume the household maximises (1) subject to (2) and (8) by choosing the elements of the choice set c_{it}, $h_{h,it}$, $h_{f,it}$, $h_{of,it}$, g_{it}, $q_{o,it}$. The Kuhn-Tucker first-order conditions are equation (2) and (8) plus:

$$\frac{\partial u}{\partial c_{it}} = \lambda_1 p_{c,t}\ , \tag{9}$$

$$\frac{\partial u}{\partial h_{h,it}} = \lambda_2\ , \tag{10}$$

$$\lambda_1 \frac{\partial k}{\partial h_{f,it}} - \lambda_2 = 0\ , \tag{11}$$

$$\lambda_1 w_{of,it} - \lambda_2 \leq 0, \quad h_{of,it} \geq 0, \quad h_{of,it}\left(\lambda_1 w_{of,it} - \lambda_2\right) = 0\ , \tag{12}$$

$$\lambda_1 \frac{\partial k}{\partial g_{it}} = 0\ , \tag{13}$$

$$\lambda_1 \frac{\partial k}{\partial q_{o,it}} = 0 \tag{14}$$

where λ_1 is the marginal utility of income and λ_2 is the marginal utility of time. If an interior solution exists (i.e. off-farm labour supply is non-zero) the first part of equation (12) holds as equality. In this case the first order conditions can be solved to yield:

$$\frac{\partial u\left(c_{it}, h_{h,it}; \mathbf{z}_{\mathbf{u},it}, \mathbf{o}_{it}\right)/\partial c_{it}}{\partial u\left(c_{it}, h_{h,it}; \mathbf{z}_{\mathbf{u},it}, \mathbf{o}_{it}\right)/\partial h_{h,it}} = -\frac{p_{c,t}}{w_{of,it}} \tag{15}$$

and

$$\frac{\partial k\left(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}\right)}{\partial h_{f,it}} = w_{of,it}\ . \tag{16}$$

If a farm household only works on the farm, the first part of equation (12) does not hold as equality and:

$$\frac{\partial k\left(v_t, v_{m,t}, p_{o,t}, h_{f,it}, \mathbf{z}_{\mathbf{q},it}, q_{m,it}\right)}{\partial h_{f,it}} > w_{of,it} \tag{17}$$

Equation (15) implies that the marginal rate of substitution between leisure and consumption goods is equal to the ratio of the consumption good prices to the wage rate. Equation (16) implies that, if off-farm labour is supplied, the marginal product of farm labour is equal to off-farm wage. Equation (17) implies that, if no off-farm labour is supplied, the marginal product of farm labour is strictly larger than off-farm wage. The left-hand side of equation (16) and (17) is the shadow price of labour used on the farm. This shadow price, the marginal product of labour, does not depend on the output price of milk (see Appendix A for a graphical amplification). From equation (2) and (8) till (14) we derive the reduced form functions for off-farm labour supply $l_{of}(\ )$ and on-farm labour supply $l_f(\ )$. These are functions of all variables in equation (1) to (8) except the variables in the choice set. This results in:

$$h_{of,it} = l_{of}\left(w^n_{of,it}, p^n_{c,t}, p^n_{m,t}, v^n_{m,t}, q_{m,it}, p^n_{o,t}, y^n_{o,it}, \mathbf{z}_{\mathbf{u},it}, \mathbf{z}_{\mathbf{q},it}, \mathbf{o}_{it}, t^0_{it}\right), \tag{18}$$

$$h_{f,it} = l_{f}\left(w^n_{of,it}, p^n_{c,t}, p^n_{m,t}, v^n_{m,t}, q_{m,it}, p^n_{o,t}, y^n_{o,it}, \mathbf{z}_{\mathbf{u},it}, \mathbf{z}_{\mathbf{q},it}, \mathbf{o}_{it}, t^0_{it}\right). \tag{19}$$

where the superscript n indicates that the corresponding variable is normalised by the price index of variable inputs. This is done to impose linear homogeneity in prices and income. Milk price, milk output (that is equal to milk quota in The Netherlands) and other income are explanatory variables in equations (18) and (19). These are all variables that are influenced by the 2003 CAP reform for dairy farmers. For this reason equation (18) and (19) are suitable for assessing the impact of the 2003 CAP policy reform on labour supply.

3. Empirical model

Equation (18) and (19) show that labour supply is expressed in time units and is, amongst others, explained by individual wages. The data set of Dutch dairy farmers at our disposal contains on-farm hours. However, it does not contain off-farm hours and individual wages. This section explains how we deal with these limitations and results in empirical specifications for equation (18) and (19).

3.1 Off-farm labour supply data

Instead of off-farm hours, our data set contains off-farm income. This paragraph explains how it is possible to estimate the parameters in the off-farm labour supply equation, using off-farm income instead of hours. To this end, we assume that (18) has the following functional form:

$$\ln\left(h_{of,it}\right) = \beta_i + \beta_w \ln\left(w_{of,it}\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\beta}_{-\mathbf{w}} + \varepsilon_{it}. \tag{20}$$

where $\mathbf{x}_{-\mathbf{w},it}$ is the row vector of all explanatory variables except off-farm wage, ε_{it} is an error term with expectation zero, β_i is a farm specific effect, β_w is the parameter associated with the log of wage and the column vector $\boldsymbol{\beta}_{-\mathbf{w}}$ contains parameters associated with the other explanatory variables. For notational convenience, the content of $\mathbf{x}_{-\mathbf{w},it}$ is not specified the equations in this section.

Off-farm income, $y_{of,it}$, is by definition:

$$y_{of,it} \equiv h_{of,it} w_{of,it}. \tag{21}$$

Taking the natural logarithm of (21) gives:

$$\ln\left(y_{of,it}\right) \equiv \ln\left(h_{of,it}\right) + \ln\left(w_{of,it}\right). \tag{22}$$

Substituting for $\ln\left(h_{of,it}\right)$ in (20) from (22), we obtain

$$\ln\left(y_{ofit}\right) - \ln\left(w_{of,it}\right) = \beta_i + \beta_w \ln\left(w_{of,it}\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\beta}_{-\mathbf{w}} + \varepsilon_{it} \tag{23}$$

or equivalently,

$$\ln\left(y_{ofit}\right) = \beta_i + \breve{\beta}_w \ln\left(w_{of,it}\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\beta}_{-\mathbf{w}} + \varepsilon_{it} \,. \tag{24}$$

where $\breve{\beta}_w = \beta_w + 1$. This derivation shows the possibility to estimate the parameters of equation (22), in which labour time is the dependent variable, using the logarithm of labour income as dependent variable instead. The only thing that has to be taken into account is that the estimated parameter on $\ln w_{of,it}$ is not β_w but $\left(\beta_w + 1\right)$.

3.2 Off-farm wage

Instead of farm specific off-farm wages, our data set contains national wages for labourers in the agricultural sector (w_t). Data on these wages differ between periods, not between farms. Using this national wage rate for individual farmers implies a measurement error (ζ_{it}). We assume:

$$w_{of,it} = w_t \zeta_{it} \quad \text{with } \zeta_{it} > 0 \tag{25}$$

Inserting (25) into (24) gives:

$$\ln\left(y_{of,it}\right) = \beta_i + \breve{\beta}_w \ln\left(w_t\right) + \breve{\beta}_w \ln\left(\zeta_{it}\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\beta}_{-\mathbf{w}} + \varepsilon_{it} \tag{26}$$

We assume that the relation between the measurement error and the other explanatory variables is:

$$\ln\left(\zeta_{it}\right) = \mathbf{z}_{it}\boldsymbol{\alpha} + a_{it} \tag{27}$$

where $\mathbf{z}_{it}$ is a part of $\mathbf{x}_{-\mathbf{w},it}$, containing education level and age. Inserting (27) into (26) gives:

$$\ln\left(y_{ofit}\right) = \beta_i + \breve{\beta}_w \ln\left(w_t\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\beta}_{-\mathbf{w}} + \breve{\beta}_w \mathbf{z}_{it}\boldsymbol{\alpha} + \tau_{it} \tag{28}$$

where $\tau_{it} \equiv \breve{\beta}_w \alpha_{it} + \varepsilon_{it}$. Recall that the variables in $\mathbf{z}_{it}$ are also in $\mathbf{x}_{-\mathbf{w},it}$. We are interested in the estimator $\boldsymbol{\beta}_{-\mathbf{w}}$. From (28) it follows that $\breve{\beta}_w$ and the parameter estimates of variables in $\mathbf{z}_{it}$ are biased through the term $\breve{\beta}_w \mathbf{z}_{it}\boldsymbol{\alpha}$. Parameters of variables in $\mathbf{x}_{-\mathbf{w},it}$ that are not in $\mathbf{z}_{it}$ are not biased by the measurement error. Milk price; quota amount and external income are examples of these variables. Therefore, estimating equation (28) leads to a suitable model for policy simulation, even though it does not lead to a correct off-farm labour supply equation.

From (19) it follows that off-farm wage is also an explanatory variable in the on-farm labour supply function. Therefore, in this function we also have to deal with the fact that we do not have data on farm specific off-farm wages. To this end we choose the functional form in (19) comparable to the functional form in (18) given in equation (20):

$$\ln\left(h_{f,it}\right) = \gamma_i + \gamma_w \ln\left(w_{of,it}\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\gamma}_{-\mathbf{w}} + \nu_{it} \tag{29}$$

where ν_{it} is an error term with expectation zero. γ_i is a farm specific effect, γ_w is the parameter associated with the log of wage and the column vector $\boldsymbol{\gamma}_{-\mathbf{w}}$ contains parameters associated with the other explanatory variables. Inserting (25) in (29) using (27), we obtain:

$$\ln\left(h_{fit}\right) = \gamma_i + \gamma_w \ln\left(w_t\right) + \mathbf{x}_{-\mathbf{w},it}\boldsymbol{\gamma}_{-\mathbf{w}} + \gamma_w \mathbf{z}_{it}\boldsymbol{\alpha} + \omega_{it} \tag{30}$$

where $\omega_{it} \equiv \gamma_w \alpha_{it} + \nu_{it}$. Similar to the off-farm labour supply equation γ_w and the parameter estimates of variables in $\mathbf{z}_{it}$ are biased through the term $\gamma_w \mathbf{z}_{it}\boldsymbol{\alpha}$. However the parameter estimates of the policy variables are not biased by the measurement error. Therefore, estimating equation (30) leads to a suitable model for policy simulation, even though it does not lead to a correct on-farm labour supply equation.

4. Data

This section gives a description of the data used in estimation. The farm specific data come from the Dutch Agricultural Research Institute (LEI) unbalanced rotating panel data set of Dutch farms. A farm is classified to be a dairy farm if its returns consist for 50% or more of milk revenues. The data set consists of 6338 observations on 1307 farms. The period investigated is from 1987/88 until 1999/00. National data come from Statistics Netherlands (CBS). Off-farm labour is represented by off-farm income. The total number of family hours worked on the farm represents on-farm labour. Off-farm wage is represented by the national index of wages for agricultural hired labour. 1991 is the base year for this and subsequent indices. Price variables, influencing short-term farm income, are the milk price index, a Thornqvist price index for variable input, the price index for cattle, and a Thornqvist price index for other output. Variable input contains, amongst others, feed and veterinary costs. Cattle consists of cows aged one and older. Other output contains marketable crops, veal, pigs, poultry and other farm revenues. Quota is the amount of milk output a farmer is allowed to produce and is expressed in metric tonne. Other income is a monetary value. It includes, amongst other, income from externally allocated capital, income from social allowances and subsidies in the form of income transfers. These subsidies are mainly the acreage premium for maize. Most farmers produce more maize than the amount for which they receive subsidy. From this follows that the premium does not influence maize production and the subsidy can be seen as an income transfer. Land is expressed in the number of hectares used by the farmer. Machinery is the average value of machinery over the year divided by the Thornqvist price index for machinery. Debt is the total value of short and long-term debt. Assets are represented by their value calculated by the LEI. Unemployment is expressed as the national unemployment rate. From the LEI data set it is possible to derive the importance of different activities as a percentage of total activity. This is based on output and the allocation of resources. The percentage for milk production is used as the specialisation rate of dairy farmers. Household variables used are number of household members, a dummy for the presence of a successor and a dummy variable indicating the education level of the head of the household. In table B.1 in Appendix B an overview of the units, mean and standard deviation of the variables used is given.

5. Estimation of a linear panel data model

Since we have panel data at our disposal we can use the extra information contained in panel data compared to cross-section data by using a linear panel data model estimation approach to estimate equation (30). A linear panel data model is given by:

$$n_{it} = \mathbf{x}_{1,it}\boldsymbol{\theta}_1 + \mathbf{x}_{2,i}\boldsymbol{\theta}_2 + a_i + v_{it} \tag{31}$$

where n_{it} is the dependent variable, $\mathbf{x}_{1,it}$ is a vector of observable explanatory variables that vary both over farms and time with corresponding vector of unobservable parameters $\boldsymbol{\theta}_1$, $\mathbf{x}_{2,it}$ is a vector of observable explanatory variables that vary over farms but are constant over time $\boldsymbol{\theta}_2$, a_i is an unobservable farm effect and v_{it} is an unobservable error term. Mundlak's (1978) linear panel data model estimation approach is used in this research.

Mundlak (1978)

Mundlak deals with the individual specific effects in (31) by replacing them by the average values over time of the explanatory variables resulting in:

$$n_{it} = \mathbf{x}_{1,it}\boldsymbol{\theta}_1 + \mathbf{x}_{2,i}\boldsymbol{\theta}_2 + \overline{\mathbf{x}}_{1,i}\boldsymbol{\rho} + v_{it} \tag{32}$$

where $\boldsymbol{\rho}$ is a parameter vector to be estimated. The parameter vectors are estimated by pooled regression of equation (32). The Munlak (1978) approach does not transform variables. Therefore, with this approach it is possible to obtain parameter estimates for the time invariant variables.

6. Estimation of a panel data model with sample selection

Not all farmers in The Netherlands supply off-farm labour. It is assumed that the group of farmers that do supply off-farm labour is not a representative sample of all farmers. This calls for a sample selection estimation approach. Since we have panel data at our disposal we can use the extra information contained in panel data compared to cross-section data by using a panel data sample selection model estimation approach to estimate equation (28) in which $\mathbf{x}_{-\mathbf{w},it}$ contains the explanatory variables in (18) except off-farm wage. This section describes the estimation approach proposed by Wooldridge (1995), which is used in the empirical analysis.

Off-farm labour is only observed for those households that choose to supply it. We therefore introduce an indicator variable d_{it} that takes the value one if household *i* supplies off-farm labour in period *t*. It is assumed that this decision depends on a vector of explanatory variables $\mathbf{m}_{it}$ via

$$d_{it} = I\{\mathbf{m}_{it}\boldsymbol{\psi} + b_i - u_{it} \geq 0\} \tag{33}$$

where $I\{\cdot\}$ is an indicator function that takes the value one if the event in the curly brackets occurs but is zero otherwise, $\boldsymbol{\psi}$ is a vector of unknown parameters, b_i is an unobservable farm effect, and u_{it} is an unobservable error term. If $d_{it} = 1$ and so off-farm labour is supplied then the log of off-farm labour supply, y_{it}, is assumed to be generated by

$$y_{it} = \mathbf{x}_{1,it}\boldsymbol{\beta}_1 + \mathbf{x}_{2,i}\boldsymbol{\beta}_2 + c_i + v_{it} \tag{34}$$

where $\mathbf{x}_{1,it}$ is a vector of observable explanatory variables that vary both over farms and time with corresponding vector of unobservable parameters $\boldsymbol{\beta}_1$, $\mathbf{x}_{2,it}$ is a vector of observable explanatory variables that vary over farms but are constant over time with corresponding vector of unobservable parameters $\boldsymbol{\beta}_2$, c_i is an unobservable farm effect and v_{it} is an unobservable error term.

Two problems arise in the estimation of equation (34). First, the individual effect, c_i, is unobserved. Second, there is a potential sample selection bias if the selection equation, equation (33), does not select a random sample from the underlying population. Below, we describe how Wooldridge (1995) addresses these problems in his estimation method.

Wooldridge's (1995) method

Wooldridge (1995) models c_i as an explicit function of the explanatory variables in the fashion proposed by Mundlak (1978) and Chamberlain (1982). The potential sample selection bias is circumvented by including the Mill's ratio as an additional regressor in the off-farm labour supply equation in the spirit of Heckman (1979). For the latter device to be successful, the errors to the off-farm labour supply and selection equations must be jointly normally distributed. Therefore, Wooldridge's approach requires explicit parametric assumptions about the individual effect and the error distribution. The advantage is that if these assumptions are correct then Wooldridge's method yields consistent estimators of $\boldsymbol{\beta} = (\boldsymbol{\beta}_1', \boldsymbol{\beta}_2')'$, that is the parameters on both the time varying and non-time varying explanatory variables.

In both equations, the individual effect is replaced by a linear combination of the means of the time varying explanatory variables. To make this substitution in the selection equation, it is necessary to define first a partition of $\mathbf{m}_{it}$ into time varying and non-time varying variables, that is $\mathbf{m}_{it} = (\mathbf{m}_{1,it}, \mathbf{m}_{2,i})$. The selection equation becomes

$$d_{it} = I\{\mathbf{m}_{it}\boldsymbol{\psi} + \overline{\mathbf{m}}_{1,i}\boldsymbol{\pi} - u_{it} \geq 0\} \tag{35}$$

where $\overline{\mathbf{m}}_{1,i} = T_i^{-1}\sum_{t=1}^{T_i}\mathbf{m}_{1,it}$ and $\boldsymbol{\pi}$ is a vector of unknown parameters. Assuming that off-farm labour is supplied $(d_{it} = 1)$, the off-farm labour supply equation can be written as

$$y_{it} = \mathbf{x}_{1,it}\boldsymbol{\beta}_1 + \mathbf{x}_{2,i}\boldsymbol{\beta}_2 + \overline{\mathbf{x}}_{1,i}\boldsymbol{\kappa} + \eta\lambda_{it}(\boldsymbol{\psi}, \boldsymbol{\pi}) + e_{it} \tag{36}$$

where $\overline{\mathbf{x}}_{1,i} = T_i^{-1}\sum_{t=1}^{T_i}\mathbf{x}_{1,it}$, $\boldsymbol{\kappa}$ is a vector of unknown parameters, and

$$\lambda_{it}(\boldsymbol{\psi}, \boldsymbol{\pi}) = \frac{\phi(\mathbf{x}_{it}\boldsymbol{\psi} + \overline{\mathbf{x}}_i\boldsymbol{\pi})}{\Phi(\mathbf{x}_{it}\boldsymbol{\psi} + \overline{\mathbf{x}}_i\boldsymbol{\pi})} \tag{37}$$

Under the assumption that u_{it}, v_{it} are jointly normally distributed conditional on $\{\mathbf{m}_{it}, \overline{\mathbf{m}}_{1,i}, \mathbf{x}_{1,it}, \mathbf{x}_{2,i}, \overline{\mathbf{x}}_{1,i}\}$, the error term e_{it} satisfies $E[e_{it} \mid \mathbf{x}_{it}, \overline{\mathbf{x}}_i, \mathbf{m}_{it}, \overline{\mathbf{m}}_{1,i}] = 0$. Therefore, if $\boldsymbol{\psi}$ and $\boldsymbol{\pi}$ were known (and so $\lambda_{it}(\boldsymbol{\psi}, \boldsymbol{\pi})$ were calculable) then OLS estimation of (36) based on those observations for which $d_{it} = 1$ would yield a consistent estimator of $(\boldsymbol{\beta}', \boldsymbol{\kappa}', \eta)'$. In general, $\boldsymbol{\gamma}$ and $\boldsymbol{\pi}$ are unknown, and so the latter estimation is infeasible. To circumvent this problem, Wooldridge proposes obtaining preliminary estimates of the selection equation parameters, $(\hat{\boldsymbol{\psi}}', \hat{\boldsymbol{\pi}}')'$ say, from a pooled probit estimation of (35), and then using these estimates to obtain the sample analogue to the Mill's ratio. Estimates of $(\boldsymbol{\beta}', \boldsymbol{\kappa}', \eta)'$ are then obtained via OLS regression of y_{it} on $\mathbf{x}_{1,it}, \mathbf{x}_{2,i}, \bar{\mathbf{x}}_{1,i}$ and $\lambda_{it}(\hat{\boldsymbol{\psi}}, \hat{\boldsymbol{\pi}})$ based on the sample of observations for which off-farm labour is supplied, that is $\{(i,t); d_{it} = 1\}$. Wooldridge shows that these estimates are consistent and asymptotically normal.

7. Estimation results

This section gives the estimation results for the off-farm labour supply equation (28) estimated with Wooldridge's (1995) approach and the estimation results for the on-farm labour supply equation (31) estimated with Mundlak's (1978) approach. Remember that Wooldridge's (1995) estimation approach requires estimation of a binary choice model for off-farm labour supply. This is not of primary interest in this paper. Therefore, we describe its estimation results briefly in Appendix C.

Sample selection estimation approaches require that we have at least one explanatory variable in the off-farm labour decision equation that does not appear in the off-farm labour supply equation. Weiss and Briglauer (2000) find that farms with a higher specialisation have a higher propensity to use off-farm income to spread income risk. We assume that this effect works mainly through the choice to work off-farm and less through the decision on the amount of off-farm work. Based on this assumption we only include specialisation in the off-farm labour decision equation and not in the off-farm labour supply equation. An effect of specialisation on on-farm labour use is an often-found result in economic research. Table 1 gives the estimation results for the off- and on-farm labour supply equations.

Table 1. Estimation results for labour supply equations.

Estimation approach:	Wooldridge (1995)		Mundlak (1978)	
Dependent variable:	Log off-farm labour		Log on-farm labour	
	Est	t-stat	Est	t-stat
Constant	12.65	2.16*	5.91	13.92*
Log off-farm wage	3.60	7.35*	-0.27	-6.18*
Milk price	1.22	0.74	0.14	1.37
Other output price	-0.03	-0.05	-0.02	-0.55
Cattle price	3.88	2.06*	-0.04	-0.50
Other income	-3.97	-1.71*	-1.04	-4.97*
Quota	-3.04	-3.94*	0.22	1.91*
Land	2.93	3.32*	0.14	2.02*
Buildings	-2.18	-4.12*	-0.03	-1.12
Machinery	-0.83	-0.97	0.00	0.01
Debt over asset ratio	0.70	1.57	0.03	0.99
Unemployment rate	0.04	1.37	0.00	0.31
Age	-0.19	-3.06*	-0.01	-1.34
Specialisation			-0.14	-2.11*
Household members	-0.01	-0.39	0.03	35.27*
Successor dummy	1.09	4.30*	0.17	41.77*
Education	1.17	2.80*	-0.02	-6.25*
Mills ratio	6.61	3.09*		

* indicates significance at the 10% level.

Before describing the estimation results we focus on the assumption that the group of farmers that supply off-farm labour is not a representative sample of all farmers. Based on this assumption we choose to use sample selection estimation approaches. The Mills ratio used for sample selection correction in the Wooldridge (1995) estimation approach is significant at the 5% level. Therefore, we conclude that our sample selection assumption is correct. Now we know that a major assumption we made is justified, we can focus on the parameter estimates. From section 3 follows that the parameter estimates for off-farm wage; education level and age are biased in our estimated models. These variables control for the fact that we use a time invariant national off-farm wage rate instead of individual specific wages. The estimation results for the other parameters are discussed below.

The parameter estimates for milk price do not show strong evidence for an income effect. They are insignificant. However, the other income parameter is significantly negative in both equations. This implies that there is a negative income effect on labour. The fact that we do not find this through the milk price is caused by the limited variability in the milk price variable. This is both because we do not have farm specific milk prices and because the milk quota policy is partly introduced to reduce milk price variability. The parameter estimates for other output price in both equations are insignificant. This can be explained by the facts that all farms in the data set are specialised dairy farms and that there is little variability in the price variable. The effect of cattle price on off-farm labour supply is positive. This is in correspondence with a substitution effect between on-farm and off-farm labour supply. The complete substitution effect requires a negative effect of cattle price on on-farm labour supply. This effect is not found. However, cattle price also has a substitution effect between cattle and other input variables like on-farm labour, which is opposite to the substitution effect between on-farm and off-farm labour. From the insignificant value of the cattle price parameter in the on-farm labour supply equation, we conclude that neither of the two opposing effects is stronger. The parameters for quota are significant and have expected signs based on a substitution effect. Land has a significantly positive impact on on-farm labour supply. It also has a significantly positive effect on off-farm labour supply. This indicates that larger farms supply more off-farm labour and is in correspondence with other estimation results for off-farm labour supply (see e.g. Goodwin and Holt (2002) and Ahituv and Kimhi (2002)). Buildings have a significantly negative effect on off-farm labour supply. This is an unexpected result. An explanation is that redundant buildings are rented out and the found effect is an income effect. The maintenance of the buildings explains that this effect is not found for on-farm labour. Machinery does not have a significant impact on labour supply. The debt over asset ratio and the unemployment rate do not have a significant effect on labour supply. Specialisation in milk production has a significantly negative effect on on-farm labour input, as expected. Number of household members only has a significant effect on on-farm labour supply. This reflects farmers' work ethic in which household members are expected to contribute to the activities on the farm. Apparently, this does not translate in an expectation to contribute to off-farm labour income. Overall, most parameters estimated have expected signs. Furthermore, it shows that time invariant variables are important for labour supply explanation.

8. Policy simulations

In this section we describe the simulations performed to investigate the possible effect of decoupled payments within the proposed CAP reform agreement of June 26, 2003 on labour supply of Dutch dairy farms. As base run we take the actual situation in 1999/00, the last year for which we have data. We calculate the effects as if the reform would be fully implemented in 1999/00, so we do not take the phased introduction or dynamic effects (e.g. structural changes) into account. Therefore, one could say that we do not pretend to give predictions but just provide information that is helpful to understand the effects of the 2003 CAP reform for Dutch dairy farming.

The three elements of the 2003 CAP reform are a milk price reduction, a quota increase and an introduction of decoupled income payments. Milk price and quota are explanatory variables in our estimated models. We simulate the effects of decoupled income payments by increasing the other income variable with the decoupled income payment.

We calculate the effects for the following scenarios:

1. S1a: CAP reform. For this simulation we assume a milk price reduction of 21%, this is based on the intervention price cuts in the CAP reform for skimmed milk powder and butter of 15% and

25% respectively. To determine the milk price we multiplied the intervention price reduction of skimmed milk powder with 0.4 and 0.6 for butter, as is done in the Mid Term Review proposals of the European Commission. The quota increase is 1.5%. Decoupled income payments equal 35.5 €/tonne.

2. S1b: As S1a but without income compensation.
3. S2a: see S1. Given the uncertainty about what the milk price will be after the CAP reform we assume a 15% price decrease. This can be considered as a minimum price decrease.
4. S2b: As S2a but without income compensation.

During the simulations we keep all other variables at their 1999/00 level. Therefore the simulation results can be seen as a ceteris paribus propensity to adjust labour as a result of the policy change.

9. Simulation results

Below we describe the simulation results. Although we calculate for each individual farm in the sample the policy effects, we only present average changes. Labour supply is rather insensitive to the 2003 CAP reform. In S1a on-farm labour increases 0.51% and off-farm labour decreases 1.05% (see Table 2). One has to take into account that the results are presented in percentage change and that off-farm labour supplying dairy farmers supply more on-farm then off-farm labour. Calculations suggest that on average on-farm labour supply is about 15% of total labour supply for off-farm labour supplying farms. This results in an increase of total labour supply in S1a. In S2a, where the milk price decrease is 15% instead of 21%, the income effect on labour supply is less. On-farm labour increases 0.29% and off-farm labour decreases 1.82%. Again, there is a shift from off-farm to on-farm labour supply. However, now total labour supply remains approximately the same.

Table 2. Policy simulation results

	S1a	S1b	S2a	S2b
On-farm labour supply	+0.51%	+0.95%	+0.29%	+0.73%
Off-farm labour supply	-1.05%	+0.49%	-1.82%	-0.30%

S1b and S2b show that both on-and off-farm labour supply increases if income is not compensated by a decoupled income payment. This confirms the theory of Findeis (2002) that lump-sum payments increase leisure. However, even though the results are statistically significant, the changes are limited. Based on these results we can not conclude that decoupled payments have an economically significant impact on labour allocation of Dutch dairy farmers. And will, therefore, also not have an impact on production decisions through labour allocation. This result is similar to the result obtained by Dewbre and Mishra (2002) based on a study of U.S. farmers receiving decoupled payments.

10. Summary and conclusions

The purpose of this paper is to determine the effect on on-farm and off-farm labour of proposed decoupled payments as part of a package of policy changes. To this end we estimate reduced form on-farm and off-farm labour supply equation for Dutch dairy farmers using panel data estimation techniques and taking possible sample selection in the off-farm labour supply equation into account. These reduced form equations are used for policy simulations. All Dutch dairy farmers supply labour to their farm. We use the linear panel data estimation approach of Mundlak (1978) for estimation of the on-farm labour supply equation. About half of Dutch dairy farmers supplies labour off-farm. We assume that the farmers that supply off-farm labour are not a representative sample from the Dutch dairy farmers' population. Therefore, we use the panel data sample selection estimation approach of Wooldridge (1995) to estimate the off-farm labour supply equation. This approach is based on the estimation approach of Mundlak (1978). The estimated equations are used to simulate the effect of the 2003 CAP reform policy changes. Part of these changes is the introduction of decoupled payments.

Decoupled payments are advocated by the World Trade Organisation (WTO) as a way to transfer income to farmers with minimal potential to distort production and trade. However, there are many conditions under which lump-sum payments can have impact on production (USDA, 2005). Based on the simulation results we can not conclude that decoupled payments have an economically significant impact on labour allocation of Dutch dairy farmers. And therefore, will also not have an impact on production decisions through labour allocation.

The results of our study are obviously subject to some qualifications. The model used for simulation can be characterised as a comparative static short-term model, since technology, most production factors (capital, land and labour) and prices of variable inputs are assumed fixed and no explicit time path for the changes is given. In the longer term factors and variable input prices are no longer fixed and alternative technologies may come available. Moreover, it is unclear what the effect of 2003 CAP reform on the milk price will be, estimations in the Netherlands vary between 15% and 21%. We do not take into account farm continuation problems that might arise given the large decrease in profits. Making the model dynamic and including environmental policies could be interesting topics for future research. The model presented here can serve as a building block in this type of extended analysis.

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Appendix A: Supply quota

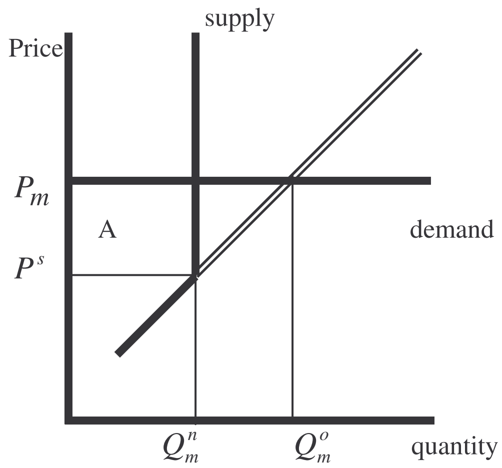

Figure A.1. Supply quota

Quota rent: A

In the case of a supply quota Q_m^n and market price P_m, the shadow price of production P^s gives the marginal costs of production. The market price is the reward for the production right (quota) and the factor inputs supplied by the farm household (labour and capital). The shadow price of the quota equals $P_m - P^s$ and is the reward for the production right. The shadow price of production is the reward for the factor inputs labour and capital. Figure A.1 shows that the shadow price of production, P^s, does not change with a change of the market price, P_m, as long as $P_m > P^s$. Therefore, the reward for the factor inputs labour and capital do not change. From this it follows that the marginal products of the factor inputs are not dependent on the market (output) price.

Appendix B: Data

Table B1. Data for average specialised dairy farm in the Netherlands in 1999/00.

Variable	Unit	Mean	Standard deviation
Off-farm income (> 0 for 46.2% of observations)	1000 Euro of 1991	5.087	7.765
On-farm labour	Hours	4068	1484
Off-farm wage index	1991 = 100	105.46	10.74
Milk price index	1991 = 100	98.44	5.15
Other output price index	1991 = 100	100.08	11.11
Input price index	1991 = 100	100.42	4.71
Other income	1000 Euro of 1991	10.291	8.821
Quota	1000 Kilo	444.547	277.351
Land	Hectares	35.264	19.820
Buildings	1000 Euro of 1991	171.216	105.044
Machinery	1000 Euro of 1991	77.371	51.463
Debt	Percentage of Assets	27.45	18.02
Unemployment rate	Percentage	6.19	1.28
Specialisation in milk	Percentage	75.39	9.43
Household members	Number	4.65	1.91
Successor	Percentage	41.67	
Education	Dummy	2.45	0.60

Appendix C: Off-farm labour decision estimation results

Table C1. Estimation results for off-farm labour supply decision.

Estimation approach: Pooled probit

	Estimate	t-statistic
Constant	3.67	0.98
Log off-farm wage	0.18	0.48
Milk price	0.97	1.19
Other output price	-0.25	-0.64
Cattle price	1.19	1.54
Other income	-0.89	-0.53
Quota	-0.47	-1.11
Land	0.45	0.85
Buildings	-0.29	-1.01
Machinery	-0.18	-0.26
Debt over asset ratio	0.27	0.90
Unemployment rate	0.01	0.57
Specialisation	0.01	0.02
Number of household members	0.01	1.11
Successor dummy	0.13	3.71*
Education	0.31	10.96*

* indicates significance at the 10% or smaller level.

Table C.1 gives the parameter estimates for the off-farm labour decision equation used in the Wooldridge (1995) estimation. These results are not of primary interest in this paper. Therefore, we do not describe them extensively. The overall impression is that there are not many significant parameters. Only the presence of a successor and education are significant. None of the parameters associated with time varying variables are significantly different from zero.