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Off-Farm Work and On-Farm Investment

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Abstract

This work has developed a theoretically consistent model of a farm household's choice between working on-farm and working off-farm and the effects of that choice on farm investment choices. The theory demonstrates the potential for wages driven by local economic conditions to be more important to dairy farm investment decisions than characteristics of dairy farms and farmers. The switching regression model developed from the theory is then tested with data from a representative sample of Wisconsin dairy farms. The econometric results demonstrate the importance of wages to farm investment decisions.

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Results are preliminary, please do not cite without authors' permission

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Off-Farm Work and On-Farm Investment

Jeremy Foltz and Ursula Aldana

Price support programs form the basis of much of US Federal farm policy to maintain farms in business. These price supports and price floors are especially common in the dairy industry. Support programs such as the milk income loss contract (MILC) have clearly put money in the pockets of farmers, but have had mixed effects on maintaining farm business numbers. For example Foltz (2004) shows that the Northeast Dairy Compact increased farm incomes by an average of \$10,000 per year, but had relatively little effect on farm investment or exit decisions. Foltz's work demonstrated an important effect of local economic conditions on dairy farm entry and exit decisions. Such results suggest that other economic factors such as off-farm work may play an important role in farm investment decisions even among dairy farmers who are typically "full-time" farmers.

There is an extensive literature on the role and importance of off-farm work by farmers (see recently e.g. Kwon, Orazem, and Otto, 2006; Andersson et al. 2002; and Ahituv and Kimhi 2002) and an extensive literature on farm growth and survival (see e.g., Weiss, 1999). That work has established the importance of the link between off-farm work and investment, but has not fully established the mechanisms and effects of different policies on farm survival and expansion. How do output price changes and wage changes differentially affect off-farm work and on-farm investment? This study develops a theoretical model and tests it empirically with a population of Wisconsin dairy farmers.

The research strategy builds a theoretical model of off-farm work versus on-farm investment decisions in this case adding more cows. This model leads to two propositions and a set of farm investment equations that can be used to test the theory with empirical data from Wisconsin dairy farms. The farm investment equations are different depending on whether the farm family works off-farm or not, implying a switching regression model. The switching regression model developed from the theory is then tested with data from a representative sample of Wisconsin dairy farms.

Theory:

The theoretical model is based on labor market models such as MaCurdy (1981) that use a life-cycle setting to study labor supply. In this model farm households have the following choice variables farmwork, off-farm work, leisure, own consumption, and on-farm investments. On-farm investments, more cows, are assumed to be complements to farm work such that more cows implies more labor demand on the farm. The household is further assumed to have access to perfect capital markets, which allows the use of a permanent income style parameter to collapse the problem to a manageable level (see Kwon, Orazem, and Otto, 2006 for a test of this assumption).

The farm household maximizes

$$\underset{C_t, l_t, N_t, \Delta V_t}{Max} \sum_t \delta^t U(C(t), l(t))$$

Subject to:

$$(1) \quad \sum_t R_t N_t W_t + \sum_t R_t p_t F(L^* - N_t - l_t, V_{t-1} + \Delta V_t) = \sum_t R_t C_t + \sum_t R_t m_t \Delta V_t + A_0$$

where N_t is number of hours working off farm in period t , L^* is the total stock of time per period, l_t is leisure, C_t is consumption, V_t is the total number of cows, $F(.)$ is the dairy farm production function, p_t is the price of dairy products, m_t is the cost of cows and A_0 is the level of initial assets. R_t is given by $1/(1+r)^t$ where r is the interest rate per period.

The first order conditions (Frisch equations) for the problem are given by:

Consumption: $(2) \quad \delta' U_c(C_t, l_t) - \lambda p_t R_t = 0$

Leisure: $(3) \quad \delta' U_l(C_t, l_t) - \lambda p_t R_t F_1(L^* - N_t - l_t, V_{t-1} + \Delta V_t) = 0$

Investment: $(4) \quad \lambda R_t m_t - \lambda p_t R_t F_2(L^* - N_t - l_t, V_{t-1} + \Delta V_t) = 0$

Off-farm work: $(5) \quad \lambda W_t - \lambda p_t R_t F_1(L^* - N_t - l_t, V_{t-1} + \Delta V_t) \leq 0$

The values of C_t , l_t , ΔV_t and N_t that solve the FONC are replaced in the budget constraint to solve for λ . The solutions to these FONC constitute what is known as Frisch equations.

The characteristic of the solution will vary according to the optimum number of hours worked outside the farm. In case the number of hours worked off farm is zero, the solution will be characterized by (2) and:

$$(6) \quad \delta' U_c(c_t, l_t) - \lambda p_t R_t F_1(L^* - 0 - l_t, V_{t-1} + \Delta V_t) = 0$$

$$(7) \quad \lambda R_t c_t - \lambda R_t p_t F_2(L^* - 0 - l_t, V_{t-1} + \Delta V_t) = 0$$

$$(8) \quad \lambda W_t - \lambda p_t R_t F_1(L^* - 0 - l_t, V_{t-1} + \Delta V_t) < 0$$

The Frish equations above can be solved to show the relationship between off-farm work opportunities and on-farm investment. To demonstrate this we propose the following two propositions.

Proposition 1: If investment and on-farm work are complements, an increase in the wage rate has an unambiguous negative effect on farm investment. Increases in the wage rate have two effects that work in the same direction. They raise off-farm work effort inducing less on-farm investment and they increase the demand for leisure by raising the household's permanent income which induces less on-farm investment.

Proposition 2: If investment and on-farm work are complements, an increase in farm output price has an ambiguous effect on farm investment. Higher farm output prices have two effects that work in opposite directions. They increase the returns to farm output which induces more on-farm investment, but they also increase the demand for leisure by raising the household's permanent income which induces less on-farm investment.

Importantly these two propositions suggest that in the context of dairy farms, where on-farm work and investments in the number of cows are complements, output price policy may have less of an effect than other prices in the economy. That is the theory implies that changes in the local wage rate, perhaps driven by local economic growth, may have a greater effect on farm investment than federal milk policy. Below we develop an econometric model to test this.

Empirical Implementation:

The first order conditions above are written with interior solutions for consumption, leisure, and investment while off-farm work may be at a corner solution. When off-farm work hours are positive, $N_t > 0$, then the solution will be characterized by (1), (2), (3) and:

$$(9) \quad \lambda W_t - \lambda p_t R_t F_1(L^* - N_t - l_t, V_{t-1} + \Delta V_t) = 0$$

When the optimal solution involves no off-farm work, $N_t = 0$, then the following equation holds:

$$(10) \quad \lambda W_t - \lambda p_t R_t F_1(L^* - 0 - l_t, V_{t-1} + \Delta V_t) < 0$$

These two equations represent the conditions for working off-farm.

In the first regime, (where the number of hours worked off farm is zero) consumption, leisure and expansion can be expressed as functions of lambda and all the exogenous variables (by solving equations (2), (6) and (7). Replacing the number of cows as well as leisure as functions of the exogenous variables into equation (8), we can express the condition for not working off farm as a function of lambda and all the exogenous variables. Using a first order approximation it is possible to express this condition in a linear form as:

$$(11) \quad W_t < \theta X_t + \phi \lambda + \varepsilon$$

Where X is a vector containing all the exogenous variables and ε is given by other variables that might affect participation in the off farm labor market. All the households that do not work off farm are supposed to satisfy this condition. Additionally, the households that work off farm must not satisfy condition (11) (wage should be bigger or equal than the right hand side for these households).

On the other hand and, as already said, expansion leisure and consumption for the households that do not work off farm can also be expressed as functions of lambda and of the exogenous variables. It is important to notice that, since we are solving a system, these functions will include all the exogenous variables of the model¹. The function that relates expansion to lambda and to the exogenous variables (X) can be expressed linearly as a first order approximation:

$$(12) \quad \Delta V_t = \beta^N X_t + \phi^N \lambda + u$$

Where u contains all the variables that affect expansion and that are not included in X or lambda.

In the same manner, it is possible for us to solve the system of equations for the households that do not work off farm. For these households the system is given by equations (2), (3), (4) and (9). As before, the relationship between expansion and X and lambda can be expressed in a linear form:

¹ Equation (11) contains all the exogenous variables, for the same reason.

$$(13) \quad \Delta V_t = \beta^w X_t + \phi^w \lambda + u$$

λ cannot be measured and consequently: the estimated coefficients of the exogenous variables in the expansion equations and in the participation equation will include the impact of these variables over lambda.

Empirical Implementation:

The above equations describe the process of household choices between working on and off-farm and their relationship to farm investments. Farm investment choices will vary depending on whether the household is in the on-farm or off-farm work regime. If we assume the error terms in (11), (12), and (13), u and ε , are distributed bivariate normal, this set up leads to an endogenous switching regression model. The endogenous switching regression will have the following likelihood function for each observation:

$$(14) \quad l^i(X_t^i, \Delta V_t^i, \beta, \theta, \Omega) = \int_{-\infty}^{w_t^i - \theta X_t^i} \varphi(\Delta V_t^i - \beta^w X_t^i, \varepsilon_i) \int_{w_t^i - \theta X_t^i}^{+\infty} \varphi(\Delta V_t^i - \beta^N X_t^i, \varepsilon_i)$$

where Ω is the variance-covariance matrix of the bivariate normal distribution. This equation is then estimated using maximum likelihood methods, where the choice of number of cows, ΔV_t , is endogenously determined with the choice of whether to work off farm or not.

Data:

The data used to test our model come from a 2003 survey of a representative sample of Wisconsin dairy farmers. The data have 750 observations on dairy farms, representing a 48% response rate to the survey. The farmers were asked about their current (2002) farm

and farming practices and off-farm work as well as the state of these variables in 1997, five years earlier. This allows both the use of initial conditions in the estimation and data on farm expansion. Before turning to the econometric estimation and the variables used therein, we use the data from similar surveys in 1993 and 1997 to demonstrate trends in farm expansion in Wisconsin.

The average herd size in Wisconsin has grown at a relatively steady rate of about 3% annually over the past half century, with a slight dip in growth rates in the early 1990s and then an acceleration in the late 1990s. The average herd size in Wisconsin was about 55 cows in 1993, 66 in 1997, and 83 in 2002. While much attention has been given to the recent expansion of Wisconsin dairy farms, the most notable feature of the growth is how gradual it has been over time. Table 1 reveals some major changes in the proportion of cows in the different herd size categories, especially in recent years. For example, a comparison of 1997 and 2002 shows that the proportion of herds in the state with over 200 cows was 7% in 2002, 3% in 1997, and about 1% in 1993. The proportion of herds with over 100 cows also grew from 6.5% in 1993 to 10% in 1997 to 13% in 2002. At the same time that this growth in larger herds was occurring, a substantial decline in the proportion of herds in the 24-49 cows occurred, from 48% in 1993 to 29% in 2002. All of the other herd size categories depicted in table 1 kept approximately constant shares over the previous historical decade. The longer historical view evident in table 1 shows the overall trend toward more herds above 75 cows, but this change in herd size distribution has also been relatively gradual.

Table 2 shows expansion behavior during this period using a transition matrix that shows herd sizes in 1997 and the proportions of farms that stayed in their same herd size

category and that moved into other herd size categories. One observation from table 2 is that among the smaller herd size categories, there was very little investment that would move them into the larger herd size categories. For example, none of the farms with fewer than 50 cows made the transition during this five-year period into the categories of more than 100 cows. Instead, the vast majority of the farms in the two smaller herd size categories in 1997 either exited or remained in their same herd size category. The only other noteworthy movements for these two groups was 11% of less than 25 cow operations in 1997 moving into the 25-49 cow category in 2002 and 9% of the herds in the 25-49 cow range moving into the 50-74 cow range. Overall, these smaller herd size categories in 1997 tended not to invest in further cows for their operations.

The smaller operations are also those most likely to have family members working off-farm, which is suggestive of the results from the theoretical model. For herds under 100 cows, there was almost no movement into the over 200 cow range during this time period, and only substantial movement into the over 100 cow range for herds that started in 1997 with 75-99 cows. These transition data show very clearly that major expansions were rare events for operations with less than 100 cows between 1997 and 2002. In contrast there was a significant amount of expansion in the over 100 cow farms, which are the farms least likely to have household members working off-farm.

Thus overall the Wisconsin dairy farm data shows an industry that is making investments, but where those investments are concentrated in certain types of farms. The theoretical model presented above suggests one of the key characteristics that could be driving those expansion choices, off-farm work opportunities. We test this proposition

along with other key characteristics potentially driving expansion in the econometric estimates in the next section.

Estimation and Results:

Based on the theoretical model presented above we hypothesize that the choice of working off farm and of expanding the number of cows on farm will be a function of (i) the wage rate, (ii) operator characteristics including age and education, and (iii) farm characteristics including the initial number of cows. Since all three equations have the same variables, we allow the non-linearity in the likelihood function to identify the parameters.

Results are presented in table 3 below. The results shown in table 3 demonstrate a number of the hypothesized effects. Households with larger farms are less likely to work off-farm, but even controlling for the size effect on off-farm work larger farms add more cows over this time period. Higher wage rates lead to higher probabilities of working off-farm and reduce the expansion rate for those working off-farm. It does have a negative effect on expansion for those not working off-farm, but this effect is not significant. Among the farmer characteristics, the major effect comes from age differences with older farmers being less likely to expand. Spouses with more than a high school education are more likely to work off farm. Finally we find that farms in more urbanized areas are more likely to expand. This may be due to their having more valuable land that can be mortgaged to pay for an expansion.

Conclusions:

This work has developed a theoretically consistent model of a farm household's choice between working on-farm and working off-farm and the effects of that choice on farm investment choices. It improves on the previous literature which has either focused on farm investment without considering the effects of off-farm labor or focused on off-farm work without consideration of on-farm investment decisions. The theory demonstrates the potential for wages driven by local economic conditions to be more important to dairy farm investment decisions than characteristics of dairy farms and farmers. The econometric results demonstrate the importance of wages to farm investment decisions as well as the proxies for urbanization.

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Table 1: Distribution of Farms according to herd size

#Cows	1993	1997	2002
	%	%	%
1 to 24	8.6	7.7	8.1
25 to 49	47.8	36.9	29.2
50 to 74	29.1	31.5	32.2
75 to 99	7.3	11.0	11.1
100 to 199	6.5	10.1	12.8
200 or more	0.7	2.8	6.7
Total	100.0	100.0	100.0

**Table 2: Transition of Wisconsin Dairies by Herd Size Class 1997- 2002.
(Number of Dairy Farms in the Dairy Farm Poll 2003)**

	2002							
1997	1 to 24	25 to 49	50 to 74	75 to 99	100 to 199	200 to 499	Exit	Total
Entered since 97	10	10	2	2	4	2		30
1 to 24	37	9	2				31.7	80
25 to 49	7	164	35	2			175.7	384
50 to 74	2	17	169	31	13	3	91.8	327
75 to 99		3	16	40	21	2	32.0	114
100 to 199	1	3	3	2	50	21	24.7	105
200 or more				1	2	19	7.5	30
Total	57	206	227	78	90	47	363.5	1068

Note: Exits were estimated by comparing the 1997 and 2002 data and inferring the number of exits by farmsize category.

Table 3 Determinants of Farm Expansion (number of cows added)

	Probit on Working Off-farm (Off-farm =1)	Expansion if Working Off- farm	Expansion if not Working Off-farm
Number of Cows in 1997	-0.9 (0.1)***	1.9 (0.1)***	1.8 (0.01)***
Wage	23.8 (8.9)***	-37.5 (19.9)*	-14.9 (16.7)
Operator age	0.1 (0.4)	-1.3 (0.6)**	-0.8 (0.3)**
Operator completed high school	-3.3 (24.4)	4.8 (44)	-4.3 (48.7)
Operator studied more than high school	-13.9 (24.6)	5 (45.5)	8.4 (48.5)
Spouse studied less than high school	-20.8 (30.3)	29.3 (41.7)	9.2 (50.5)
Spouse completed high school	15.6 (14.3)	-8.9 (27.5)	-7.7 (16.1)
Spouse studied more than high school	26 (14.3)*	-1 (26.4)	-22.2 (14.2)
Urbanization rate of town	-21.6 (15.3)	60.3 (29.7)**	6.8 (25.1)
Constant	-33.6 (34.1)	158 (79.7)*	10.2 (67.7)
Variance parameter	8475 (607.7)		
Covariance parameter	6039.7 (265.2)		

Standard errors are listed in parentheses below the estimates. Significance * = 10%, ** = 5%, *** = 1%.