

Entry, Exit, and Farm Size: Assessing an Experiment in Dairy Price Policy

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Abstract

This article models and estimates the forces behind farm exits and changes in herd-size among Connecticut dairy farms under the New England Dairy Compact. A model of sunk costs and farm capital investment is used to specify two econometric estimations: a random effects probit model of farm entry and exit and an autocorrelated generalized least squares panel data model of farm size. The Dairy Compact's price strategy reduced farm exits and moderately increased cow numbers, in contrast development pressures and historically low unemployment rates increased farm exits.

Key Words: Sunk Cost, Investment, Farm Policy, Panel Data, Dairy Compact

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Much U.S. farm policy employs price subsidies and market interventions to benefit key commodity producers. The dairy industry has been no exception with its minimum prices, complicated formulas, regional pricing systems, and since the 2002 Farm Bill a “Milk Income Loss Contract (MILC)” that extends a price floor to all dairy farmers. This MILC system, which is estimated to cost U.S. taxpayers more than \$1 billion per year, is based on the price floor model used by the New England Dairy Compact from 1997- 2002. The New England Dairy Compact, which created a price floor for New England dairy farmers, like the national legislation was intended to reduce downside price risk and keep more New England farmers in business. Do these price floors have their intended effects of maintaining farms in business? Do they lead to expansion of farm sizes? How do these price policies compare in their effect to other economic forces in dairy farmer entry and exit decisions?

This work’s contribution is to explicitly model a sunk cost theory used to justify the optimality of such price floors and then to test the effectiveness of the price floors as ways of mitigating the effects of sunk costs and as policy instruments to maintain farm numbers. Results from this work can help predict the effects of the national price floors contained in the 2002 Farm Bill, including the MILC program, in maintaining farm numbers. The results also provide evidence of the usefulness of sunk cost models as justifications of policies and as predictors of farmer response to price levels and volatility.

This work seeks to answer those questions by developing a theoretical model of farmer investment decisions under price volatility and sunk costs and then using a census of Connecticut dairy farms during the period 1996-2001 when the New England Dairy Compact came into force to test its propositions and the effectiveness of policy.¹ While

many theoretical models have demonstrated the importance of sunk costs to farm investment decisions, few ever test the propositions with micro-level farm data. The panel data econometric estimates using a random effects probit for entry and exit as well as an AR(1) random effects model of cow numbers take advantage of unique data on Connecticut dairy farms to test of the effectiveness of this price policy as well as the predictions from a sunk cost model of farmer investment decisions.

The economic literature on investment and dairy farms suggests different possible theoretical models to explain farmer choices of farm size, entry, and exit. The approach used here models farm investment decisions as a function of sunk costs under risk neutrality (e.g. Barham and Chavas; Chavas; Dixit and Pindyck). In these models a wedge between the cost and salvage value of capital can cause farmers to fall into a zone of hysteresis, or asset fixity, in which they do not respond to price signals. The policy implications of theoretical models of sunk cost in agriculture have suggested that price support programs that truncate the price distribution at a support level can reduce the probability that farmers face sunk costs and hysteresis (Chavas). The New England Dairy Compact provides a perfect natural experiment to test this proposition because one can observe investment decisions with and without a price floor as well as compare them to a counterfactual price policy without the price floor.

Empirical models of farm size, entry, and exit in the dairy industry have generally been estimated using Markov transition probabilities for a long time series often with data averaged over the population of a state (Zepeda; Rahelizatovo and Gillespie). In order to use such averaged data, one often has to use arbitrary size categories and to assume that farms only move one category at a time per period (Zepeda). The model estimated here

uses data on individual farms from 1996-2001, and thus no restrictive assumptions about category size and only moving one category are required.

In the last decade the number of Connecticut dairy farms, like numbers in the major traditional northern dairy states such as New York and Wisconsin, has declined markedly. In 1990 there were 356 Connecticut dairy farms, while by 2001 more than one third had gone out of business leaving only 211 dairy farms. While the rapid drop in the number of Connecticut dairy farms appears dramatic, consolidation in the dairy industry is part of a national trend and most northern states also lost nearly half their dairy farms over this period.² The decline in Connecticut dairy farms has continued unabated despite indirect state support in the form of farmland protection programs and direct price supports since 1997 under the New England Dairy Compact.

The decline of the Connecticut dairy industry is different from the typical farm exit or farm “crisis” situation, in that farmers are generally neither poor nor credit constrained. A 1998 survey (Foltz) showed that, due to high land values, Connecticut dairy farms have very strong asset bases, with an average of \$1.4 million in asset value, and relatively low average debt burdens of 13% of assets. Connecticut dairy farms are productive with a rolling herd average of 19,800 lbs. and have highly educated owners with an average of 13 years of formal education. While 22% of the dairy farms report that off-farm income is vital to the continued survival of the dairy farm, it is clear that farm exits in Connecticut are primarily driven by more lucrative uses of the farm’s land and labor. The model and econometric estimates developed below attempt to quantify the influence of outside opportunities on farm size and exit.

While increased suburbanization and a strong economy in Connecticut have increased the pressure for dairy farm exits, government policy to mitigate farm exits has come in the form of a milk price floor. The New England Dairy Compact instituted in July, 1997 had as its goal to assure the continued viability of dairy farming in New England. Its enactment and subsequent renewal for four years caused an on-going and costly political debate between dairy states both in and outside of the Compact. The Dairy Compact guaranteed minimum dairy prices to New England dairy farmers from the July 1997 through the end of 2001.³ This price guarantee, intended to preserve the economic viability of dairy farms in New England, raised the average price paid \$0.51 per hundred weight and reduced the downside variance of prices. The price floor reduced the variance of prices to 1.78 from the 2.98 it would have been without the Compact premiums.

Many observers and opponents of the Dairy Compact were concerned that higher average prices would not only maintain the farms in business but also increase milk supply and farm sizes, causing lower prices outside the region. Using data from the first year of the Dairy Compact, a study by Nicholson, Resosudarmo, and Wackernagel finds the Compact price premia increased milk supply in New England by 1% and cow numbers by 0.2%. For Connecticut during the first year of the Compact they estimate an increase of 1.2% in milk production per cow and 0.3% in cow numbers over the non-Compact counterfactual. Their careful econometric analysis, however, lacked an underlying theoretical structure to describe the process of farm size and exit.

Farm Investments with Sunk Costs

Following the framework in Chavas and in Barham, Chavas, and Coomes, let the production function for a dairy farm be an increasing and concave function of a stock of productive capital assets, e.g., barns, milking parlors, cows, denoted by k_t .⁴ Assume that variable inputs and capital assets are complements in the production process. Variable inputs are chosen and used up in each period, while capital assets continue between periods, although they depreciate at rate δ . Let net investment in capital be given by

$$(1) \quad I_t = k_t - (1-\delta)k_{t-1},$$

and have an associated cost function $C(I)$. Farm profits will then be:

$$(2) \quad \Pi_t = p_t f(k_t | \omega) - C(k_t - (1-\delta)k_{t-1}),$$

where $f(k_t | \omega)$ is the production function with parameters ω and p is the price for output.

The parameter ω will describe, amongst other things, the farm technology and returns to scale. The farm manager has a monetary budget constraint:

$$(3) \quad w_t = A(w_{t-1}) + p_t f(k_t) - C(k_t - (1-\delta)k_{t-1}) - z_t,$$

where z_t is consumption and w_t is monetary wealth that has intertemporal returns described by the function $A(\cdot)$. The function $A(\cdot)$ represents returns on monetary investment vehicles (interest rates, stock returns, etc.), normalized to the risk-free interest rate.

The farmer learns over time about the distribution of prices, using the current realization to update his prior beliefs about their true distribution according to Bayes rule.

Assume that the manager is risk averse, has a personal discount factor β ($0 < \beta < 1$), and maximizes the expected utility of the flow of profits over a planning horizon of T periods.

The farmer's time separable utility function can be expressed as:

$$(4) \quad E_t \sum_{t=1}^T \beta^t U_t(z_t | \mathbf{v}),$$

where $U(z)$ is an increasing and concave utility function with parameters \mathbf{v} and E_o is the expectation operator. The farmer's maximization problem can be expressed as the following value function:

$$(5) \quad V_t(w_t, k_t) = \underset{z_t, k_t}{\text{Max}} E_t \sum_{t=1}^T \beta^t U_t(z_t | \mathbf{v}) : \text{subject to equations (1) and (3)}.$$

Given these assumptions the Bellman equation for the farm manager's inter-temporal optimization problem as:

$$(6) V_t(w_t, k_t) = \underset{z_t, k_t}{\text{Max}} \{U_t(z_t | \mathbf{v}) + \beta E_t V_{t+1}(A(w_t) + p_{t+1} f(k_{t+1}) - C(k_{t+1} - (1 - \delta)k_t) - z_{t+1}, k_{t+1})\},$$

where E_t is the expectation operator based on the information available at time t about the randomness in output prices. The first order conditions for the optimal investment with respect to consumption, z , and capital, k , will, assuming an interior solution, be

$$(7A) \quad \partial E_t U_t / \partial z_t - \beta \partial E_t V_{t+1} / \partial w_t = 0 \quad \text{and}$$

$$(7B) \quad \partial E_t V_{t+1} / \partial k_t - \beta (\partial E_t V_{t+1} / \partial w_t) \partial C / \partial I_t = 0.$$

These can be rearranged to give the following equation describing the relationship between the net present value of investing and its cost:

$$(8) \quad \beta (\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t = \partial C / \partial I_t,$$

where I_t is net investment. Thus, one gets the fairly standard result that at the optimum the expected marginal value of capital relative to current consumption equals the marginal cost of investing in capital.

The Bellman equation can also be solved recursively through backward induction to yield optimal decision rules for consumption, $z_t^*(w_{t-1}, k_{t-1})$, and capital investment, $I_t^*(w_{t-1}, k_{t-1})$. Similarly the optimal level of capital on the farm at time t can be written as $k_t^* = (1-$

$\delta)k_{t-1} + I_t^*$. These equations will be functions of the parameters of the production and utility functions, output prices, investment returns, and investment costs.

Dairy Farms and Sunk Costs:

The above theoretical model applies to any general type of firm maximizing profits. There are, however, a number of key differences important to the dairy industry. First there is significant output price volatility. And second a number of observers (see for example Barham and Chavas) have suggested the importance of sunk costs in farmer decision making. In particular there are sunk costs and unrecoverable transaction costs associated with adding cows, building new barns, installing milking parlors, and purchasing land that make those investments partially sunk costs.⁵

In order to capture the stochastic nature of output prices let the price of output follow a white noise process. The process can be described as follows: $p_t = \bar{p} + \sigma\varepsilon_t$, where \bar{p} is the average price, σ is a constant representing a mean preserving spread parameter, and ε_t is a stochastic component that has mean zero and a variance of one. A price support program, such as the New England Dairy Compact, should increase \bar{p} and decrease σ .

To capture the sunk costs associated with dairy farm investments we make two further assumptions on the cost function $C(I)$:

- (A1) $\partial C / \partial I_{I>0} > \partial C / \partial I_{I<0}$
- (A2) $C(I) > |C(-I)| \geq 0$ for any $I > 0$

The first assumption states that costs are partially sunk in terms of marginal costs while (A2) implies a sunk cost in terms of total costs as would be the case with a fixed transaction cost. For simplicity of exposition let the marginal cost for positive investments

be described by $s = \partial C / \partial I_{I>0}$ and let the marginal cost for dis-investment, the salvage value of capital, be $S = \partial C / \partial I_{I<0}$.

In the absence of price uncertainty, the sunk costs have no effect on the optimal allocation between consumption and investment. Because of the effect of the random variable ε_t on output prices, the sunk costs will affect the optimal investment decision (Chavas; Dixit and Pindyck). We can now rewrite equation (8) as the following investment conditions:

$$\begin{aligned}
 (9a) \quad & \beta(\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t \geq s_t, & I_t^* > 0 \\
 (9b) \quad & \beta(\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t < s_t, & I_t^* = 0 \\
 (9c) \quad & \beta(\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t > S_t, & I_t^* = 0 \\
 (9d) \quad & \beta(\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t = S_t, & -(1 - \delta)k_{t-1} < I_t^* < 0 \\
 (9e) \quad & \beta(\partial E_t V_{t+1} / \partial k_t) / \partial U_t / \partial z_t < S_t, & I_t^* = -(1 - \delta)k_{t-1}.
 \end{aligned}$$

Equation (9a) represents net investment in the farm while (9d) shows disinvestment and (9e) characterizes exit from the industry. The equations (9b) and (9c) characterize a zone of hysteresis in which farms neither invest nor disinvest. In particular within this zone a farmer will not respond to small changes in prices by investing in more capital and initial investments may not be reversed even once initial conditions change.

The key force in the hysteresis is the value of information gained in future periods about the distribution of the random parameter ε_t which drives the uncertainty in prices. Uncertainty about future prices, by increasing the value of information, will combine with sunk costs to reduce current investment as well as delay entry and exit decisions. Also, as shown by Chavas, in the presence of sunk costs the value of information increases with current levels of capital. Higher values to information represented by higher uncertainty about prices will increase the zone of hysteresis and reduce incentives to invest, enter or

exit. In summary farmers facing sunk investment costs are less likely to either enter or exit the industry or respond to increases in output price levels with more capital investment.

The different levels of the left hand side terms in equations (9a) – (9e) determining investment decisions will be functions of current capital and wealth levels, sunk costs, output price and its variance, production function parameters, the returns to non-farm wealth, and utility function parameters. Assuming that farmers know the mean and variance of prices, the formulation for investment choices in (9a) – (9e) can give an expression for the optimal capital:

$$(10) \quad k_t^* = (1-\delta)k_{t-1} + I_t^*(w_{t-1}, k_{t-1} | s, S, \bar{p}, \sigma, \omega, \nu)$$

where s is the cost of capital, S is the salvage value of capital, ω represents parameters of the production function, and ν represents parameters of the utility function. Net investment will be decreasing in both s and S , increasing in the price level \bar{p} , and decreasing in the variance, σ , because for risk averse farmers it increases the value of waiting. In addition investment in farm capital will be increasing in the productivity of farm capital, as captured by the parameters of the production function, ω .

Farm Size and Entry/Exit Econometrics

The econometric model of farm size makes use of panel data to estimate a random effects generalized least squares (GLS) model with autocorrelation. For purposes of estimating the number of cows on a farm we can rewrite farm capital as described in equation (10) as:

$$(11) \quad k_{it}^* = f((1-\delta)k_{it-1}, w_{it-1}, s_t, S_{it}, \bar{p}_t, \sigma_t, \omega_{it}, \nu_i).$$

Equation (11) shows an individual farm's current capital as a function of its past capital stock, past non-farm wealth, current capital costs and capital salvage prices,⁶ expected

output price and variance given the information available at time t , and parameters of the production, and utility functions.

The model uses the number of cows on a farm as the dependent variable measure of capital, with farms that are out of business listed as having zero cows.⁷ The standard random effects GLS estimator starts from the following model:

$$(12) \quad k_{it} = \alpha + x_{it}\beta + u_{it}, \quad \text{where } u_{it} = v_i + \varepsilon_{it},$$

where x_{it} represent the independent variables, v_i is the farm specific residual while ε_{it} is the "usual" residual which contains both a time specific element and a standard equation residual. The model assumes that x_{it} and the random effects, v_i are uncorrelated.

Since the theoretical model describes the dependent variable, number of cows on a farm, as being serially correlated year by year, simple estimation would ignore this autocorrelation. Hysteresis implies that for many farms the current number of cows is exactly equal to the previous period's. Thus this correlation of year-to-year cow numbers is likely to be well described by a single lag, AR(1), process. If ε_{it} is produced by an AR(1) process, $\varepsilon_{it} = \rho\varepsilon_{it-1} + \eta_{it}$, then first differencing the model would give:

$$(13) \quad k_{it} - \rho k_{it-1} = \alpha(1 - \rho) + \beta'(x_{it} - \rho x_{it-1}) + \eta_{it} + (1 - \rho)v_i,$$

where $\eta_{it} = \varepsilon_{it} - \rho\varepsilon_{it-1}$ (Hsiao).

In order to take into account the autocorrelation, a two-stage generalized least squares approach is used where the first stage estimates the variance components $\hat{\rho}$, $\hat{\sigma}_v^2$, and $\hat{\sigma}_\eta^2$ while the second performs a generalized least squares estimate of the model.⁸

Based on the theory presented above, the evolution of capital, the number of cows on a farm is hypothesized to have the following qualities. It is hypothesized to be:

- increasing in the price level,

- decreasing in price variances,
- highly correlated with past numbers of cows,
- increasing in the level of technology on a farm, and
- decreasing in the value of the returns to non-farm capital.

Entry and Exit Choice Econometrics

In order to estimate dairy farmers' choices whether to stay in business, we employ a random effects probit model (Guilkey and Murphy). A farmer will choose to stay in business, $I_{it}^* (\cdot) > -(1-\delta)k_{it-1}$, if the expected utility of staying in business is greater than exiting. Equations (9a)-(9e) describe the condition for exit, $I_{it}^* (\cdot) = -(1-\delta)k_{it-1}$, as a relationship between marginal future returns and the salvage value of capital, S_{it} . This relationship can be re-defined as an unobserved latent variable, Y_{it}^* , as follows:

$$(14) \quad Y_{it}^* = \beta(\partial E_t V_{t+1} / \partial k_{it}) / \partial U_t / \partial z_{it} - S_{it}.$$

Following the discussion in Guilkey and Murphy one can describe Y_{it}^* as a function of a vector of exogenous variables, X_{it} , as follows:

$$(15) \quad Y_{it}^* = X_{it}\beta + \mu_i + \varepsilon_{it},$$

where $\mu_i \sim N(0, \sigma_\mu^2)$ and $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$ are mutually independent error terms.

Although Y_{it}^* is unobserved, one does observe the indicator variable defined as follows:

$$(16) \quad Y_{it} = \begin{cases} 0 & \text{if } Y_{it}^* < 0 \quad \text{Exit} \\ 1 & \text{if } Y_{it}^* \geq 0 \quad \text{Remain in business} \end{cases}.$$

Imposing the normalizations $\sigma^2 = \sigma_\mu^2 + \sigma_\varepsilon^2 = 1$ and $\rho = \sigma_\mu^2 / \sigma^2$ while defining $\tilde{\mu} = \sigma_\mu^2 / \sigma_\varepsilon^2$.

Then the probability of the observed sequence of the indicator variable $Y_i = [Y_{i1}, Y_{i2}, \dots, Y_{iT}]$ can be described as:

$$(17) \quad P(Y_i) = \int_{-\infty}^{\infty} \prod_{t=1}^{T_i} \Phi \left\{ \left[(X_{it} \beta / \sigma_\varepsilon) + \tilde{\mu}_i \left(\frac{\rho}{1-\rho} \right)^{1/2} \right] (2Y_{it} - 1) \right\} f(\tilde{\mu}_i) d\tilde{\mu}_i.$$

Consistent and asymptotically efficient estimators can be obtained by maximizing the likelihood function:

$$(18) \quad L = \prod_{i=1}^N P(Y_i).$$

The likelihood function can be maximized by approximating and evaluating the integrals using the Gauss-hermite quadrature procedure.⁹

From the theory of sunk costs presented above, it is hypothesized that farm exits will be:

- decreasing in price levels,
- increasing in price variances,
- decreasing in current capital,
- decreasing in the level of technology, and
- increasing in the value of the returns to non-farm capital.

Data Description

The data on dairy farms comes from the State of Connecticut's licensing for the sale of milk. It represents a complete census of all dairy farms in the state during the six years from 1996-2001. This period covers the introduction of the New England Dairy Compact

in July, 1997. Since the data is collected each July, the observations on entry, exit, and cow numbers represent two years of pre-Compact information and four years during the Compact price regime. Summary statistics of all variables are presented in table 1.

The dependent variables for the farm size and exit equations are respectively: $Cows_{it}$, the number of cows on farm i in period t , and $InBusiness_{it}$, an indicator variable equal to one if farm i is in business in period t and zero otherwise. Of the 257 farms in the data set between 1996 and 2001, 8 (3%) entered the business during the period and 46 (20%) went out of business. Average farm size over the six years declined from 106 to 94 cows per farm, with 1998 having the highest average size of 112 cows per farm.

The independent variables used in the estimations provide proxies for the variables and parameters in equation (11). The key variables of interest measure the effect of price levels and price variance on farm size and exit probabilities. Other variables hypothesized to influence farm size and exit include farm and town characteristics along with measures of the state of the economy.

Farmers are assumed to have expectations of future prices based on the previous year's price distribution. The variables used in the analysis are the previous year's average milk price, $Eprice$, a proxy for the expected milk price, and $Vprice$, the month to month variance of milk prices over the previous year. To match the farm observations, the price is averaged over the twelve months from July to July and is calculated as the Boston blend price plus any premia paid by the New England Dairy Compact. Based on the theory presented above, both cow numbers and the probability of staying in business are hypothesized to be increasing in price and decreasing in the variance of prices.

The national prime lending rate, *Plend*, is used as a measure of the cost of capital. Notice that this prime lending rate is also highly correlated with the cost of a housing loan, implying that it also provides some proxy for the degree of housing demand in the town. Higher housing demand from lower interest rates will increase the value of land and therefore the returns to exiting farming. Thus the sign of the coefficient is indeterminate a-priori, being determined by whether lower capital costs will induce more on-farm investment or whether the increased land demand from lower interest rates will increase farm exits.

On the farm, *Yield* measures the farm's milk production per cow which in addition to measuring the farm's productivity provides a proxy for management ability and technology on the farm.¹⁰ As such, *Yield*, represents the parameters in the production function ω . Farms with higher yields are hypothesized to be more likely to stay in business and to add more cows. In the farm size regressions, *Yield* is measured contemporaneously, while in the exit probability estimates it is lagged one period, *LYield*, so as not to create spurious correlations.¹¹ The exit probability equation also includes a measure of the lagged number of cows on the farm *LCows* to test the hypothesis that smaller farms are more likely to exit than large farms.

Variables to describe the town are intended to capture the development pressure in the area as well as describe the local labor market. The degree of development pressure will have a direct impact on the salvage value of farm assets, S_{it} in equation (11).

PopDensity measures the town's population density in the year 2000, while *PopChange* measures the percent growth in population from 1995 to 2000. Both high population density and high growth rates are expected to have a negative effect on cow numbers and

the probability of staying in business. The town's unemployment rate, *Urate*, is added to represent the local town economic conditions and the availability of labor. A low unemployment rate is hypothesized to induce farm exit because it increases the expected value of non-farm work options and reduces incentives to expand the farm since an expansion would, in general, require hiring additional workers (Goetz and Debertin).

In addition to the price policy which is the major focus of this work, Connecticut has another program intended to preserve farms: a purchase of development rights (PDR) program which between 1979 and 2002 purchased the development rights to 26,155 acres of farmland. A 1999 survey of dairy farmers found that 20% of Connecticut dairy farms plant land in the program, but most of that is rented land. Less than 5% of farms actually own land in the program. Thus likely the major effect of the program is to maintain more farmland available for cropping, which should lessen the land constraint for dairy farms in towns where land has been preserved. In order to capture the effects of this program the variable *PDRacres* measures the number of acres in the town that have been preserved by Connecticut's PDR program.

Finally the variable *DFintown* is added to measure the number of dairy farms in town aside from the farm in question. The hypothesis is that in towns with more dairy farms they will be more politically and socially acceptable as business types. These towns will have a population more attuned to the business of farming and more political influence from the dairy farmers. These are also towns more likely to have farm friendly zoning, to stick up for farmers in disputes with neighbors, and in general to be more likely to want dairy farms to stay in business. Thus, more dairy farms in a town are expected to positively influence both the number of cows and the probability that a farm stays in business.¹²

Results

Before presenting the econometric estimation results, table 2 presents evidence of the presence of hysteresis among dairy farm investment choices and its relationship to the average and the variance of milk prices. Farms in hysteresis are defined as having a change in cow numbers of less than 10%, with farm exit representing a 100% change. The table shows the percent of farms making significant changes to be relatively small and not especially closely tied to average output prices. The year 1999 for example had the highest prices, but, perhaps due to also having the highest variance, had the highest percentage of farms in hysteresis. The year with the lowest percentage of farmers in hysteresis is 2001 when prices were average, but their variance was the lowest. This suggests the validity of a theoretical model in which sunk costs and the value of future information conspire to keep farmers in hysteresis.

Entry and Exit Estimates

Table 3 presents the results of the random effects probit estimates of the probability that a farmer stays in business. The random effects probit estimates significant parameters for ρ and σ^2_u suggesting that the panel data model is appropriate. The test statistic of a chi-square test of the random effects model versus the pooled model is 81.65 with 1 degree of freedom, which is significant at greater than a 1% level.

The price variables are both significant and have the predicted sign, positive on $Eprice$ and negative on $Vprice$. This suggests the validity of the theoretical model and the importance of the New England Dairy Compact to farm exits, the price premiums and

lower variances helped keep farmers in business. In addition the prime lending rate, *Plend*, is positive and significant, suggesting that development pressures may be more important than the cost of capital in exit decisions.

The variables describing the farm provide evidence of an important dichotomy. While higher levels of productivity of the cows on the farm, *LYield*, is significantly associated with a lower probability of exit, the size of the farm as measured by the number of cows, *LCows*, is insignificant. Current thinking in the Connecticut agricultural establishment has been that small dairy farms were “doomed” to go out of business with only the large farms surviving. In contrast the evidence from these results suggests that small size of the farm *per se* is not a significant determinant of exit, but low milk yields, a proxy for inefficiency or low levels of technical sophistication, do have a significant effect.

Among the town variables, the strongly positive and significant coefficient on the unemployment rate, *Urate*, suggests that outside labor opportunities and the lack of a local labor supply to hire for farm work influences farm exit. Among the measures of a town’s population growth rate, *PopChange*, and density, *PopDensity*, both are negative, although only the density is significant. This may suggest problems with neighbors are as important to exit decisions as the potential increases in land values, although this result may also be driven by entrants only able to find land in low density towns. Neither the number of dairy farms in the town or the amount of land preserved by the PDR program in the town has any significant effect on dairy farm entry exit decisions. Overall, the strength of the non-price variables in the equation suggests that while the Dairy Compact price policy has been effective in preserving farms, there are also other significant forces both on the farm and in the local communities that are pushing farms to exit.

Farm Size Estimates

The GLS estimates of the number of cows on the farm are shown in table 4. The model estimates a year to year correlation between cow numbers, ρ , of (0.87) suggesting the high levels of hysteresis shown in table 2. The regression coefficients show many of the same types of price and development pressure effects as the model of entry and exit.

Cow numbers on the farm are increasing in the expected price, $Eprice$, while decreasing in the variance of prices, $Vprice$. The coefficient on $Eprice$, though only significant at a 10% level, represents an elasticity of 0.80, which is by far the highest among the price variables in the equation. This analysis confirms the importance of the Dairy Compact's price support in maintaining farms. The *Yield* variable, significant at a 10% level, is suggestive of more productive farms being more likely to add cows. As in the probit equations, there is evidence to support the idea that productive farms will remain in business. The prime lending rate, $Plend$, is positive and significant suggesting the importance of development pressure on farm cow decisions.

Further evidence of the importance of development pressure on farm size decisions is provided by the negative and significant coefficient on $PopChange$. For example average town population growth rates of 2.5% would cause the average farm to have more than 10% fewer cows relative to zero population growth. In addition, the regressions provide some evidence that being in a town with more dairy farms, $Dfintown$, helps to determine the size of a farm. In contrast to the entry/exit model, neither the town density nor the unemployment rate has a significant effect on farm size. Like the entry/exit

regressions, these results show no significant effect of the PDR program on dairy farm sizes.

To illustrate the overall effects of the New England Dairy Compact price floor cow numbers in Connecticut, figure 1 compares the actual and predicted total cow numbers for the state with those that the model would have predicted if there had been no price premium.¹³ The chart illustrates that the Dairy Compact price premium maintained the overall numbers of cows in Connecticut an average of 1,900 cows higher each year of its lifetime. If those “extra” cows averaged 18,000 lbs of milk a year, that would translate into an average of 34 million pounds of milk produced each year in Connecticut due to the price floor of the Dairy Compact.

Since the Dairy Compact’s price floor both raised prices and reduced their variance the premium was able to have a disproportionate impact on cow numbers. Despite a price elasticity of 0.8 that would have predicted a 2.4% increase in cow numbers, the 3% increase in average price produced a predicted 7% increase in cow numbers over the situation without a price floor. The difference is the added variance reduction benefit that came with the price floor.

Conclusion

Using the New England Dairy Compact as an experiment in price policy, this analysis has developed a theoretical model and performed random effects estimates of farm size, entry, and exit in the Connecticut dairy industry. Theoretical models of the effects of sunk costs have often suggested price supports as a method of alleviating the effects of sunk costs in sectors such as dairy with high price volatility. This analysis has used farm level panel data

to test this proposition empirically and found qualified support for price support programs as a method of keeping dairy farms in business.

At the cost of great political confrontation and a \$0.05 to \$0.10 per gallon increase in the price of milk to consumers, the New England Dairy Compact's price premium did maintain an extra 4% of Connecticut dairy farms in business. The Dairy Compact's positive effect on cow numbers was primarily through maintaining farms rather than increasing the incentives for farms to get bigger. As a policy instrument for increasing or maintaining cow numbers, price floors such as the Dairy Compact can be more cost effective than pure subsidies in an industry with price volatility and sunk costs because they operate both on the average price and the variance. It is clear, however, that at least in Connecticut the price floor, which subsidized each dairy farmer in the state by an average of \$10,000 per year, was still a very expensive way to keep a few farms in business. Estimates of the cost to taxpayers of the 2002 farm bill's national dairy price floor, MILC, are well in excess of \$1 billion per year (Jesse and Cropp).

The importance of non-price variables in both the farm size and exit equations suggests that price policy alone will not maintain dairy farming in an increasingly suburban state such as Connecticut. However, policies such as the purchase of development rights program that lower pressures to develop land, the price of land, and rural town growth rates were also not shown to be effective. Since this work only measured one of the many possible land based policies, the effect of such land based policies relative to output price policies represents an important avenue for future research.

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Table 1 Descriptive Statistics for Dairy Farms, Milk Prices, and Farm Towns in Connecticut, 1997-2001

Variable	Definition	Mean	S. D.	Min	Max
$Cows_{it}^{(1)}$	Number of cows on the farm	108.19	119.73	0.00	1020.00
$InBusiness_{it}^{(1)}$	1 = in business, 0 = out of business	0.95	0.22	0.00	1.00
$Eprice_t^{(2)}$	Average blend price + compact premium (\$)	14.88	0.64	14.08	16.16
$Vprice_t^{(2)}$	Variance of milk prices	1.19	0.77	0.03	2.39
$Plend_t^{(3)}$	Prime lending rate (%)	8.28	0.80	6.75	9.50
$Yield_{it}^{(1)}$	Daily milk production per cow (lbs/day)	46.47	25.99	0.00	543.23
$Urate_{it}^{(4)}$	Town's unemployment rate (%)	3.21	1.60	0.70	9.70
$PopDensity_{it}^{(4)}$	Town's population density in 2000 (#/sq. mile)	296.40	290.94	24.15	1353.65
$PopChange_{it}^{(4)}$	Town's population growth rate 1995-2000, (% change)	2.58	3.01	-2.92	11.39
$Dfintown_{it}^{(1)}$	Number of other dairy farms in town	4.52	4.48	0.00	17.00

Sources: (1) author's calculations from Connecticut Dairy Producer's list, Connecticut Department of Agriculture (1997-2002), (2) Northeast Dairy Compact Commission <http://www.dairycompact.org/prices.htm>, (3) US Federal Reserve Board, (4) Connecticut Department of Economic Development, Connecticut Town Profiles, <http://www.ct.gov/eed>.

Table 2 Milk Price Mean and Variance and Farms in Hysteresis, 1997 - 2001

	1997	1998	1999	2000	2001
<i>Average Milk Price (\$)</i>	14.92	14.83	16.16	14.52	14.75
<i>Milk Price Variance</i>	1.94	0.168	2.39	1.15	1.03
<i>Farms in Hysteresis (%)</i>	64%	65%	73%	67%	49%

Table 3
Random Effects Probit Estimates of Staying in Business

Variable	Coefficient	Std. Err.
<i>Eprice</i>	1.61***	0.47
<i>Vprice</i>	-1.49***	0.44
<i>Plend</i>	0.85***	0.19
<i>LCows</i>	0.0005	0.002
<i>LYield</i>	0.04***	0.01
<i>Urate</i>	1.96***	0.40
<i>PopChange</i>	-0.06	0.06
<i>PopDensity</i>	-0.002***	0.0008
<i>DFintown</i>	-0.06	0.05
<i>Constant</i>	-28.40***	7.52
<i>sigma_u</i>	3.84***	0.66
<i>rho</i>	0.937***	0.02
Log likelihood	-188.06	
Observations	1236	
Number of groups	253	

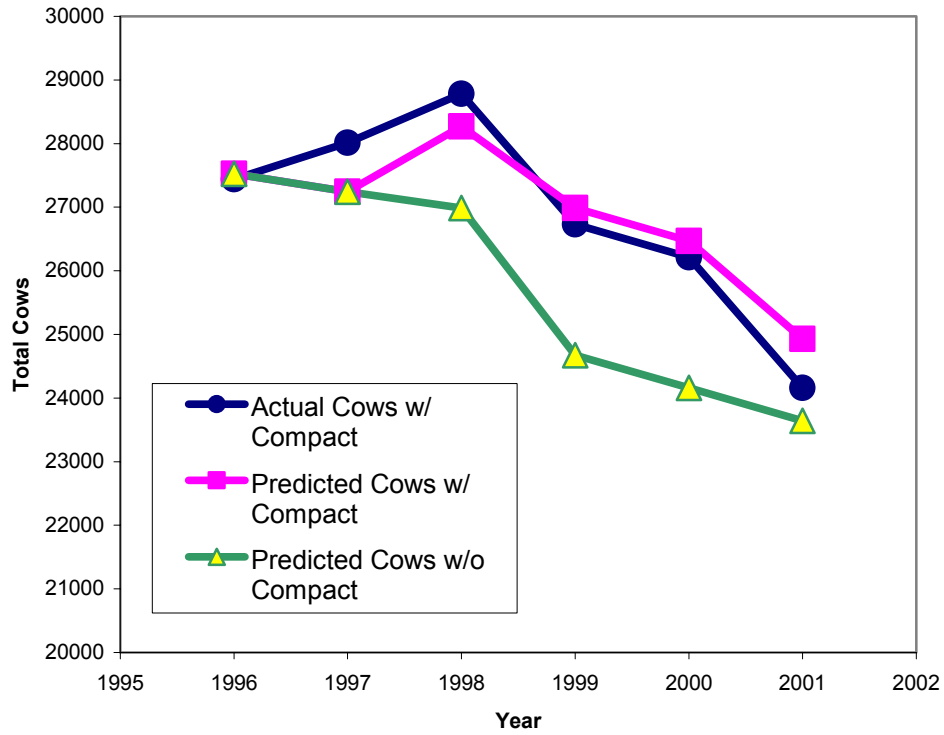
Notes: Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% levels.

Table 4 GLS Estimate of Number of Cows per Farm

Variable	Coefficient	Std. Err.
<i>Eprice</i>	5.64*	3.37
<i>Vprice</i>	-4.01**	2.05
<i>Plend</i>	3.38**	1.51
<i>Yield</i>	0.099*	0.059
<i>Urate</i>	1.69	1.62
<i>PopChange</i>	-5.31***	1.86
<i>PopDensity</i>	-0.01	0.02
<i>DFintown</i>	2.97**	1.43
<i>Constant</i>	-3.82	58.89
<i>AR(1)</i>	0.864	
Log likelihood	-7772.09	
Observations	1456	
Number of groups	253	

Notes: Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% levels.

Figure 1 Dairy Cows in Connecticut 1996 - 2001



Endnotes

¹ The availability of an accurate census of producers as well as cow numbers over the period this policy governed prices drove the choice of Connecticut as the focus of this work. During this period Connecticut was New England's third largest milk producer and its dairies represented about 10% of the farms affected by the policy.

² For comparison purposes, the state of Wisconsin lost 42% of its dairy farms over the same period, which is almost the same percentage as the 41% loss of dairy farms in Connecticut.

³ When the price of class 1 milk dropped below \$16.94 per hundred weight a premium was paid on the class 1 milk to bring it up to that minimum price. Since class 1 milk represents about 50% of the milk sold, the actual price floor fluctuated plus or minus \$0.50 around the targeted price floor for the blend price of \$13.94.

⁴ While this formulation ignores variable inputs, they can be thought of as being allocated in fixed proportions to the amount of capital in the production process as would be the case with a Leontief production function.

⁵ The sunk elements of barns and milking parlors come from their being fixed to the land and the fact that most dairy farms in Connecticut will be sold for non-dairy uses. In the case of cows the small number of farms in the state make for a thin market in milking cow re-sale, such that in the case of farm exit productive milk cows are likely to be sold at the cull cow price rather than their price as productive assets.

⁶ We introduce the notation S_{it} , implying that sunk costs are individual and time specific, in order to capture the effects of development pressure on the salvage value of a farm's assets. These development pressures will be town and time specific.

⁷ Note that this censoring at zero was not significant enough to warrant estimating a tobit model.

⁸ A suitable estimation procedure for an AR(1) panel data model (Greene, p. 639 and Baltagi, p. 83) can use one of many asymptotically equivalent estimators for the AR(1) process in the variance matrix. In this case $\hat{\rho} = 1 - dw/2$ where dw is the standard Durbin Watson statistic. The GLS results are given by estimating (13) with the variance matrix transformed such that $\hat{\beta}_{GLS} = (X' \hat{\Omega}^{-1} X)^{-1} X' \hat{\Omega}^{-1} k$ and $\hat{V}ar(\hat{\beta}_{GLS}) = (X' \hat{\Omega}^{-1} X)^{-1}$. The matrix Ω is defined as the Kronecker product: $\Omega = \Sigma_{m \times m} \otimes I_{T \times T}$, where for the T observations for unit i , the variance matrix will be $\hat{\Sigma} = E[\mathbf{u}_i \mathbf{u}_i']$, where u_{it} is now defined as $u_{it} = (1 - \rho) v_i + \eta_{it}$.

⁹ The quadrature procedure requires that the integrated function is well approximated by a polynomial, which is the case when T is not too large, under 50. Guilkey and Murphy show that the Gauss-hermite quadrature performs better than simulated moments methods. They also show that for $T=2$ the procedure performs poorly relative to a standard probit model.

¹⁰ Although Nicholson, Resosudarmo, and Wackernagel found yields to be endogenous to prices, estimates with this data could find no significant correlations between yields and the price variables used in this equation. In addition no evidence could be found that yields were endogenous to farm size as might be the case if there were increasing returns to scale. This result is corroborated by results in Foltz and Chang that show no significant relationship between size and productivity in a 1999 sample of 50% of these same farmers.

¹¹ The contemporaneous measure of yields in the farm size regressions is preferred in order to preserve an extra year of data before the price policy was instituted. Using lagged yields in the farm size regressions made no significant changes in the parameters except that the coefficient on yields became significant at a 5% level instead of 10%.

¹² Since Connecticut does not have any county government, this political and social acceptance of dairy farms is only likely to matter at the town level.

¹³ The Dairy Compact price premium was subtracted out of the price paid to farmers and the predicted values recalculated with the “no-compact counterfactual” average price and variance of prices. 95% error bounds on the predicted number of cows are plus or minus 5,540 cows.