Land Values, Market Forces, and Declining Dairy Herd Size: Evidence from an Urban-Influenced Region

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The role of land values in the dairy industry of an urban-influenced region is investigated by estimating a dairy herd equation based on pooled cross-section and time-series data from counties in New Jersey, Pennsylvania, and New York. The use of cross-terms between hypothesized causal variables and a dummy variable capturing the effect of location allowed the estimation of the differences across states in the effects of milk, feed, and land prices. Results confirm the important role of rising land values in the decline of the dairy industry in the tri-state area, and suggest greater vulnerability of dairy enterprises in urban-influenced areas to rising adverse economic forces. The adverse effects of declining milk prices and higher land values are greatest in New Jersey. The results support the notion that programs such as price support, farmland preservation, farmland assessment, and right-to-farm may have to be maintained in order to retain dairy farms at the urban fringe, where land values are rising rapidly.

For at least the past decade and a half, the United States dairy industry has experienced declines in aggregate herd size and total dairy farm population (Adelaja 1991; USDA NASS 1995). These declines have occurred in virtually every state, with some of the most rapid declines occurring in northeastern states such as New Jersey, Massachusetts, Connecticut, and Rhode Island (Blayney, Miller, and Stillman 1995; Perez 1994). In some of these states, total milk production actually declined (U.S. Department of Commerce, statistical abstracts of the United States). In New Jersey, for example, between 1983 and 1995, the total dairy herd size declined by 43%, while annual milk production fell by 36%. The number of dairy farms also declined steadily (Adelaja et al. 1997).

A number of studies have investigated the forces that drive changes in the structure of the dairy industry (e.g., Hoque and Adelaja 1984; Klemme and Chavas 1985; Chavas and Klemme 1986; Blayney and Mittlehammer 1990; Weersink and Tauer 1990; Bausell, Belsley, and Smith 1992). Others have specifically investigated the reasons for the industry's decline in regions of the nation where such declines have occurred (e.g., Adelaja, 1991). These studies typically focus on the effects of declining trends in per capita milk consumption, price support, and milk prices; the rising costs of feed and other production inputs (U.S. Department of Commerce, statistical abstracts of the United States); the role of technological change and productivity growth; and the interest among farmers in achieving economies of size through farm consolidation. These studies, however, have not explicitly accounted for the role of rising land values in explaining herd contraction in the dairy industry, despite anecdotal and other evidence from the urban fringe that optimal dairy and general agricultural production choices must involve the consideration of the user's cost of land and the potential capital gains from its sale (Lopez, Adelaja, and Andrews 1988; Parks and Quimio 1996). Given the decline in herd size and dairy production in several states where land values are relatively higher, it is potentially beneficial to policymakers to explore the effect of land values on the dairy industry.

One would expect land values to be inversely

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related to the demand for farm inputs (including milk cows) and the level of production in the dairy industry. One would therefore also expect dairy herd size to be lower at the urban fringe and to decline as suburbanization intensifies. Furthermore, one would expect a unique dairy farming structure at the urban fringe. For example, Parks and Quimio (1996) and Lopez, Adelaja, and Andrews (1988) showed that the incidence of farmland sale and the exit of farms intensify with the rate of appreciation of farmland values. On the one hand, the increased property taxes that result from higher land values have been shown to raise production costs and erode the profitability of farming at the urban fringe (Parks and Quimio 1996; Lopez, Adelaja, and Andrews 1988). On the other hand, in an environment where the profit margin in dairy farming is slim, rising land values offer dairy farmers an escape: they can "throw in the towel" and cash in on their equity, rather than "hang in there and continually suffer losses" (Adelaja et al. 1997). As farmland appreciates in value, the opportunity cost of devoting farmland to agriculture rises, making alternative uses of farmland more desirable.

Additionally, there are reasons for the decline of agriculture in general that apply to dairy. First, there is less total agriculture to begin with, and the critical mass of agricultural activity needed for efficient procurement of inputs and distribution of output may be lacking. Second, the little agriculture that is left is reoriented toward more intensive direct-market type products, which are favored in a near-urban environment. Building on the work of Muth (1961), Lopez, Adelaja, and Andrews (1988) demonstrated that suburbanization has adverse regulatory, technical, speculative, and market effects on farm viability that shift agriculture away from livestock and toward more profitable enterprises.

The regulatory effects are due to the declining political power of the farm community and restrictive regulations (e.g., zoning, building codes, and local ordinances) that surface at the urban fringe due to negative externalities of agriculture and farmer-nonfarmer conflicts. Regulation of effluent discharge and restrictions on animal density are commonly placed on livestock operations. These restrictions raise production costs, reduce farmers' enthusiasm, reduce farm profitability, and hasten the loss of farming enterprises (Lopez, Adelaja, and Andrews 1988; Lockeretz 1989). The technical effects arise from the prevalence of vandalism, loss of critical mass, break-up of farms, and diseconomies of scale at the urban fringe. These things not only affect productivity, technical efficiency, costs, and profitability, but also erode the desire to farm and make farmers view other options more favorably.

Speculative effects derive from the "impermanence syndrome" (reluctance to invest in new technology) and the excessive reliance of farmers on capital gains from farmland sales. These compromise the long-term competitiveness of farms and erode the long-term viability of many forms of agriculture (Lockeretz 1989). The market effects are due to the higher costs of obtaining inputs at the urban fringe.[1] These result in cost inefficiencies and revenue inadequacies that hasten the exit of farms, particularly those that involve animal production.

One of the ways agriculture has survived at the urban fringe is that farms have shifted to alternative high-value crops (e.g., ornamentals, herbals, and vegetables). Lopez, Adelaja, and Andrews (1988) have shown that the intensive, higher-value products are favored at the urban fringe. Their study showed that vegetable production benefits from suburbanization, while fruit, field crops, and livestock production are adversely affected; the livestock subsector is the most adversely affected and the least able to adapt.

The studies referenced above suggest the following: (1) the value of land is a determinant of land use, total herd size, and total industry size in dairy; (2) the role of land values is particularly important in near-urban areas where such values are high and are rapidly rising;[2] and (3) dairy farms in areas where land values are high (e.g., more urbanized farming environments) are more susceptible to dropout and exit than dairy farms in other areas because of the effects of suburbanization.[3]

This paper explicitly examines the role of land values in explaining the decline of the dairy industry at the urban fringe and investigates the extent to which urbanization modifies the impacts of factors

[1] Market effects also include the possibility of higher product prices at the urban fringe. However, Adelaja et al. (1997) argued that despite transportation cost allowances, little or no price advantages exist across the states under regulated milk prices.

[2] An examination of the statistics on dairy herd numbers in the Northeast suggests greater declines in New Jersey, the most urbanized state in the nation, than in the neighboring states. For example, between 1983 and 1995, the number of dairy farms declined by 56% in New Jersey (compared with 44% in both New York and Pennsylvania). The number of milk cows also declined by 43% in New Jersey (compared with 24% in New York and 13% in Pennsylvania). While milk output increased slightly in Pennsylvania and stayed constant in New York, it actually fell in New Jersey by 36%.

[3] A reason for expecting greater effects of lower milk prices, high land values, and high feed costs at the urban fringe is the greater incentive to sell out when farmers face tight financial conditions. Farmers in areas where land values are low have few options. At the urban fringe, however, farmers have the option of selling their herds and farms at high values.

that affect the direction and future of the industry. Industry size is proxied by industry herd size because it is preferred to total milk production and to the number of dairy farms. In recent years, farm consolidation has characterized the dairy industry as farmers have attempted to achieve economies of scale (Hoque and Adelaja 1984). Consolidation has shrunk the number of farms even in states where the industry has grown. Also, total milk production is subject to short-run fluctuations in yield. Long-run growth in total production may reflect productivity growth and not industry expansion. In contrast, industry herd size tends to be stable in the short-run and changes in it reflect longer-run structural adjustment.

In this paper, a theoretical rationale is developed for including land values as a determinant in a derived dairy herd size input demand equation. An empirical model of dairy herd size is estimated using data from New Jersey, New York, and Pennsylvania. These states are used as a case study because (1) they represent a well-defined marketing area (they belong to market orders 2 and 4 and border one another); (2) they all face high but varying degrees of land values (New Jersey leads the nation in per acre land values); and (3) they all face high but varying degrees of urban influence (New Jersey is the most densely populated state nationwide).

Pooled cross-section and time-series data from counties in the three states are used to estimate an empirical model of total herd size, which is specified to allow the estimation of cross-state differences in elasticities of herd size with respect to milk price and land values. These cross-state differences are highlighted by incorporating interactions between a dummy variable capturing the effect of states and variables reflecting the determinants of herd size demand in the model specification.

Theoretical Framework

The theoretical justification for including land values as an exogenous variable in a dairy herd size demand function is developed as follows. Denote the production of milk by the jth farmer by m^j and the total production of milk by all J dairy farmers in the industry by M. That is, $M = \sum m^j$ ($j = 1, 2, \ldots, J$). A dairy farmer produces milk according to the following production function:

$$m^j = \theta^j m^j (\mathbf{x}^j; e^j),$$

where e^j is management capability of the jth farmer, θ^j is a technology parameter for the jth farmer, and $\mathbf{x}^j$ is a vector of physical inputs utilized by the jth farmer such as herd size (cows) h^j, land λ^j, and labor n^j; $\mathbf{x}^j = [h^j, \lambda^j, n^j]'$, where $[h^j, \lambda^j, n^j]$ is a row vector and $\mathbf{x}$ is a column vector. Taslim (1995a, 1995b) showed that the management capability, e^j, is an important input in the production process. For any dairy farmer, management capability is determined by such factors as his experience, education, and some intrinsic abilities.[4] For simplicity, superscript j is suppressed, except in cases where aggregation from the individual producer to the aggregate level is needed.

Each farmer's production function is assumed to be of the standard neoclassical type with the standard properties. That is, output, m, is concave in physical inputs $\mathbf{x}$. Given e, the production function is subject to decreasing returns to scale in the neighborhood of the equilibrium. It is further assumed that the marginal product of $e(m_e)$, the second derivative of m with respect to $e(m_{ee})$, and the derivative of the marginal product of e with respect to $x(m_{ex})$, are all positive.

It is also assumed that a dairy farmer maximizes profit by choosing values of h, λ, and n:

$$\text{(1)} \qquad \max_{\mathbf{x}} \pi = p.\theta m\,(\mathbf{x};e) - \mathbf{w}'\,\mathbf{x},$$

where $\mathbf{x} = [h, \lambda, n]'$, $\mathbf{w}' = [\phi, \rho, \tau]$, ϕ is the per cow feed cost, ρ is the implicit rental value of farmland, and τ is the wage rate paid to hired labor or the opportunity cost of family labor. The symbol p denotes the price of milk.[5] The first order conditions for profit maximization are:

$$\text{(2)} \qquad p\theta m_h - \phi = 0,$$

$$\text{(3)} \qquad p\theta m_\lambda - \rho = 0, \text{ and}$$

$$\text{(4)} \qquad p\theta m_n - \tau = 0$$

where m_h is the marginal product of cows, m_λ is the marginal product of land, and m_n is the marginal product of labor.

Equations (2) through (4) represent the standard profit maximization condition. These equations

[4] Adelaja et al. (1997) have shown that management capability and other management-related factors are important in the success of dairy farms and that such factors vary across states. For example, they report differentials across states in milk yield and quality, somatic cell count, appropriateness of antibiotic use, adequacy of feed preparation, use of the Dairy Herd Improvement Association (DHIA) program, use of artificial insemination, and quality of recordkeeping.

[5] The standard practice in the dairy literature is to use feed price as the proxy for the price of dairy herds, the primary capital input in dairy. The reasons are: (1) feed and cows are complementary, (2) feed cost is typically 25% to 50% of total production cost, (3) as a determinant of cow demand, feed price tends to overshadow capital cost or interest rate, both of which represent the price of acquiring additional herds. Interest rate is not explicitly accounted for in this model for these reasons.

suggest that the value of the marginal product of an input must equal its marginal cost. When these equations are solved, the input demand functions of the farmer can be defined as functions of input prices, the technological parameter, and management capability. Thus, $\mathbf{x}^* = \mathbf{x}^*(\mathbf{w}; \theta, e)$, where $\mathbf{x}^*$ is the equilibrium level of inputs. Hence, the equilibrium level of herd size, land, and labor are as follows:

(5) $h^* = h^*(p, \phi, \rho, \tau; \theta, e)$,

(6) $\lambda^* = \lambda^*(p, \phi, \rho, \tau; \theta, e)$, and

(7) $n^* = n^*(p, \phi, \rho, \tau; \theta, e)$.

The optimal quantity of each input demanded by the farmers can now be substituted into the production function to derive the optimal milk output:

(8) $m^* = \theta m^*(h^*, \lambda^*, n^*; e)$.

The total market supply can be expressed as (if the identifier j is revived):

(9)
$$M^* = \sum_j m^{*j} = \sum_j h^{*j} y^{*j},$$

where y^{*j} is the optimal milk yield per cow. Assuming that aggregation over all dairy farms is possible, one could then write:

(10) $M^* = \Theta M^*(\Sigma h^{*j}, \Sigma \lambda^{*j}, \Sigma n^{*j}, \epsilon)$

where ϵ is an aggregate measure of entrepreneurial skill, and Θ is the aggregate technological parameter.

To find the response of the demand for inputs such as herd size h^* to changes in input prices, totally differentiate the first order conditions and solve to derive:

(11) $$\delta h^*/\delta p = (1/\Delta)[-m_h(m_{\lambda\lambda}\, m_{nn} - m_{\lambda n}^2) + -m_\lambda(m_{\lambda h}\, m_{nn} - m_{nh}\, m_{n\lambda}) - m_n(m_{\lambda h}\, m_{n\lambda} - m_{nh}\, m_{\lambda\lambda})].$$

The derivatives (m_{xixi} and m_{xixj}) are second order partial derivatives (or the first derivatives of marginal product). That is, $m_{\lambda\lambda}$, m_{hh}, and m_{nn} are own derivatives of the marginal product, while $m_{\lambda h}$, $m_{h\lambda}$, $m_{\lambda n}$, $m_{n\lambda}$, m_{nh}, and m_{hn} are cross derivatives of the marginal product. The determinant of the Hessian matrix (Δ) is negative by virtue of the concavity of the production function. Subject to the condition that all inputs exhibit diminishing marginal productivity ($m_{xixi} < 0$), and that cross partial derivatives are positive ($m_{xixj} > 0$), an increase in milk prices increases the demand for cows on dairy farms ($\delta h^*/\delta p > 0$). Similarly it can be shown that:

(12) $\delta h^*/\delta \rho = (1/\Delta)(m_{\lambda h}\, m_{nn} - m_{nh}\, m_{n\lambda}) < 0$,

(13) $\delta h^*/\delta \phi = (1/\Delta)(m_{\lambda\lambda}\, m_{nn} - m_{\lambda n}^2) < 0$, and

(14) $\delta h^*/\delta \tau = (1/\Delta)(m_{\lambda h}\, m_{n\lambda} - m_{hn}\, m_{\lambda\lambda}) < 0$.

Testable hypotheses about the demand for other inputs could be derived similarly. Horizontal summation of all individual demand functions yields the aggregate demand function of the dairy farmers for various inputs such as number of cows (herd size):

(15) $H^* = \Sigma h^{*j} = H^*(P, \Phi, \varphi, \Upsilon; \Theta, \epsilon)$

where P, Φ, φ, and Υ are, respectively, the industry equivalents of p, ϕ, ρ, and τ; Θ and ϵ are as previously defined. The aggregate demand functions exhibit essentially the same properties as the individual demand functions.

As noted earlier, since the early 1980s, total herd size and total dairy farm population have declined in the Northeast and the nation. New Jersey has actually experienced reductions in total milk output (see note 2). The farms remaining are, in general, larger than before (USDA NASS 1995). An empirical model based on the theoretical model above is hypothesized to be useful in explaining the changes in the dairy industry in the region. In specifying the empirical model, it is important to note that the literature on agriculture at the urban fringe and the analysis above suggest that, due to differences in management capability, structural differences may exist across states in the effects of causal variables. The empirical model should therefore account for these differences as well.

As defined in equation (15), the profit-maximizing aggregate demand for an input is a function of output and input prices (or opportunity costs), the technology parameter, and the management capability of the farmers. If output and input prices are held constant, then input demand and output supply become functions of management capability only.[6] It is easily shown that total revenue, cost, and profit are all monotonically increasing functions of management capability. Figure 1 illustrates the optimal behavior of farmers. The maximum revenue, R^*, and minimum cost, C^*, for the industry can be represented by the R^* and C^* shown in panel A. In the example above, any farmer who has management capability less than e_0 cannot cover the costs of production and hence, may have to exit from the business. Only farmers with management capability of at least e_0 will break even or make profits, and therefore, are likely to remain in the business. The same is shown in panel B, where the optimal industry profit Π^*

[6] For details see Taslim 1995a.

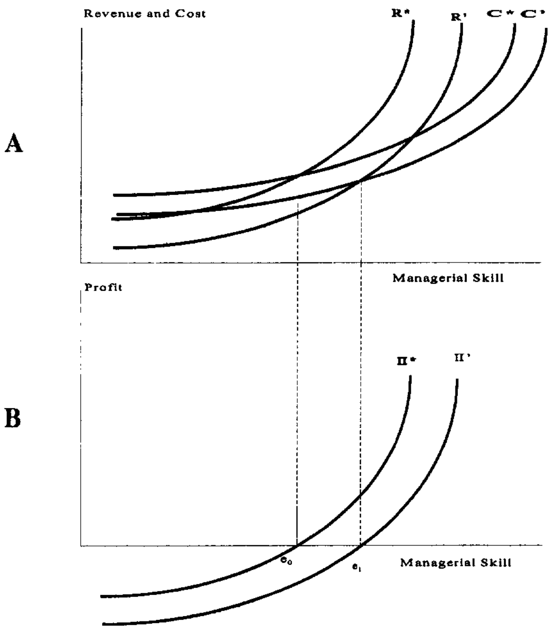

Figure 1. Optimal Revenues, Costs, and Profit in Dairy Farming

curve is derived by vertical subtraction of C^* from R^* curve in panel A. In both panels, e_0 defines the critical management capability that separates profitable from unprofitable farms.

The above model and diagram in figure 1 help explain the decline in dairy herd size in the Northeast in recent years (Blayney, Miller, and Stillman 1995). The region's dairy industry has experienced significant changes in both milk price and input costs in recent years. Until the early 1980s, dairy farms were largely protected by the federal milk price support program, which raised milk prices above the free market level (Adelaja et al. 1997). Since the enforcement of the Dairy and Tobacco Adjustment Act of 1983, the real price of milk has fallen (Adelaja 1991). Simultaneously, per capita milk consumption has trended slightly downward both regionally and nationally (Haidacher and Blaylock 1988; Senauer, Asp, and Kinsey 1991). These changes are likely to have resulted in downward shifts of both the optimal revenue and optimal cost curves. However, in the example in figure 1, it would seem that the shift in the R^* curve (to R) for the three states has been relatively greater than that in the C^* curve (to C) such that the optimal profit curve Π^* shifted downward to Π. Therefore, to run their businesses profitably or to break even, dairy farmers in New Jersey, New York, and Pennsylvania need greater managerial capability than before (at least e_1). In figure 1, operators with skill between e_0 and e_1 who previously could have earned a profit would not be able to survive in the new market environment. Hence, the number of dairy farmers remaining in business would have to decline.

Dairy farming has also witnessed substantial increases in milk yield and productivity of labor over the last few decades (Adelaja et al. 1997). In terms of the model, this development apparently implies an upward shift in R^* and either a downward or a less than proportionate upward shift in the C^* curve such that the Π^* curve unambiguously shifts upward, making entry of new farms in the business profitable. However, this is only part of the story. As farming becomes more productive, each farmer produces more milk, increasing the market supply. This imparts downward pressures on R^* and Π^*, thus offsetting the upward pressure. Another offsetting force is the possible increase in the wage rate (increase in C^*), which usually accompanies labor productivity increases.

Lopez, Adelaja, and Andrews (1988) suggest that farmers at the urban fringe are subject to higher relative costs of many production inputs such as electricity, transport, and feed. Adelaja et al. (1997) show higher costs of these inputs in New Jersey vis-à-vis New York and Pennsylvania. Higher costs push up the C^* curve, thus moving the Π^* curve downward. This suggests that the managerial capability of New Jersey farmers must be higher than for farmers in neighboring states in order for them to compete. Otherwise, the declines in milk prices or increases in production costs will cause greater declines in the size of the dairy industry in New Jersey. In general, if farmers at the urban fringe face higher land values and production costs, then milk price declines and feed cost increases will result in greater declines in herd size than in other regions.

Empirical Model, Data, and Estimation

Econometric estimation of the aggregate demand for cows (herd size) and empirical testing of hypotheses related to the effects of input and output prices on herd size require specification of an explicit demand equation. The following linear approximation of the aggregate demand function for cows was specified:

(16)
$$\begin{aligned} H^* = {} & b_0 + b_1 P + b_2 \varphi + b_3 \Phi + b_4 Y + b_5 D_1 \\ & + b_6 D_1 P + b_7 D_1 \varphi + b_8 D_1 \Phi + b_9 D_1 Y \\ & + b_{10} D_2 + b_{11} D_2 P + b_{12} D_2 \varphi + b_{13} D_2 \Phi \\ & + b_{14} D_2 Y + \upsilon \end{aligned}$$

where D_1 and D_2 are dummy variables to capture the effects of location (D_1 = 1 if state = New Jersey, and D_1 = 0 otherwise; D_2 = 1 if state = Pennsylvania, D_2 = 0 otherwise). The term υ is an error term assumed to have a zero mean and a constant variance. The coefficients b_1 through b_4 capture the direct effects of causal factors on herd size. The coefficient b_0 is the intercept for New York, while the intercepts for New Jersey and Pennsylvania are $b_0 + b_5$ and $b_0 + b_{10}$, respectively. The coefficients b_5 and b_{10} therefore capture independent effects of location. The coefficients b_6 through b_9 and b_{11} through b_{14} capture the effects of interaction terms between the dummy variables and the direct causal factors. The optimization process suggests that $\delta H^*/\delta P > 0$ and $\delta H^*/\delta\varphi$, $\delta H^*/\delta\Phi$, $\delta H^*/\delta Y$ are <0.

The inclusion of the dummy variables allows testing of the hypotheses of structural differences across states. The inclusion of the interaction terms allows testing of the hypotheses of state-related differentials in the effects of the conceptualized causal factors. The dummy and interaction terms help to explain the roles of differentials in management capability and other factors that may differ due to the varying degrees of urbanization or other variables. As explained above, in executing the regression it has been assumed that land value could be used as a proxy for φ.

Data on herd size, land value, milk price, and feed price for census years from 1964 to 1992 for all counties in New Jersey, New York, and Pennsylvania that had dairy farms in 1964 were used for the regression analysis. Pooled time-series and cross-section data were used in order to generate a sufficient number of data points (928 observations). The dependent variable was the natural logarithm of cow numbers. This was obtained from the various agricultural censuses for New Jersey, New York, and Pennsylvania, and for the United States.

Land value was measured as the average value of land and buildings. This information was obtained from Barnard and Jones (1987), with updates for 1983 through 1992 from Barnard. Feed and milk prices for the Northeast were obtained from *Agricultural Prices* (USDA NASS 1994). The specific prices used were the price indexes provided for milk and feed. Wage rates and interest rates were obtained from the same NASS source.

The dummy variables used to distinguish between the three states (New Jersey, New York, and Pennsylvania), and the cross-terms between these dummy variables and other variables in the model, allow one to observe the differential effects of variables identified through the theoretical model. As mentioned above, these differentials can be attributed to differences in the degree of urbanization, land values, and management capability across states. New Jersey is widely known to be more urbanized and to feature much higher land values than New York and Pennsylvania (Adelaja et al. 1997). Because New Jersey may not have a critical mass of farmers to support state and extension programs for dairy as in New York and Pennsylvania, the management capability of farmers in the state appears lower (note 5).

All variables, except the dummy variables, were entered in natural log form. Land values, wage rates, and milk and feed prices were deflated by the Consumer Price Index (CPI) for the particular state in question in order to account for the differential effects of inflation across states. Many agricultural price indices, such as indices of feed, interest rate, land values, and labor, which are typically available at the national level, are not available for New Jersey, New York, and Pennsylvania. Feed and milk prices and the wage rate were measured as the moving average of prices for the three years prior to the census years in question. This measure recognizes that moving average prices (not a single period price) are more likely to reflect price signals that farmers receive and respond to when making decisions about near-fixed assets such as herd size. Data on land values were available for each county for each year, while feed and milk prices and the wage rate data were the same for all the counties in each state in a given year, although they varied across the three states. The cross terms were created by multiplying the logs of the moving average milk prices, feed prices, wage rates, and land values by the dummy variables.

Empirical Results

Preliminary empirical estimates of equation (16) yielded some statistically significant estimates. The coefficients for milk price and land values were significant, but many others were not. The wage rate variable, the cross terms between the wage rate and the dummy variables, the independent dummy variables, and many of the cross terms were not statistically significant. Chow F-tests led to the conclusion that many of the insignificant variables could be dropped. A final restricted model was estimated with milk price, feed price, land values, the cross term between milk price and the New Jersey dummy, and the cross term between land values and the New Jersey dummy remaining as independent variables. The specification of the final empirical model is as follows:

Table 1. Regression Results to Explain Differences in Herd Size across New Jersey, New York, and Pennsylvania Counties, Census Years 1964–92

Variable	Coefficients	Parameter Estimates	Standard Errors	T for H_0 Parameter = 0	Prob>|T|
Intercept	a_0	16.70	1.40	11.97	0.0001
Moving average milk price	a_1	1.25	0.58	2.17	0.0305
Land value	a_2	−0.79	0.06	−12.40	0.0001
Moving average feed price	a_3	−1.06	0.45	−2.35	0.0190
NJ dummy × milk price	a_4	2.52	0.52	4.82	0.0001
NJ dummy × land value	a_5	−0.95	0.18	−5.38	0.0001

NOTE: Sample size = 928, R^2 = 0.3333, adjusted R^2 = 0.3297.

$$(17)\quad H^* = a_0 + a_1P + a_2\varphi + a_3\Phi + a_4DP + a_5D\varphi + \upsilon,$$

where $D = 1$ if state = New Jersey, and D = 0 otherwise. The general effect of land value changes on herd size is captured by a_2. The additional effect that accrues in the case of New Jersey farms is captured by a_5. Similarly, general and additional effects of milk prices are a_1 and a_4, respectively. The effects of feed price is captured by a_3. The maintained hypothesis is that a_4 and a_5 are not equal to zero because of structural differences across states. Parameter estimates for the variables that were statistically significant in the preliminary and final models were robust: the estimates did not change much in magnitude. The insignificance of wage rate coefficients may be due to the wage rate uniformity across the states as a result of the close proximity of the states and the mobility of labor markets.

Parameter estimates from the final restricted model (equation [17]) are reported in table 1. The estimated adjusted R-square was 0.33, which is reasonably high, considering that the data base is largely cross-sectional. All parameter estimates in the final demand model are statistically significant at the 5% level, and all except two were statistically significant at the 1% level. The rest of the discussion in this paper is based on the final empirical model estimate (equation [17]).

The coefficient of the average value of land and buildings, as expected, was negative and was statistically significant at the 1% level. The moving average prices of feed and of milk were both significant at the 1% level for a two-tailed test. As expected, based on the theoretical model above, the coefficient of feed price was negative and the coefficient of milk price was positive. Feed is the single most important cost item in the farm budget. Any change in feed price affects the budget appreciably, and consequently also influences the demand for milk cows. The estimated coefficients of the cross term between milk price and New Jersey and the cross term between land value and New Jersey also have highly significant coefficients.

Examine first the elasticity of herd size with respect to milk price. As shown in table 1, the elasticity is 1.25 for New York and Pennsylvania. While this is consistent with Blayney and Mittlehammer's estimate (1990) of 1.14 for Washington State and Bausell, Belsley, and Smith's (1992) national estimate of 1.49, it is much higher than Adelaja's estimate (1991) of 0.2 for the Northeast.[7] The elasticity of herd size with respect to milk price is much higher in New Jersey (3.77) than in the remainder of the tri-state area. This suggests much greater vulnerability of New Jersey farms when milk prices are declining.

The elasticity of herd size with respect to feed price is −1.06 for New Jersey, New York, and Pennsylvania. An elasticity of herd size with respect to feed of −1.06 is rather large, compared with the herd size elasticity estimates by Blayney and Mittlehammer (1990) for the state of Washington. This may suggest greater herd size sensitivity to feed prices in the tri-state area.

The estimated coefficient for the land value variable is −0.79 for Pennsylvania and New York, and −1.74 for New Jersey. These suggest not only that higher land values result in a contraction of the herd size in all three states, but also that the effects are greater in New Jersey than in the neighboring states. Recall that the milk price elasticities are 1.25 for New York and Pennsylvania, and 3.77 for New Jersey, while the elasticity of feed price is −1.06 for all three states. While these, on the surface, seem to indicate that milk and feed price changes have greater impacts on herd size than land values, it should be noted that the downward trend in herd size has been influenced more by

[7] Note that Adelaja (1991) decomposes the elasticity of herd size into the elasticity of average herd size and the elasticity of farm population. Hence, the herd size elasticities estimated in this study are equivalent to the combined elasticities from Adelaja 1991.

rising land values than the changes in milk and feed prices. The percentage increase in land values has exceeded the percentage decrease in milk prices and the percentage increase in feed cost in recent years. For example, while the average percentage increase in nominal land values in the three states exceeded 750% for the 1964 to 1992 period, nominal milk prices fell by less than 50%. The conclusion is that the major reason for the loss of dairy in the three states is rising land values. The identification and confirmation of land values as a major determinant of the size of the dairy industry is the primary contribution of this paper to the literature.

The structural difference in the impact of milk prices and land values between New Jersey and the neighboring states is worth further attention. The greater responsiveness of New Jersey dairy farmers to land values and milk prices suggests that these farmers are more vulnerable to price swings in these two important economic factors than farmers in New York and Pennsylvania. In other words, any given downward swing in milk prices or upward swing in land values results in declines in New Jersey's dairy industry at a greater rate than the rest of the region. New Jersey's apparent vulnerability is an issue that policymakers need to consider because it has implications for the survival of the state's dairy industry. Their vulnerability to declining milk prices is particularly relevant as the recent changes in the direction of federal dairy policy take hold.

New Jersey policymakers should also be particularly concerned about swings in land values. Although the elasticity of milk price is higher than for land value, agricultural land values have increased much more dramatically than milk prices have declined, and have increased more so in New Jersey than in the other states in the region. Agricultural land values rose more than 900% in New Jersey, by more than 800% in Pennsylvania, and by more than 600% in New York between 1964 and 1992. They can be expected to continue to rise faster in New Jersey than in the other two states. It appears that in the past, both the higher elasticity of herd size with respect to land values for New Jersey and the greater increase in land values for the state have combined to cause a greater decline in herd size in New Jersey relative to Pennsylvania and New York.

It is important to note that the differentials in the effects of milk prices and land values in New Jersey may also indicate a more stringent business and regulatory climate, lower management capabilities, or simply infrastructural inadequacies that accentuate the decline of the state's dairy industry. As noted above, Adelaja et al. (1997) indicate that because of the lack of a critical mass of farmers, New Jersey does not offer all the services that Pennsylvania and New York do (e.g., a pro-dairy program, milk testing, assistance with recordkeeping, etc.). Adelaja et al. (1997) also showed that (1) milk output per cow is lower in New Jersey than in New York and Pennsylvania, (2) in recent decades, milk output per cow declined in New Jersey while it increased in New York and Pennsylvania, (3) fewer New Jersey farmers utilize programs that are important for dairy management (e.g., Dairy Herd Improvement Associations), and (4) the costs of most production inputs are higher in New Jersey vis-à-vis New York and Pennsylvania. These conditions tend to make New Jersey dairy farms more vulnerable to output and input market conditions.

Summary and Conclusion

This paper examines the role of land values in the changes in the dairy industry in New York, New Jersey, and Pennsylvania. Results indicate that rising land values have been a major reason why dairy herd sizes have declined in recent decades. Previous studies overlooked the influence of land values. This study suggests that this variable should not be ignored when investigating the problems of dairy at the urban fringe, especially in states such as New Jersey, where land values have increased by about 1600% over the past forty-five years. The value of land is a key reason why so few dairy farms remain in New Jersey today.

The finding that dairy farmers at the urban fringe are more vulnerable to rising land values and declining milk prices suggests tougher days ahead for farmers in the tri-state area, especially those in New Jersey. The greater vulnerability of New Jersey farmers may be due to differences in capability, infrastructure to support the dairy industry, the degree of urbanization, and socioeconomic characteristics of the farmers themselves. Already, milk prices are at the lowest levels in decades. The 1996 Federal Agricultural Improvement and Reform (FAIR) Act prescribed greater reliance on market mechanisms to determine prices and the merging of the federal milk market orders, which many dairy farmers fear will force milk prices down further. If these fears materialize, New Jersey dairy farmers and others at the urban fringe will face critical decisions about their future in the dairy business. Their greater vulnerability suggests that programs such as farmland assessment, farmland preservation, right-to-farm, and other policies designed to protect farmers or offer them a unique advantage may need reinforcement if dairy farms are to survive there.

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