Do the Largest Firms Grow the Fastest?

The Case of U.S. Dairies

Almuhanad Melhim, Erik J. O'Donoghue, and C. Richard Shumway

- Almuhanad Melhim is a graduate research assistant in the School of Economic Sciences, Washington State University, Pullman. (509) 335-1492 (office), amelhim@wsu.edu
- Erik J O'Donoghue is an economist with the Economic Research Service, U.S. Department of Agriculture. (202) 694-5585 (office), eo'donoghue@ers.usda.gov
- C. Richard Shumway is a professor in the School of Economic Sciences, Washington State University, Pullman. (509) 335-1007 (office), (509) 335-1173 (fax), shumway@wsu.edu

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007

The views expressed are those of the authors and do not necessarily correspond to the views or policies of ERS or the U.S. Department of Agriculture.

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Abstract

We analyze growth and diversification of U.S. dairy farms by examining longitudinal changes in ten size cohorts and new entrants through three successive censuses. Gibrat's law (random walk) and mean reversion hypotheses of growth are tested and rejected. Growth rates are bimodal with the largest farm cohort growing the fastest. All cohorts become more diversified over time, and smaller farms diversify most rapidly. New entrants are generally large, and they diversify more rapidly than incumbents. These data suggest that scale economies persist even for the largest cohort of dairy farms and that scale economies dominate scope economies for large farms.

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In recent decades, the U.S. dairy sector has been undergoing significant structural changes. These changes include industry consolidation, size and geographic concentration of agricultural production, contractual and integrated production schemes, and increasing numbers of large operations.

Similar statements could be made about most agricultural industries, but the changes have been particularly acute in the dairy industry. While the number of U.S. farms declined by 21% between 1974 and 2002, the number of farms with milk cows declined by an astounding 79% (USDA, 2002). This rapid drop in number of dairies would be remarkable in its own right, but it is part of a continuing trend. The number of dairies declined by 71% in the preceding decade (Matulich, 1978). They dropped another 15% in the three years following the last Census of Agriculture (USDA, 2003, 2006). Thus, there were only 5% as many farms with milk cows in 2005 as in 1964.

With 60% as many milk cows on farms, the dairy industry has become much more concentrated. In fact, between 1974 and 2002, all of the decline in number of farms with milk cows was in size categories with fewer than 500 cows. The number of farms with 500-999 milk cows grew by 36% and the number with 1,000 or more milk cows more than doubled.

Consolidation is also occurring at the cooperative level. Dairy cooperatives, which currently process 86% of the milk produced and represent 67% of all dairy operations, declined in number from 265 in 1992 to 196 in 2002, a 26% drop in one decade (Liebrand, 2005).

Further, the U.S. dairy industry has become more geographically concentrated, particularly in the West. The abundance of land, favorable climate, and availability of inputs has allowed dry lot dairy farms to capture large scale economies and realize larger farm sizes (Miller and Blayney, 2006; Sumner and Wolf, 2002).

The rapid changes in this industry suggest several important empirical research questions and testable hypotheses with regard to firm and industry growth that could have profound implications for public and private decision making. For example, profit-maximizing, price-taking firms are expected to grow if they can exploit scale and scope economies. Scale economies exist as long as the firm experiences decreasing average costs as output increases, while scope economies exist if the average total cost of production decreases as a result of increasing the number of goods produced. The existence of both economies in a wide variety of food production and manufacturing industries has been reported by many empirical studies, and some have even found that such economies apply to the largest firms (e.g., Mulik, Taylor, and Woo, 2005; Morrison-Paul, Nehring, and Banker, 2004; Helmers and Atwood, 2003; Mafoua, 2002; Morrison-Paul, 2001; Ollinger, McDonald, and Madison, 2000; Ben-Belhassen and Womack, 2000;). Scale and scope economies have been credited as important driving factors behind the structural changes occurring in the U.S. agricultural sector. Nevertheless, the evidence remains ambiguous as some have found constant or declining returns to scale/scope for the larger firms (Mosheim and Lovell, 2006; Just, Mitra, and Netanyahu, 2005; Chavas and Aliber, 1993; Matulich, 1978).

Resolving this dilemma is of great import. If the largest food production firms do experience economies of scale and scope and if those economies do not dissipate, the perfectly competitive nature of this industry could eventually disappear. A necessary condition for a competitive industry is that there are many firms. To assure an equilibrium with many firms, they must face increasing average costs well before market demand is satisfied. If economies of scale and/or scope actually exist over all observed firm sizes, then we would expect movement toward a single firm. The agricultural production sector is currently so far from consolidating ownership under a single firm that the thought seems unimaginable. Yet, if the rate of decline experienced over the last four decades in the number of farms with milk cows were to continue for 12 more decades, the entire market for milk in the U.S. would be supplied by just 10 firms.

While much of the earlier research has focused on measuring economies of scale and scope, cost economies for short, as drivers of firm growth, this paper contributes to the existing literature by seeking answers to three fundamental questions that have not previously been addressed. First, do dairy firms in the largest size cohorts grow at least as rapidly as firms in medium size cohorts? If they grow less rapidly, it would suggest that convergence toward an equilibrium size could ultimately occur, but that equilibrium size may not have been observed yet. On the other hand, if firms in the largest size cohorts grow at least as fast as those in the medium size cohorts, we must conclude that firms are not yet approaching an equilibrium size. Second, do firms become more diversified over time? If they do, it would provide evidence of increasing economies of scope. Third, if they do become more diversified over time, do larger firms diversify more rapidly than medium-sized firms? If the answer to all three questions is yes, then even without further analysis, we can conclude unambiguously that the largest firms are expected to continue to grow more rapidly, and no equilibrium firm size is currently in sight. That would imply that the major structural changes that have occurred in this industry during the last four decades are likely to continue unabated. In addition to seeking answers to these three growth and diversification questions, we examine incumbent firms and new entrants separately.

Method of Analysis

Typically, cost economies are analytically derived from either primal or dual econometric approaches. We approach the topic in a nonparametric way. Rather than econometric modeling, we track farms in 10 initial size cohorts through three successive censuses, determine differences in growth rates, level of diversification, and industry exit rates. We also track new entrants to determine similarity to incumbent firms. While our findings do not provide explanations about the causes of structural change, they do contribute essential missing links in understanding how structural change is being implemented at the firm level. They also create an informational base that can help focus subsequent econometric analysis of causal factors.

The first question is addressed by examining the relationship between initial cohort size and mean growth rate of each incumbent cohort. This relationship will provide inferential evidence concerning whether an equilibrium firm size exists to which firms are converging, and if it does exist, whether it is stable. Cohorts that are growing the most rapidly are likely operating under increasing returns to scale and/or scope.

We also test two hypotheses relevant to the first question from the dynamic firm growth literature: Gibrat's law and mean reversion. Under Gibrat's law, firms are hypothesized to face the same distribution of possible growth rates independent of their size. If they do, they follow a random walk growth pattern. No convergence to steady state equilibrium size occurs. Under mean reversion, growth rates are hypothesized to be inversely related to firm size. In this case, larger firms grow relatively slower than smaller firms, which implies that firms converge to a stable steady state equilibrium. The remaining alternative is that cost economies are sufficiently great that larger firms grow relatively faster than smaller firms. Similar to Gibrat's law, this case implies that no convergence to a steady state equilibrium occurs.

The bulk of prior empirical evidence, based mainly on corporate firm growth, has failed to reject the random walk assumption of growth and has supported Gibrat's law (Geroski, 1998). The empirical evidence on the growth of farms, however, has been inconclusive. For example, although several of the previously cited studies found evidence of increasing returns to scale for larger farms, Kostov et. al. (2005) implicitly rejected that hypothesis as well as explicitly rejecting Gibrat's law in favor of the mean reversion hypothesis for a sample of Irish dairy farms. Smaller farms grew at faster rates than larger farms which suggested greater potential for extracting additional cost economies among smaller farms.

We test whether incumbent dairy farms have grown in accordance with Gibrat's law or mean reversion hypotheses using a linear, fixed-time-effects regression between the initial cohort sizes and their respective annual growth rates. The least squares dummy variable (LSDV) model is specified as follows:

(1) $$y_i = \beta_1 D_{1992} + \beta_2 D_{1997} + \beta_3 r_i + \varepsilon_i, \qquad i = 1, \ldots, 20$$

where y_i is the annual compound growth rate of the cohort mean between its census and the subsequent census, D_{1992} and D_{1997} are census dummy variables, r_i is the mean size of cohort i in the respective census, 1992 or 1997, and ε_i is independently and identically distributed white noise.

The hypothesis tests are equivalent to a t-test of the significance of β_3. If this parameter is significantly different from zero, the null hypothesis that cohorts grow in accordance with Gibrat's law is rejected. If it is not significantly negative, the null hypothesis that cohorts grow in accordance with the mean reversion hypothesis is rejected. If both hypotheses are rejected in favor of a significantly positive β_3, the hypothesis that cost economies are sufficiently great that larger firms grow relatively faster than smaller firms is not rejected.

To address the second and third questions about increasing diversification, farms are separated into four sales categories in each census. The sales categories differ only by the contribution of the farm's milk and dairy product sales to its total agricultural sales: 90% or greater, 75-89.9%, 50-74.9%, and less than 50%. The sales category of each incumbent and new entrant farm is determined for each census. Evidence of increasing diversification over time and inferential evidence of economies of scope would occur if subsequent censuses reveal increasing portions of farms in the lower sales categories and decreasing portions in the higher sales categories. Positively correlated rates of increase in lower sales categories with cohort size would provide evidence that larger farms experience relatively greater economies of scope.

Data

Longitudinal data from the Census of Agriculture in 1992, 1997, and 2002 are used in this study. Except for retired and residential/lifestyle farmers, the incumbent sample includes all farms classified as dairy farms in the 1992 Census of Agriculture. It includes all farms for which the owner checked farming as his/her main occupation and for which at least 50 percent of all agricultural income (exclusive of government payments) in 1992 came from the sale of milk and dairy products. About half of all farms reporting milk cows in the 1992 Census are included in our sample.

The sample of new entrants in 1997 and 2002 meet the same criteria for the census of entry. New farm entrants in 1997 constitute a new cohort and are followed through the 2002 census. New farm entrants in 2002 are included as another new cohort.

Dairy farms in the 1992 Census of Agriculture are ranked based on the value of agricultural sales excluding government payments. They are then partitioned into ten non-overlapping cohorts based on size. They have equal numbers in each cohort. Farms in each initial cohort are followed through the 1997 and 2002 censuses. Because some firms exit the industry between successive censuses, the longitudinal data files for the incumbent sample form an unbalanced panel.

By using the Census Farm Number (CFN) and Personal Operation Identification System (POIDS) codes, these data permit us to track most individual farms through subsequent censuses based on the legal entity for tax purposes. However, because the administration and conduct of agricultural census was moved from the Bureau of the Census to the USDA National Agricultural Statistics Service, the tracking was not perfect. In the 1992 and 1997 censuses, farms were identified by the Bureau of the Census using the CFN which used land to recognize farms over time. For these censuses, each individual "farm" operator received one form for his/her farm, even though the farm might have included several pieces of lands or separate farming businesses. For the 2002 census, farms were identified by the National Agricultural Statistics Service using the

POIDS which recognized farms by operator/operation. Following this code, each distinct agricultural operation (e.g., a farm, ranch, feedlot, or greenhouse) was considered a separate farm record. In other words, an operator received as many forms as the number of different businesses s/he ran. Consequently, the matching of farms between the 1997 and 2002 censuses was not as precise as between the 1992 and 1997 censuses. The matching mechanism was a correspondence rather than a function and resulted in a bias in the absolute number of entering and exiting farms in 2002. Because the bias affected all size cohorts, we limit our analysis of the cohorts to relative changes.

Summary statistics are computed for each cohort in each census to determine changes in size distribution characteristics of dairy farms over time. They include: (1) number of farms, (2) mean size, (3) median size, (4) size range, (5) size standard deviation, (6) size skewness, (7) size kurtosis, (8) number of exiting firms, and (9) portion of farms in each of the four sales categories (i.e., 90% or more, 75-94.9%, 50-74.9%, or less than 50% percent of all agricultural sales from milk and dairy products). Incumbent farms in subsequent censuses do not change their cohort assignment. Therefore, size ranges of cohorts in the 1997 and 2002 censuses overlap due to growth or decline in size of individual farms but represent all surviving farms in each cohort.

For the 1997 and 2002 censuses, an additional cohort of new entrants is created for farms entering the dairy business since the previous census. The same statistical information is recorded for each cohort of new entrants. In addition, the number of new entrants that are in the size range of each 1992 cohort is also recorded.

To permit valid calculations of firm growth between censuses, agricultural receipts in each census are deflated by the index of prices received. Milk and dairy product sales for each sales category in each cohort are deflated by the index of prices received for dairy products. The remaining agricultural sales are deflated by the index of prices received for all farm products (USDA, 2001, 2005).

Results

We discuss our findings with regard to each of the questions raised in the objectives: (1) Do dairy firms in the largest size cohorts grow at least as rapidly as firms in medium size cohorts? (2) Do firms become more diversified over time? (3) If they do become more diversified over time, do larger firms diversify more rapidly than medium-sized firms? Answers to these questions are provided by examining results for the incumbent cohorts. We also report the results of the two hypothesis tests associated with the first question and determine temporal changes in the distribution of firms within cohorts. We then report findings with regard to entry and exit of firms over the 10-year data period between the 1992 and 2002 censuses. Before providing results with regard to those questions, we describe the distributional properties of the data for the incumbent cohorts.

Firm Distribution by Cohort and Census

The first four statistical moments of the 1992 farm size distribution of each cohort are reported along with median and approximate range in Table 1. The relatively small size of most farms with milk cows is evident from these data. Although our sample of 73,406 farms excluded retired and residential/lifestyle farmers, nearly half had agricultural sales of less than $100,000 in 1992. Only 10 percent had sales in excess of $330,000.

Cohorts 1-9 had medians that were very similar to their means, and they had small standard deviation, skewness, and kurtosis coefficients. The distribution of cohort 1 was slightly left-skewed, indicating a little higher probability of farms being larger than the cohort mean. The distributions of cohorts 7-9 were slightly right-skewed. The distributions of cohorts 2-6 were approximately symmetric. Kurtosis coefficients were all positive and of similar magnitude for cohorts 1-9. They imply that each cohort had a higher probability of extreme sizes than would occur if the distribution of farm size within the cohort were normal.

The moments for the tenth cohort were very different from the others. It is readily apparent that this cohort contained some very large farms. The estimated median and mean values were very different. The standard deviation was much larger than for any of the other cohorts. The large skewness coefficient implies a highly right-skewed distribution. The very large kurtosis coefficient further documents that much of the variance was due to infrequent extreme deviations as opposed to frequent modest-sized deviations.

In subsequent censuses, size ranges of the cohorts overlapped since farms within a designated 1992 cohort could expand or contract operational size over time. The four moments, median, and range width for each incumbent cohort are reported for 1997 and 2002 in Table 2. The most dramatic and prevalent results for each of the first nine cohorts were: (1) the gap between median and mean farms increased over time, (2) the values of the higher moments became much larger, and (3) the size range of the cohort widened greatly, in most cases 50-100 times wider. For cohort 10, the gap between median and mean farms and the size of its standard deviation also increased over time, but its skewness and kurtosis coefficients were actually smaller in 1997 and 2002 than in 1992. Consequently, for each of the first nine cohorts in both 1997 and 2002 censuses, size distributions became considerably flatter and more asymmetric with a thicker left tail, and farms within each of these cohorts became more size heterogeneous. It is also apparent that a few farms in each cohort grew considerably. On the other hand, the tenth cohort became somewhat more symmetric and peaked. Its distributional variance was driven by less frequent extreme deviations and more frequent modestly sized ones.

Firm Growth

Mean growth rates of 1992 dairy farms that remained in production varied considerably both among cohorts and between censuses. After adjusting for inflation between the censuses, the dairy farms grew at an average compound rate of 1.1% per year between the 1992 and 1997 censuses and 1.8% per year between the 1997 and 2002 censuses, averaging 1.5% between 1992 and 2002.

As evident from Figure 1, the most rapid growth rates occurred at both ends of the 1992 size distribution. Average size of cohorts 2-5 each grew less than 1% per year over the 10-year period. However, the smallest cohort grew at a compound rate of 2.9% per year, making it the 2nd most rapidly growing cohort. Each of the three largest cohorts also grew rapidly, resulting in a bimodal growth distribution. The largest cohort grew the most rapidly – 3.3% per year.

The bimodality of the growth distribution occurred mainly in the 1st five years. In that period, cohort 1 grew more rapidly than any other – 4.9% per year. With the exception of cohort 10 which grew at a 2.9% rate, none of the other cohorts reached a 1.0% growth rate and most grew at a rate of less that 0.5%. In the 2nd five years, the growth rate was strongly and positively correlated (0.90) with cohort number. With the exception of cohort 3, all cohorts grew at a more rapid (or only slightly slower) rate than the next smaller cohort.

In order to answer the first question, do dairy firms in the largest size cohorts grow at least as rapidly as firms in medium size cohorts, we classified cohorts 4-9 as medium-sized firms. These firms received agricultural revenue in 1992 ranging from $95,000 to $330,000. Only firms in cohort 10 received more than $330,000 so this cohort was classified as the larger firms. The mean size of the largest cohort grew more rapidly over the 10-year period and over each 5-year period than the mean size of all other cohorts except the smallest cohort. Thus, the answer to the first question is clearly yes.

The estimated parameters for the LSDV model, equation (1), are reported in Table 3. From these parameter estimates, both of the hypotheses from the dynamic firm growth literature can be tested. Support for Gibrat's law (i.e., firm growth follows a random walk) would be implied by the parameter on *r* being zero. Support for mean reversion (i.e., firm growth is inversely related to initial size) would be implied by a significantly negative parameter on *r*. The estimated parameter on this variable was both positive and significant at the 1% level. Although its magnitude is small, both of the dynamic firm growth hypotheses are rejected for the U.S. dairy industry in favor of the alternate hypothesis that firm growth is positively related to initial firm size. The size distribution is not converging to a stable steady state equilibrium.

Consequently, the nonparametric examination of rates of growth by cohort and the results of the statistical hypothesis tests both render support to the alternative view that an equilibrium firm size (i.e., one operating at the minimum point on the average cost curve) has not yet been reached in the dairy industry.

Firm Size and Diversification

Because of the criteria used to select farms to include in the sample, no dairies in 1992 were in the most diversified sales class (with less than 50% of agricultural sales from milk and dairy products). That selection criterion excluded about half of all farms with milk cows from the sample. It is widely accepted that U.S. dairy farms are highly specialized in milk production and generate most of their agricultural revenue from the sale of milk and dairy products. Yet many farms had milk cows in 1992 that did not meet that minimum hurdle for inclusion in the sample.

Further, as apparent from the first panel of Figure 2, the largest cohort (cohort 10) was the most specialized and the smallest cohort (cohort 1) was the most diversified in their source of agricultural revenue. A little more than a quarter of farms in the smallest cohort received at least 90% of their agricultural revenue from the sale of milk and dairy products while close to half the farms in the largest cohort were that specialized. A third of cohort 1 farms and a fifth of cohort 10 farms received less than 75% of their revenue from dairy sales.

In successive censuses (see the second and third panels of Figure 2), each cohort became more diversified. [1] For example, the percent of firms in cohort 1 that received 90% or more of their agricultural sales from milk and dairy products declined from 28% in 1992 to 14% in 2002. For Cohort 10, the corresponding numbers were 45% in 1992 and 42% in 2002. Much more dramatic was the change in number of farms in the most

[1] An exception was that a larger portion of farms in cohorts 3-10 received 90% or more of agricultural revenue from sale of milk and dairy products in 1997 than in 1992. However, a substantial share of farms in all cohorts moved into the most diversified sales class in 1997.

diversified sales class. By 2002, 62% of farms in cohort 1 and 24% of farms in cohort 10 received less than half of their agricultural sales from milk and dairy products, whereas none did in 1992.

Across cohorts, diversification followed roughly the same pattern in 1997 and 2002 as in 1992. The smallest cohort was the most diversified and the largest cohort was the most specialized in each census. The graphical evidence of less diversification in the larger cohorts than in the smaller ones was confirmed statistically by the correlation between firm size and diversification tendency. Correlation coefficients between cohort number and the percent of farms in the most specialized sales category were 0.71, 0.82, and 0.92 in 1992, 1997, and 2002, respectively. The correlation coefficients with the least diversified sales category were -0.88 in 1997 and -0.94 in 2002. These statistics document a clear tendency toward greater specialization as firm size increased, and this tendency became stronger over time. [2]

Dairy operations of all sizes have undergone changes in their scope of production towards more diversified production plans with less reliance on dairy and dairy-related production. The initial size only influenced the extent of the adjustment. Thus, the answer to the second question, do firms become more diversified over time, is also an unqualified yes.

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[2] While the diversification trends between 1997 and 2002 followed those between 1992 and 1997, some caution should be exercised when interpreting the most recent statistics. Milk and dairy product sales do not include cull dairy cow or other cattle sales, and milk price was lower in 2002 than in 1992 or 1997. Consequently, it is possible that part of the apparent increase in diversification in 2002 was due to a higher than normal culling rate induced by the lower milk price.

In order to answer the third question, do larger firms diversify more rapidly than medium-sized firms, we examine the percent of agricultural sales from milk and dairy products for the medium- and large-sized farms for each census. These statistics are reported in Table 4. For each census, the distribution of farms is consistently more specialized for the large-sized farms than for the medium-sized farms. Further, the medium-sized farms diversify at a more rapid rate than do the large-sized farms. Thus, the answer to the third question is no.

Firm Entry and Exit

Between each pair of censuses, approximately twice as many dairy firms exited the industry as new firms entered. Over the 10-year period, cohorts 1-8 had ratios of exits to entries ranging from 2.1 to 2.8. The average for cohorts 9-10 was just over 1.0. Only the largest category had more entrants than exits. The correlation between exit/entry ratio and cohort number was -0.78.

The distribution of new entrants was very different than the distribution of incumbent farms. Their mean size was very large, falling between the means of incumbent cohorts 8 and 9 in 1997 and cohorts 9 and 10 in 2002. Their median size fell between the median sizes of incumbent cohorts 4 and 5 in 1997 and cohorts 7 and 8 in 2002. Standard deviations of both were a little below those of cohort 10. Skewness and kurtosis coefficients were near the highest of any incumbent cohort. They were also highly specialized when they entered the dairy industry; their distributions among sales classes were very similar to the 1992 distribution of the largest incumbent cohort (see Table 4).

They also behaved differently over time. Between 1997 and 2002, there was little change in the 1^{st} and 2^{nd} moments of the 1997 cohort of new entrants, but the 3^{rd} and 4^{th}

moments and the range dropped markedly. So rather than becoming larger, more dispersed, and more asymmetric like the incumbent cohorts, the distribution of firms in the new entrants cohort became more compact and symmetric. Although they were as specialized when they entered the industry as the largest incumbent cohort had been, they increased their level of diversification almost as much in five years as the medium-sized cohorts did in 10 years.

Conclusions and Implications for Decision Making

The existing empirical literature on firm growth in competitive markets provides no conclusive evidence about the relationship between firm size and its growth. In this paper we examine scale and scope economies in the dairy industry. For this purpose we use a nonparametric approach. We conclude inferentially that both scale and scope economies persist in the largest cohort of dairy farms but scope economies appear to be greater in the smaller cohorts.

Results show large dairy farms still experience significant scale economies that do not dissipate. They grow at a faster rate than medium-sized farms. This suggests that size distribution is not approaching a stable steady state equilibrium. Results also show that new entrants are generally large. This indicates that the minimum farm size below which dairy production is no longer profitable without a niche market is getting larger.

Dairy farms of all sizes diversify their output over time. A growing number of dairy producers are making the strategic decision of becoming less dependent on production of milk and dairy products in favor of other agricultural outputs. The rate of diversification is highest among small producers, and new entrants diversify more rapidly than incumbents.

These findings have important decision-making implications for dairy producers. If the pattern of growth and diversification that occurred between 1992 and 2002 continues, a new type of industry will develop that is very different from the highly specialized, relatively small firms that have dominated the dairy industry in the past. In this event, small and medium-sized producers will lose market share and even their businesses to larger ones. The livelihood of small rural households who depend on production of milk and dairy products will be increasingly at risk. However, small producers and new entrants can capture scale economies by partnering or cooperating with others to invest in large herds or consolidate. They can capture scope economies by adopting alternative technologies or business models that allow more diversified output.

These findings also have important decision-making implications for policy makers. Important policy goals include promoting competition, preserving the vitality of rural communities, and preventing environmental degradation. Policies and political access that inadvertently give preferential treatment to large firms can undermine the competitive nature of agriculture. Rather, policy instruments and incentives that focus on helping small- and medium-sized dairy producers consolidate and/or diversify may be needed to slow the decline of small dairy farms. Virtually all dairy farms in these cohorts qualify as small businesses. Facilitation of new business models, information dissemination, and access to credit for small businesses could all be crucial for consolidation and diversification. Although inconceivable even a few decades ago, continuation of the long-term rapid growth rate of firm size experienced in the dairy industry could result in a highly concentrated industry. Because such a concentrated industry would also adversely affect the viability of rural communities and the quality of the environment, policies to facilitate small business growth and diversification could achieve multiple policy objectives. Further, because public concerns about air and water pollution from confined animal production units increase with the geographic concentration of the industry, strengthening policy instruments to mitigate negative environmental externalities could simultaneously promote a less concentrated, competitive industry of small businesses.

References

Ben-Belhassen, B., and Womack A.W., 2000, "Measurement and Explanation of Technical Efficiency in Missouri Hog Production", *A paper presented at the American Agricultural Economics Association Annual Meeting*, Tampa, Florida

Chavas, J.P., and Aliber M., 1993, "An Analysis of Economic Efficiency in Agriculture: a Nonparametric Approach", *Journal of Agriculture and Resource Economics*, vol. 18, no. 1, pp. 1-16

Geroski, P.A., 1998, "The Growth of Firms in Theory and in Practice",

Helmers, G., and Shaik S., 2003, "Economies of Scope and Scale Efficiency Gains Due to Diversification", *A paper presented at the Western Agricultural Association Annual Meeting, Denver,* Colorado

Helmers, G., Shaik S., and Atwood J., 2003, "Scope and Scale Efficiency Gains Due to Vertical Integration in the U.S. Hog Sector", *Annual Meeting of Southern Agricultural Economics Association,* Mobile, Alabama

Herath, D.P., Weersink A. J., and Carpentier C.L., 2004, Spatial and Temporal Changes in the U.S. Hog, Dairy and Fed-Cattle Sectors, 1975-2000", *Review of Agricultural Economics*, vol. 27, no.1, pp. 49-69

Just, R.E., Mitra S., and Netanyahu S., 2005, "Implications of Nash Bargaining for Horizontal Industry Integration", *American Journal of Agricultural Economics*, vol. 87, no. 2, pp. 467-481

Kostov, P., Patton P., Moss J., and McErlean S., 2005, "Does Gibrat's Law hold amongst Dairy Farmers in Northern Irland?", Paper prepared for the 11th EAAE (European Association of Agricultural Economists), Copenhagen, Denmark

Liebrand C., 2005, "Cooperatives in the Dairy Industry", USDA Cooperative Information Report Section 16.

Mafoua, E.D., 2002, "Economies of Scope and Scale of Multi-Product U.S. Cash Grain Farms: A Flexible Fixed-Cost Quadratic (FFCQ) Model Analysis", *Annual Meeting of American Agricultural Economics Association,* Long Beach, California

Matulich, S.C. 1978. "Efficiencies in Large-Scale Dairying: Incentives for Future Structural Change." *American Journal of Agricultural Economics*, *60*(4), 642-67.

Mosheim, R., and Lovell C.A.K., 2006, "Economic Efficiency, Structure and Scale Economies in the U.S. Dairy Sector", Selected paper for AAEA annual meeting, Long Beach, California

Miller, J.J., and Blayney D.P., July 2006, “Dairy Backgrounder”, **Economic Research Service**, U.S. Department of Agriculture, LDP-M-145-01

Mulik, K., Taylor R.D., and Koo W.W., “Estimating Efficiency Measures in North Dakota Farms”, Agribusiness and Applied Economics Report No. 565, Center of Agricultural Policy and Trade Studies, North Dakota State University

Ollinger, M.E., McDonald J.M, and Madison M, 2000, “Structural Change in U.S. Chicken and Turkey Slaughter”, **Economic Research Service**, U.S. Department of Agriculture, Agricultural Economic report No. 787

Paul, C.J.M., 2001, “Market and Cost Structure in the U.S. Beef Packing Industry: A Plant-Level Analysis”, *American Journal of Agricultural Economics*, vol. 83, no. 1, pp. 64-76

Sumner, D.A., and Wolf C., “Diversification, Vertical Integration, and the Regional Pattern of Dairy Farm Size”, *Review of Agricultural Economics*, vol. 24, no.2, pp.442-457

U.S. Department of Agriculture. 1992, 1997, 2002. *Census of Agriculture.* National Agricultural Statistical Service. Available online: http://www.nass.usda.gov/Census_of_Agriculture.

United States Department of Agriculture. 2001, 2006. *Agricultural Statistics.* National Agricultural Statistical Service. Available online: http://www.nass.usda.gov/Publications/Ag_Statistics/.

Figure 1: Annual growth rates

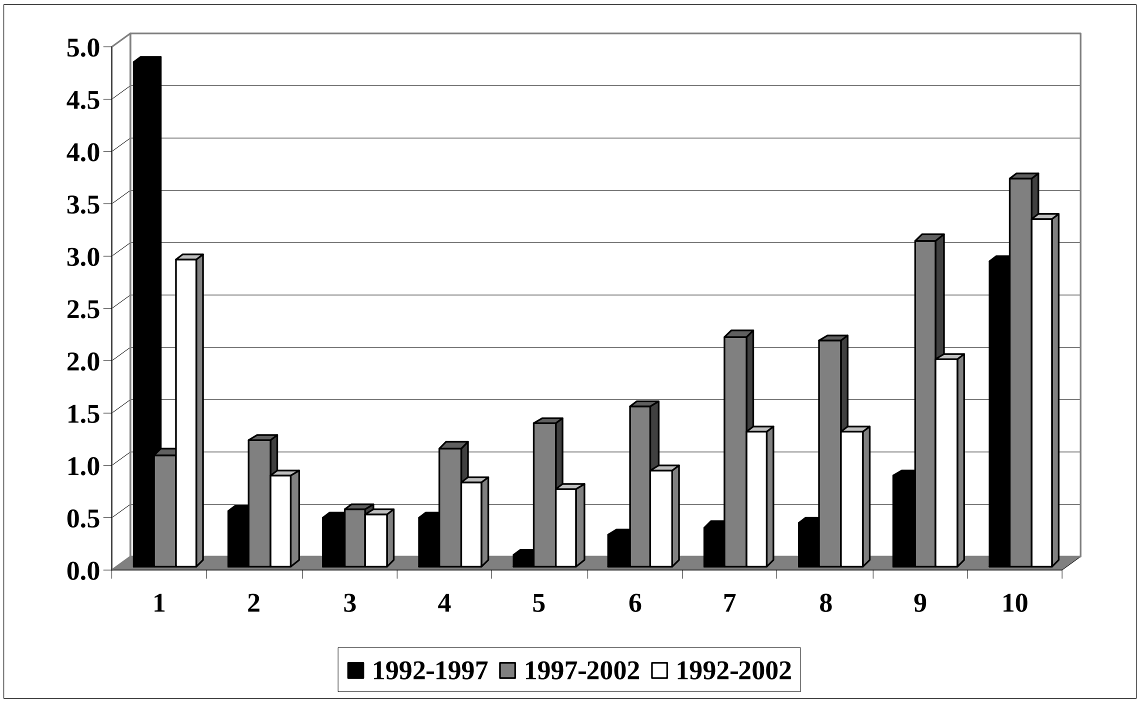

Figure 2. Farm diversification

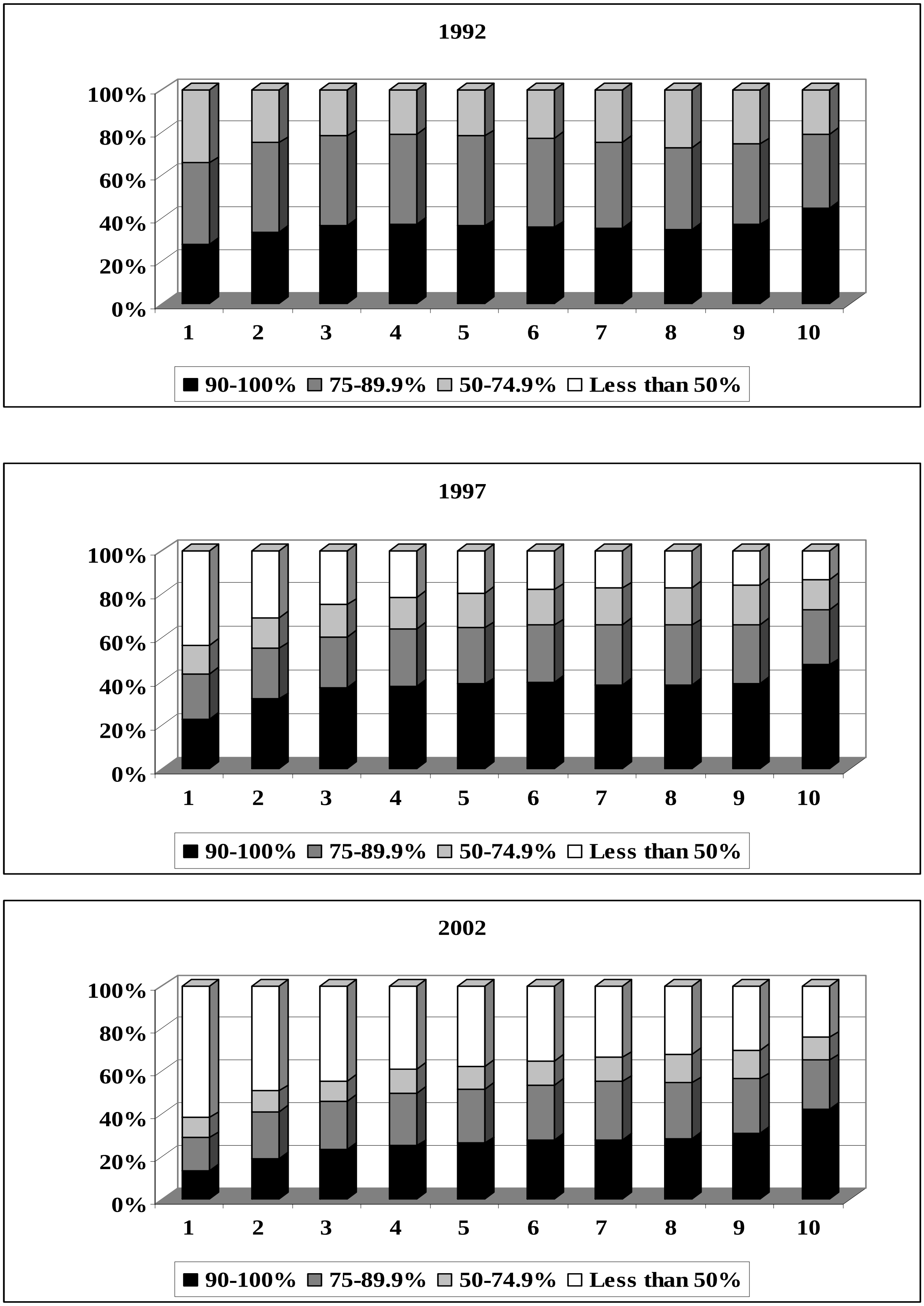

Table 1: 1992 Agricultural sales range, median, and sample distribution moments for cohorts [a]

Cohort	Range ($1,000)	Median ($1,000)	Mean ($1,000)	Standard Deviation ($1,000)	Skewness Coefficient	Kurtosis Coefficient
1	<37	25	24	10	-0.32	1.32
2	37-58	48	48	7	-0.04	0.98
3	58-76	67	67	6	-0.02	1.07
4	76-94	85	85	6	0.00	1.04
5	94-114	104	104	6	0.04	1.22
6	114-136	124	125	7	0.05	1.26
7	136-169	151	152	10	0.14	1.40
8	169-221	192	193	15	0.17	1.61
9	221-330	262	267	31	0.37	1.97
10	> 330	490	777	940	9.05	169.07

[a] Sample size: 73,406. Data source: Agricultural Census, (USDA, 1992)

Table 2: 1997 and 2002 Agricultural sales range width, median, and sample distribution moments for incumbent cohorts [a]

Cohort	Range Width ($1,000)	Median ($1,000)	Mean ($1,000)	Standard Deviation ($1,000)	Skewness Coefficient	Kurtosis Coefficient
1997 Census						
1	1,644	22	32	52	9.7	223.6
2	1,771	45	51	55	9.0	209.9
3	2,306	66	71	68	11.0	284.4
4	1,921	85	91	73	7.1	123.9
5	1,940	104	108	75	5.7	95.9
6	2,522	126	131	88	6.9	137.3
7	2,390	151	160	107	5.4	73.6
8	3,500	193	204	130	6.0	100.9
9	3,229	270	288	177	4.1	42.9
10	30,384	553	925	1,258	6.6	89.5
2002 Census						
1	2,000	15	31	73	7.8	172.1
2	1,725	37	50	81	6.5	99.8
3	2,056	55	67	96	5.8	84.5
4	5,020	77	88	131	15.7	530.5
5	3,472	93	106	122	7.0	151.4
6	4,312	115	129	162	9.3	185.7
7	3,410	143	163	188	4.9	53.6
8	4,920	183	207	223	5.8	85.0
9	8,750	256	307	357	6.9	110.3
10	42,322	551	1013	1578	7.1	131.5

[a] Sample size: 66,333 in 1997, 41,369 in 2002. Data source: Agricultural Census (USDA, 1997, 2002)

Table 3: The coefficient estimates of the LSDV model [a]

Variable	Growth Rate
D_{1992}	0.0064
	(0.0042)
D_{1997}	0.0127**
	(0.0043)
r	0.00003*
	(0.00001)

[a] Standard errors are in parentheses. Significant parameters are marked with an asterisk: one at the .05 level and two at the .01 level.

Table 4: Distribution of farms among sales categories [a]

Census	Agricultural Revenue from Milk and Dairy Products	Farm Size of Incumbents		New Entrants	
		Medium (Cohorts 5-9)	Large (Cohort 10)	1997	2002
1992	90-100%	35.7	44.8		
	75-89.9%	40.0	34.2		
	50-74.9%	24.3	21.0		
	<50%	0	0		
1997	90-100%	38.8	47.5	46.0	
	75-89.9%	26.8	25.3	30.8	
	50-74.9%	16.8	14.1	23.2	
	<50%	17.6	13.1	0	
2002	90-100%	28.1	42.0	32.5	44.7
	75-89.9%	26.0	23.1	26.4	36.3
	50-74.9%	12.0	10.6	11.1	19.1
	<50%	33.9	24.3	30.0	0

[a] Data source: Agricultural Census (USDA, 1992, 1997, 2002)