

Scale Economies and Structure in Dairy Farming: Background

Strong structural changes—specifically, the ongoing shift of production to larger operations—suggest that there may be significant economies of scale in dairy production, in the form of cost advantages accruing to increased herd sizes. This report assesses the sources, magnitude, and extent of scale economies, and traces their impact on the industry. However, there are several elements to the link between scale economies and farm structure, and we must first describe those elements.

A longrun average cost curve is depicted in figure 2.⁴ The figure consists of three regions. At low levels of output, average costs decline with increases in output. The figure also displays a range of constant average costs, in which average costs do not vary with increases in output, and a range of diseconomies of scale (rises in average cost as production increases).⁵

Five elements of figure 2 are important for evaluating scale in an industry:

- The level of output at which scale economies are just exhausted (and at which constant returns set in) is called the firm's *minimum efficient scale*.
- The *cost penalty from small scale*—how much higher are the costs of small firms that are unable to realize minimum efficient scale?
- The output level at which diseconomies set in is called the *maximum efficient scale*—the largest firm size that can be achieved while still realizing all scale economies. Diseconomies are clearly important in agriculture, since even very large farms are still fairly small businesses.
- Cost curves are *efficiency frontiers*—they reflect the minimum costs that a firm can achieve, given available technology and prices paid for inputs. In practice, actual costs could exceed frontier costs (and thus be *inefficient*) because some inputs are in fixed supply and cannot easily be adjusted to the level needed to achieve the efficiency frontier, because of a poor operating environment (reflecting weather or topography) or because the operator is less effective than other operators.
- A cost curve reflects a given set of input prices. Changes in input prices would shift the curve, but could also alter scale relationships and therefore the shape of the curve.

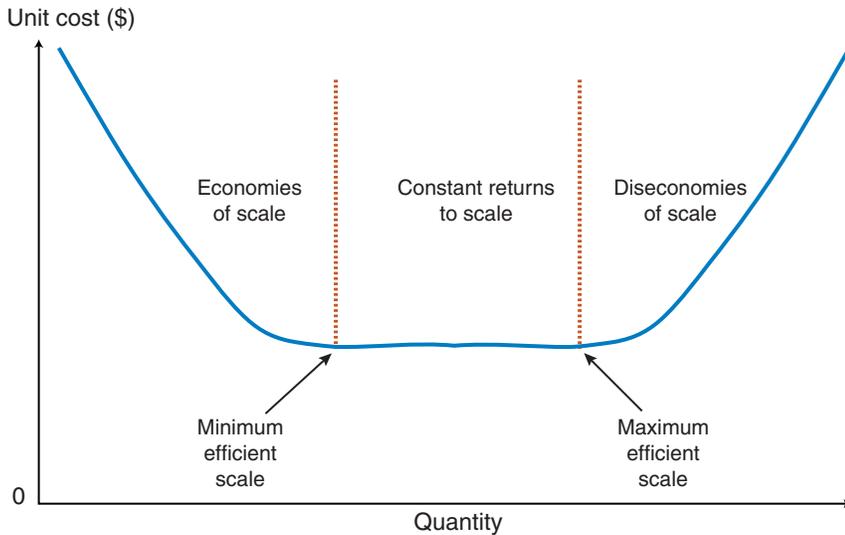
When we assess how cost-scale relationships affect the size structure of farms, it is important to consider all of these elements. Minimum and maximum efficient scales drive the potential range of farm sizes and, coupled with product demand, largely determine how many farm operations will be in business in the long run. The cost penalty from small scale affects the likely survival of smaller operations that cannot realize minimum efficient scale. The efficiency of operations affects survival and the actual industrywide cost changes from structural change. Finally, relative price changes could alter the existing pattern of scale advantages. Increases in prices paid for hired labor, purchased feed, or manure transportation would, all else being equal, raise costs more for large dairy farms than for small since they use those inputs more intensively.

⁴The average cost curve represents how costs vary with output, for a given set of input prices. Changes in input prices, or technological innovations, could shift the position and shape of the curve.

⁵Technically, Chambers (1988) reserves the term “economies of scale” for a specific technological relationship—the increase in output attendant upon an equiproportionate increase in all inputs. However, if production is not homothetic, then that technological relationship will not capture the full change in longrun average costs attendant upon output growth (in non-homothetic production, cost minimizing factor proportions vary with output). Chambers uses the term “economies of size” for relationship between costs and output, but we use “economies of scale” to be consistent with the industrial organization literature (Panzar, 1989).

Figure 2

Visualizing scale economy concepts



Source: USDA, ERS.

Explicit and Implicit Costs in Dairy Production

In assessing dairy production costs, analysts must be careful to account for all relevant costs. Some are explicit and easy to record. For example, farms that purchase feed record feed expenses and quantities. Hired labor is also an explicit cost to operations; the operator incurs a specific expense for the hours worked during any time period.

But significant implicit expenses are also incurred on dairy farms and are much harder to measure. For example, farm operators and their families contribute labor to the dairy enterprise. Although unpaid, the cost of the labor should still be recognized. The operator or family members could have earned income by working off the farm, and their foregone labor earnings represent the opportunity cost of the farm's unpaid labor.

Dairy farms often incur two other important implicit expenses, for home-grown feed and for capital equipment and structures. Homegrown feeds and forage represent implicit costs because the operator could have sold the feeds or the land supporting their production. Many operations own equipment and structures, and do not record an explicit annual expense for their use. But capital use remains an implicit cost to the farm that could have invested the money elsewhere and earned a return on it.

Two other issues pertain in developing cost estimates: joint production and common costs. Dairy production yields a joint product—milk and livestock, the dairy animals that are culled from the herd and sold. If products are truly joint, the costs of producing them cannot be attributed separately to each product, and attempts to do so may simply underestimate the costs of the enterprise. Next, some costs—such as taxes, administrative overhead, and some energy expenses—are borne at the level of the whole farm (they are common to all commodities produced on a farm). Different analytical

approaches may have different means of accounting for joint products and common costs, and this may lead to different estimates.

Measuring Dairy Costs With ARMS

USDA's Agricultural Resource Management Survey (ARMS) provides data on input use, expenses, production, and farm characteristics for a large representative sample of U.S. farms (Appendix). The annual survey contains multiple versions, some targeting producers of specific commodities. Two dairy versions underlie our analyses; one collected data from the year 2000 from dairy farms in 22 States, and the other collected data for the year 2005 from dairy farms in 24 States.

The 2005 survey included specific questions targeted at organic dairy operations and a sample design that would ensure adequate statistical coverage of them. About 1 percent of the Nation's dairy cows were certified organic in 2005. Organic operations tend to be smaller than conventional farms, and to have higher expenses and higher revenues per cwt of milk produced. Our 2005 cost analysis excludes organic operations because their cost structure differs significantly from conventional producers. Organic operations were not separately identified in the 2000 data, when they accounted for about 0.4 percent of the nationwide herd, and some organic operations probably appear in that data set.⁶

The ARMS asks dairy producers about cow inventories and milk production, technology choices, structures and equipment, input use and expenses, and manure management strategies and technologies. It also elicits information on revenues, expenses, production, assets, and liabilities at the whole-farm level, as well as information about the farm operator's household.

The survey's information can be combined with additional analyses and data to estimate implicit expenses. ERS staff use off-farm wage data from another version of ARMS to estimate the opportunity costs of unpaid labor hours used on the farm. Market price data, from other USDA sources, are used to value the reported quantities of homegrown feed and forages fed to dairy cows. Finally, ERS analysts produce annualized estimates of the cost of replacing the capital used for cattle housing, milking facilities, feed storage structures, manure handling and storage structures, feed handling equipment, tractors, trucks, and purchased dairy herd replacements, plus the interest that the remaining capital could have earned in an alternative use. ARMS respondents report the type, capacity, and characteristics of different types of equipment and structures in the dairy enterprise. ERS analysts add information on acquisition prices, useful lives of various types of capital, and interest rates to estimate annual capital replacement costs.

⁶McBride and Greene (2007) provide an analysis of organic dairy costs of production, and a comparison to conventional production, using the 2005 survey.