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Enterprise Size Relationships in Agriculture*

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My objectives for this seminar are not to make definite statements about size relationships either from a theoretical, methodological or from a more practical viewpoint. Rather my objective is to outline the extent of the problem. And I hope to be able to demonstrate to you that even to outline the problem is an undertaking of considerable magnitude.

Introduction

Since about 1930 estimates of statistical cost functions have become rather numerous. Statistical cost functions were estimated in this country as well as in Europe. Such cost functions were derived for sundry industries such as railroads, cement industries, leather belt shops, steel industries, waterways and hosiery mills. In agricultural economics H. J. Bressler's study on the "Efficiency in Milk Marketing in Connecticut" is considered to be a fundamental study. This study was at the beginning of an era during which numerous more or less successful measurements of statistical cost functions - on the farm and in agricultural processing industries - were made. It needs to be pointed out that all of these studies were only concerned with economies of size in the production and none, to my knowledge, studied possible marketing economies at the same time. However, there is some evidence that marketing economies may be of greater importance than production economies of size. Nevertheless, this problem of production economies of size was by 1954 considered of such

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importance that a major portion of a conference in Chicago was the order to discussing it. Out of this conference grew a book which is edited by Heady, Johnson and Hardin and is entitled "Resource Productivity, Returns to Scale and Farm Sizes."

Since then scale studies have been removed from the spotlight of the agricultural economics stage. Instead, the spotlight is on the problem of agricultural adjustment. Two books discussing the problems of agricultural adjustment have grown out of conferences similar to the one mentioned above. And although these books primarily discuss agricultural adjustment it is not difficult to trace all throughout the book explicit or implicit assumptions about the shape of the long-run average cost curve. Thus it is safe to say that interest in long-run average cost curves has not diminished but has only taken different form. But what is most interesting, after several decades of study of long-run average cost curves it is still difficult if not at all impossible to reach agreement as to the shape of long-run average cost curves for various enterprises or industries. Assumptions about and conceptions of the long-run average cost curves and their shape and characteristics differ, and the question now becomes which one of the assumptions or the concepts are the correct ones. These questions need to be asked because answers to them are of importance in making predictions of vital economic interest. It may therefore be quite discouraging to look at the literature on statistical cost functions and then to come up with a conclusion like the one of Hans Staehle in a review of the statistical cost functions, published in the American Economic Review. Staehle's conclusion is as follows:

"The literature on statistical cost functions so far produced has certainly, as all measurements are bound to do, enhanced understanding and awareness of the complexity of the subject. But I cannot help thinking that it also represents a case which bears out just that, and not much else."

Theory

This disagreement about the shape of the LAC curve may, at first glance, seem surprising, since the theory of cost of production is that portion of our economic theory structure which appears to be least controversial. This relatively well agreed upon relevant theory of production can be summarized briefly as follows:

(1) A long run average cost curve may be defined as the curve denoting the least possible cost per unit of producing various outputs when the firm has time to build an desired scale of plants, that is to say when all the resources are variable. This means that unit cost is a function of output. Stating it this way it immediately becomes clear that long-run average cost curves involve only two variables, and two variables only, namely, unit cost and output. As far as the other variables are concerned the famous and at the same time dread ceteris paribus condition must hold. This condition becomes highly important for any empirical analysis and in the interpretation of empirical results. There will be chance to examine this statement later on.

(2) The long-run average cost curve is generally considered to be U-shaped.

(3) This shape is determined by proportionality as well as scale effects.

(4) In most textbooks managment limitations or management problems are cited as the most important, sometimes even as the only factor, which

would cause the long-run average cost curve to turn up after a certain level of output is reached, i.e. management is the reason for diseconomies of scale. This has for a long time been, and still is, a controversial issue in the theory of production.

(5) The point of production, that is the level of output at which it should be produced is determined by the interaction of the marginal cost and the marginal revenue curve. Thus, if marginal revenue is equal to price the equilibrium position for a firm with a U-shaped long-run average cost curve would be at the lowest point of the LAC curve. The long-run equilibrium position for a plant with an inverse J-shaped LAC curve would be indeterminate, but very large, and the equilibrium position for a firm with a J-shaped long-run average cost curve would be "out-of-business".

Empirical Measurement Problems

What does this theoretical structure lead us to conclude as far as farm production is concerned, if all the cost curves derived so far have the shape of an inversed J? - and the usual result of estimates of statistical cost functions are LAC curves of the shape of an inversed J!! The conclusion would be that farms or enterprises should be extremely large. Yet in reality we observe first, farm and farm enterprises grow larger, but only very slowly, and much slower than the pronounced economies of size should make us expect; second, small enterprises not only survive but keep establishing themselves.

This apparent disagreement of theory, empirical measurements and practical observations immediately raises some questions: First, is our theory, which is used as a basis of evaluation, wrong? Second, are our

empircal methods weak? Third, is our approach to the problem too narrow?

I should like to limit my discussion to the last 2 points, primarily because I cannot find anything basically wrong with our theory, while I find fairly serious shortcomings in our methods and in our approaches.

Let me then discuss some of the weaknesses of our empirical methods used in studying size relationships. The first point I have to make is the fact that early size relationship studies used small enterprises, found that unit costs decreased rapidly as the size of enterprise increased and then concluded that these savings continued to occur at the same rate as size of enterprises increased beyond the sizes for which measurements were obtained. This shortcoming, I believe, is today generally recognized. My second point is that our empirical procedures used to study size relationships have serious limitations even if observations are taken over a wide range of output. A review of the methods used in estimating long-run cost curves would show that essentially 3 broad categories of analysis have been used: (1) tabular analysis, (2) regression analysis and (3) budgeting of "most efficient" organizations of production in combination with regression analysis. Long-run cost curves estimated by any of these methods are "average" long-run average cost curves rather than a true long-run average cost curve, which is defined as the curve denoting the least possible unit cost of producing various outputs. One might argue that using the method of budgeting most efficient organizations of production in combination with regression analysis would yield a close approximation to the true long-run average cost curve. But even if this method is used the resulting long-run average cost curve is an average cost curve, since the production functions in which the budgeting coefficients are based are usually "average" relationships. As a result then budgeted most efficient operations are at best operations which combine "average" production

functions in a most efficient manner. Furthermore budgeting of the most efficient organization leaves a lot of room for subjective judgement, so that there is danger that the analyzer subconsciously introduces into his analysis a relationship which he thinks exists.

But since the primary interest is in the shape of the long-run average cost curves rather than the absolute unit cost at various levels of output, "average" long-run average cost curves estimated from cross sectional data could be satisfactory, if certain assumptions are valid. These assumptions are homogeneity of variance of unit costs at all levels of output, the same degree and direction of skewness of the distribution of unit costs at all levels of output, and the same degree of deviation of the points of operation from the minimum points on the short-run cost curve at all levels of output. The latter assumption implies that large operators who are likely to have a lower short-run cost curves than very small operators, would not operate further to the right of the minimum point of their plant cost curve than small operators. Given the same product prices for all operators, a technically most efficient operators would thus be farther away from the economic optimum production, namely where marginal cost equals marginal revenue.

The above assumptions have usually been recognized explicitly or implicitly but have not been tested because of one or more of the following reasons: (1) failure to recognize their importance, (2) lack of information with which to objectively evaluate this situation, (3) belief that assumptions are reasonable, (4) lack of objective methods of cost curve estimation that avoided these assumptions. Yet, if these assumptions are violated, the shape of the estimated long-run average cost curve may be seriously biased. Suppose, for example, that the variation in unit cost estimated

from a cross section of firms is considerable greater at low levels of output than high levels, and furthermore the degree of upwards skewness of the distribution of unit costs is higher at low than at high levels of output, then a regression estimate of a long-run cost curve may show decreasing unit cost as output is increased while the true long-run average cost curve may actually increase with increase in size. In order to avoid such fallacies and to get more reliable estimates it may be desirable in future long-run cost studies to check the validity of the above assumptions or to use other methods of estimating unit cost curves.

Earl Kehrberg and myself used a different method of statistically estimating the true long-run average cost curve when studying relationships between unit cost and size in the laying flock enterprise. We decided to use a new method instead of testing the assumptions mentioned above because our data did not permit us to test these assumptions. (And I might add that this inability of testing the assumptions is the usual rather than the unusual situation in cost studies.) The method we used is essentially one where we looked at every individual cost output observation as a cost vector and then proceeded to select the least cost vector for a given level of output. We then fitted a regression function to these least-cost vectors. (The reasoning behind this method is very much the same as the reasoning behind Joan Robinson's best technology vector.)

I should like to point out that the method we used is only <u>one</u> alternative method for statistically estimating long-run average cost curves and may not be the best one. (For example, if one had a very large number of observations over a wide range of output, it would be much less work and possibly even more objective to simply hand-pick

the lowest cost observation at various levels of output and then fit a regression equation to the lowest cost observation.)

Now to the question whether our approach to the problem of size relationships is too narrow or in other words whether it is sufficient to simply describe change in unit cost to a change in the quantity of the product produced and then go back to our theory structure to use it as a guide in our thinking and to arrive at conclusions as to what is or what should be or what will be. This theory which we use (we don't have to use, but we do use it) postulates a ceteris paribus condition, if the familiar unit cost output relationship is to hold. But do we measure unit-cost-size relationships only in our empirical studies or do we measure changes in other factors as well? Suppose that size is associated with age of operator, managerial ability of operator, techniques of production (level of technology), age and type of equipment, quality of labor, farm organization, etc., then the resulting estimates of the coefficients will be biased. If so, statistically estimated size relationships need to be interpreted differently than it has been done hitherto, if they can be reasonably interpreted at all.

Empirical findings

Some of the questions raised above were examined on empirical findings for the laying flock and the swine enterprise. These empirical findings indicate that there is need to reexamine size relationships in the above light.

(1) A test for homogeneity of variance in the swine enterprise study showed that we were actually dealing with a non-homogeneous variance. This, as was pointed out, will result in a biased estimate of the long-run average cost curve if either the method of tabulating simple averages

or the method of fitting a regression equation is used. Since the variance of costs per hundredweight of pork produced was larger at lower levels of output than at higher levels of output, the bias of the estimates is in the direction of economies of size. The normality of distribution, that is goodness of fit was not tested in either the swine enterprise or the laying flock enterprise because of limitations in the data. However, once non-homogeniety of variance is found to exist, a bias is already introduced, and only by chance would a bias introduced through non-normality of distribution work in the opposite direction and wipe out the bias introduced by non-homogeneity of variance. This is really more than we can hope for. Thus, long-run average cost curve derived by conventional methods need to be evaluated and interpreted very cautiously.

(2) When using the so-called vector regression method for estimating a statistical long-run average cost curve for the laying flock enterprise, very little evidence for returns to size were found beyond a relatively small level of output. When total unit cost was broken down into its component, namely feed cost, labor cost, capital cost, and miscellaneous expenses it was found that only labor and capital costs decreased up to a certain point and then leveled off. After that point they continue to decrease but at a very small rate. Feed cost and miscellaneous expenses were the same for all size flocks.

(3) It was also found that factors such as age of operator, age of equipment used are correlated with size of enterprise and farm size. What are the farm management and policy implications of these findings?

Since age of operator and age of equipment are positively correlated with size of enterprise there is a definite bias towards economies of size in the regression equation unless these factors are included as

independent variables. Usually this is not done, and it has not been done in Model 1 of our study of the laying flock enterprise. Therefore, a recommendation to the effect that a farmer should move to a larger enterprise because he would then achieve considerably lower unit cost, would not be correct. Or to make this statement somewhat more precise, it would only be correct as regards direction of change, but not the magnitude of change as indicated by these regression equations and tabular analysis. Why is this so? Our study shows that operators with a small laying flock are considerably older and have considerably older equipment than have operators and owners of relatively large laying flocks. Therefore a movement from a low level of output to a high level of output would not only involve a change in the size of the enterprise but also means a change in the quality and type of factors of production. This change is not one which is by its very character a change which is associated with economies of size, but is is a change which is due to the dynamic characteristics of any business enterprise and which creeps into our analysis as a distrubing factor. (We have thus moved to a different level of technology and thereby violated the ceteris paribus condition instead of only moving to a different technique without violating the ceteris paribus condition. A level of technology is here defined as the state of arts in a given time period. Given such a level of technology it is possible for firms of various size to employ different techniques of production. These techniques may result in varying technical efficiency, and small firms may not be in a position to employ the same techniques as large firms.)

(4) Another point of interest can be discussed by going behind the figures. The fact that feed cost and miscellaneous expenses are the same per unit of output at all levels of output means that if a farmer has no or little opportunity cost for labor or little or no opportunity cost for capital used in the laying flock enterprise his real cost for producing a unit of output may be smaller than the real cost incurred by a large operator, although our statistical cost functions show returns to size. The question is: Are there situations where there is little or no opportunity cost for both labor and capital or either one of these factors. As far as the laying flock enterprise is concerned the answer must certainly be yes. It has just been mentioned that the age of operators as well as age of equipment at low levels of output are significantly higher than the age of operator and equipment in the case of large laying flocks. It would be very difficult to argue that the opportunity cost for labor of an operator about 56 years old is the same as that for an operator of 36 years of age. It would be equally difficult to argue that the age of 22-year old housing and equipment has about the same opportunity cost as housing and equipment only about 8-years old. The conclusion then must be, and I point out that this is a short-run conclusion, that small operators may have a lower cost of production, with respect to their own operation as well as with respect to society, than large operators, no matter what statistically estimated cost functions show.

These data and relationships also grant some insight into the way and speed with which laying flock sizes are likely to change. As the operator grows older, his opportunity cost for labor also decreases.

similar reasons hold true for capital. Consequently, there is no economic reason why it should be impossible for a small operator to compete with large operators inspite of the fact that economies of size exist. As a matter of fact there is no reason from an economic viewpoint why small operators should not be able to keep establishing themselves. The rate at which these small operators keep establishing themselves will depend upon the rate at which farmers retire to a lighter farm work and the rate of technology relevant to the production of eggs.

(5) Likewise, in the 2-litter swine enterprise unit costs decrease very quickly at a relatively low level of output (namely at an enterprise size of about 25 to 30 sows) and then the long-run average cost curve tends to increase slowly. When total unit costs are broken down into their components it is seen that miscellaneous expenses are the same for all levels of output, that labor as well as capital cost tend to decrease quite quickly up to an enterprise level of about 25 sows and then continue to decrease but at a very slow almost imperceptible rate. An examination of unit cost of feed in its relation to output reveals that feed cost first decreases very rapidly (similar to capital and labor cost) and then begin to increase slightly after an enterprise size of about 30 sows is reached. This increase in unit cost of feed is larger than the combined decrease in unit cost of capital and labor so that the net effect on total cost is an increase in total unit cost after an enterprise size of about 28 sows is reached. This increase in the unit cost of feed as size of enterprise increases is a highly important question, since feed cost comprise roughly 70% of the cost of production. Unfortunately as of yet we are in no position to give explanations as to why this relationship is as we found it. All we can advance are some hypotheses. When we

began to analyze the data and for the first time found this positive relationship between unit cost of feed and size of swine enterprise we were highly concerned at this type of relationship and were looking for errors in our analysis and our procedures. But when numerous checks on data and procedure revealed no such errors, we accepted this relationship as one actually existing. The outlook which was recently prepared by the United States Department of Agriculture supports our findings insofar as it shows that the amount of grain consumed per 100 lb. of pork produced increased over the last 10-15 years. Since we also know that the size of the swine enterprise increased on the average the findings derived from different sources as well as by different procedures agree quite well.

(6) A wide variation of costs at all levels of output was observed when studying the swine enterprise as well as the laying flock enterprise. In both cases some relatively small producers were able to produce a unit of output at about the same cost at which quite large producers were producing them. This strongly suggests that size per se does not cause unit cost to decrease. Instead, here is an indication that we ought to place more emphasis on efficiency and management on technique of production and levels of technology. This is further emphasized by results obtained from the study of the swine enterprise when a simultaneous equation approach is used. These results show that if labor is increased the amount of capital used increases likewise. (These results are not due to the fact that the model was built this way. The model was built in such a manner that the opposite relationship could have been taken care of just as easily, simply by a change in sign of one of the coefficients. The estimated coefficient is positive however, instead of negative, and this is so because the observations as collected in the field portray this relationship.) My conclusion from this relationship is that in the

particular enterprise study the ability to make correct decisions with respect to resource combination is either of less importance than the ability to supervise or is available in sufficient amounts.

(7) A correct interpretation of statistical long-run cost curves must also take into account their static nature. Cost curves are generally derived for a given system of management, for a given type of equipment and for a given level of management. Results from both our poultry and swine enterprise study suggest that these factors are of significant importance in determining unit cost of production. Thus, innovations in management and technology may decrease unit cost at either end of a long-run cost curve and consecuently render a statistical estimate of a long-run average cost curve "obsolete."

I suspect that the sum total of my comments on size relationships is suited to induce you to agree with Staehle whom I cited at the outset of the seminar and who said that empirical measurements of statistical cost functions help to see the complexity of the problem but very likely not much more. Although I basically agree with this statement I do not believe that the complexity of the problem is so overwhelming that we have to shy away from it. Therefore I should like to point out what might be some fruitful approaches to future research in this area: (1) If we want to understand the real and important relationships involved we ought to include other factors than unit costs and size when we study size relationships. (2) We need to measure management in a manner so that it can become an analytical tool. (3) We need to improve our measurements so that they may indicate quality of factors, opportunity cost of factors and interdependence of multiple enterprises. (4) We need to devote attention to the fixed asset problem. (5) We need to

study size relationships not only in a static framework, but these studies might be much more fruitful and above all useful if they would be studied in a dynamic, risk, and uncertainty framework.

I realize that the classification of approaches is not of such a nature that one of the approaches could be used without taking into consideration the other approaches. I also realize that the areas mentioned here are bottlenecks in all production studies. And I furthermore am aware of the fact that in successfully working in some of these areas we may have to go to different methods of research with different concepts and different thinking than we are used to. Should we decide that we go this route our criteria for achievement will have to be whether our new concepts and our new empirical procedures actually do explain relationships of the real world and how useful they are for predictive purposes.