ECONOMIC REPORT

ER82-7 August 1982

ANOTHER LOOK AT ECONOMIES OF SIZE
STUDIES IN FARMING

by

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PREFACE

The research reported in this publication is a contribution to University of Minnesota Agricultural Experiment Station Project 14-38 and to IR-6, "National and Regional Planning Research Evaluation, Analysis, and Coordination."

As part of the evaluation process for public sector agricultural research, subsequent analyses will be conducted to determine the relationship(s) between this research (and the technology which it generates) and the structure of the U.S. farming sector.

The structure issue in agriculture has rekindled interest within the USDA and the Land Grant University system in economies of size studies and measurements. Interests are particularly focused on economies of size within the farming sector. They appear to center on obtaining answers to the question: At what size of farm are most or all of the economies of size realized? If that size of farm can be identified for various types of farms in various areas, then supposedly policy instruments can be developed to encourage that size of farm--a farm size consistent with resource efficiency, supposedly an objective appealing to society as a whole. Although farmers, along with other social groups, may be interested in resource efficiency, they are also interested in level of income per farm, and the farm size that exhausts all or most of the economies of size may not be the size that generates a satisfactory income. Moreover, public policy makers presumably are interested not only in questions of resource efficiency, but also in questions of income distribution.

Thus, one phase of analysis is to identify conceptually the nature of size-technology (and, therefore, size-cost) relationships to develop an operational framework for measuring this relationship, and to use this framework for measuring size-technology relationships for farming systems in the North Central Region.

A second phase of the analysis is to assess the relationship(s) between public sector research and available technology in the farming sector. This information then will be used to relate past public sector research programs to the resulting farming structure. Most past research and development (R & D) work in agricultural technology probably was undertaken without much attention to its likely impact on economies of size, and most past expositions on this topic have been more impressionistic than analytic.

ANOTHER LOOK AT ECONOMIES OF SIZE STUDIES IN FARMING*

by

H. R. Jensen**

Introduction

The objective of this paper is to try to improve the conceptual framework and the measurement of cost-size relationships for economies of size studies in farming.

The approach used to achieve this objective is first to review the literature on the economies of size in farming over the last 16 years or so, the primary source being the American Journal of Agricultural Economics. On the basis of that background, a short section summarizes the orientation of past studies of economies of size mostly in farming.

Who gains from changes in technology and associated changes in farm size is briefly reviewed followed by a section on cost-size relationships, short- and long-run, as expressed in neo-classical economic theory.

Problems in modeling and measuring long-run cost-size relationships are then identified followed by some suggestions for coping with these problems.

Review of Literature

J. Patrick Madden provided an excellent review of economies of size studies up through 1965.[1/] In addition, he examined the theoretical basis for economies of size studies and described some alternative analytical methods for making this type of study.

Madden's main contributions, aside from the literature review are:

- Developing and clarifying the differences among labor, management and entrepreneurship, and emphasizing their existence in the real world.

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* The author wishes to acknowledge the helpful suggestions of W. B. Sundquist and V. R. Eidman, Professors, Department of Agricultural and Applied Economics, University of Minnesota, who reviewed the manuscript.

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1/ See Madden, J. Patrick, Economies of Size in Farming, Agricultural Economics Report No. 107, ERS, USDA, February 1967.

- Explaining the existence of small and large farms side-by-side by identifying goods and services farm firms and off-farm labor as explanatory variables.

- Comparing alternative methods for analyzing economies of size. But here he fails to suggest that the method chosen may be a function of whether the objective is primarily to explain or describe what exists, or to improve the farm planning process.

Madden offered no help in solving the difficult problem of how to measure implicit costs--operator and family labor, management, entrepreneurship--as well as how to measure some of the other inputs that usually give us trouble, such as land.

Let me now move on to a review of the size of farm studies that have been published in the American Journal of Agricultural Economics since Madden's paper.

In addressing the question of optimal size of farm under varying tenure forms, Heady (1971) linked capital-labor price ratios to stages of economic development and argued that at the more advanced stages of economic development, the real price of capital is lowest relative to labor; consequently, large amounts of capital are used which increase the fixed costs of farming and the minimum level on the cost function occurs with larger farms.

In analyzing the relationship between farm size, rural income and consumer welfare, Heady and Sonka (1974) saw post-war prosperity that made capital available along with technological improvements that produced scale economies favoring larger farms as factors explaining the increased trend toward fewer farms and a smaller farm labor force. Their analysis showed trade-offs from policies favoring smaller farms versus those favoring larger farms. Larger farm sizes can be expected to cause some sacrifices in net income to the farm sector, in income to the rural communities, in farm numbers and in farm employment.[2/] Expected advantages of larger farms are higher incomes to farm families who operate them and somewhat lower food costs to consumers.

Irving Hoch (1976) used Cobb-Douglas analysis to study returns to scale in dairy farming. His study does not support constant returns to scale. Market milk producers had decreasing returns while manufacturing milk producers had increasing returns. Hoch observed that "the assumption of constant returns can lead to embarrassments, including infinite supply elasticities and the likely incompatibility of competition and even small differences in technical efficiency between firms." He indicated that as the sum of the elasticities approaches 1.0, small differences in firm effects lead to much larger differences in firm size. For instance, for a population of farms with an elasticity sum of 0.99, a firm 10 percent

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2/ Their results show wheat, feed grains, soybeans and cotton prices are highest for the small farm alternative and lowest for the large farm. These product prices were generated by a linear programming model for three farm-size alternatives. The lower prices for the large farm alternative are due to lower production costs giving rise to lower supply prices.

above average efficiency has an equilibrium output of about 14,000 times the average output.

According to Gardner and Pope (1978), pecuniary and technical economies of scale along with government policies are the hypotheses usually set forth to explain increased scale of farms. They suggest that these hypotheses need to be subjected to more empirical testing. For instance, the impacts of random environments--disease, weather, technical change--are not yet sufficiently understood. Therefore, to say that technical change alone is the mechanism that induces both productivity increases and increases in farm size may be attributing too much to this one variable.

Seckler and Young (1978) made some very interesting observations on economies of size in their paper on "Economic and Policy Implications of the 160-Acre Limitation in Federal Reclamation Law." They question Stigler's survival theory and the conclusions following from the premise underlying that theory, namely, that under reasonably competitive conditions firms in an industry will be driven toward the lowest point on the long-run average cost curve for that industry. The conclusions drawn from that premise which they question are: (1) a frequency distribution of farm sizes will reveal the lowest LRAC point since firms will tend to cluster at that point, and (2) if technological change or other forces shift this point over time, this fact will be revealed by the tendency for the average firm size to increase. The authors argue that increasing farm size doesn't necessarily imply the existence of economies of size; it may simply imply the absence of diseconomies. If it is the better managers that shift out, as they argue later, one could presume that those managers do a better job of handling the technology, hence have superior production coefficients, suggesting economies of size or lack of diseconomies, which then are due in reality to superior managers concentrated on the right-hand side of the distributions. On the other hand, if the objective is to help farmers choose a size of firm for long-run planning, given alternative technologies and a set of prices, then it seems reasonable to believe that at some size of farm, any given manager could be expected to encounter supervision and coordination problems and, hence, diseconomies. The other conclusion purported to follow from the premise, namely, that a frequency distribution of farm sizes will reveal the lowest LRAC point because firms will cluster there, could be challenged in a dynamic setting. In a technologically risky and innovative economy and in a dynamic setting, it would seem that a shifting out of firms may more than offset the tendency toward concentration.

Seckler and Young suggest that the Stigler survival theory attributes increasing farm size to economies of size. Their substitute survival theory attributes increasing farm size to differences in managerial ability and the desire for income. Obviously, their objective is to arrive at a more satisfactory explanation of why farms have become bigger than that obtained from the Stigler model. They leave to the reader's imagination what the implications of their study might be for farmers' long-run planning. They say that the seven smallest farms in their regression (based on farm accounts) have too much weight in the regression relative to their numbers in the population, and that these seven farms greatly influence the shape of the curve. My response to that argument is that a random sample from a population is not the appropriate sample for regression analysis; rather, the appropriate sample is a stratified random one stratified in this instance by farm size with approximately the same number of observations in each stratum.

They do conclude that perhaps both survival theories contain some explanatory power. They conclude, moreover, that facile generalizations about economies of size drawn from the Stigler theory alone will not stand up and that hard, empirical studies of intertemporal change are needed. We are left with the implication that an explanatory model of why farmers have become larger requires a dynamic framework of considerable complexity--including many variables.

Hall and Leveen (1978) review and evaluate several California studies on farm size--economic-engineering studies, a California survey of farms approach, and a study using agricultural census data. Their main conclusions on the economic-engineering studies are (1) the long-run average cost curve is L-shaped, i.e., production costs decline rapidly for the initial increases in size and then decline slowly, if at all, (2) the technical advantages of very large farms (3,200 acres and above $500,000 sales) are small relative to those for more modest-sized farms, (3) technological advantages are even more limited when small farms are allowed to rent specialized equipment instead of owning it, and (4) nearly all farms above 80 acres incur less than $1 costs per $1 of sales. They mention also that these economic-engineering studies provide little evidence of increasing costs for very large farms. On this point, it would be helpful if Hall and Leveen had indicated what this evidence or lack of evidence was. Was it because few of the studies allowed for increasing costs, or was it because although the studies allowed increasing costs, the cost increases were based on assumptions rather than empirical data? Another point worth mentioning here is that in an economic-engineering study set up to determine technical economies of size, should some farms and not others be allowed to rent rather than own specialized equipment? As a guide to farm planning, more useful information is attained when, say, all farms of varying size are first studied assuming full ownership of all assets. Thereafter, the study could be altered to permit the small farms to rent resources rather than own them and, in this way, provide information on the relative costs that must exist for renting versus owning to result in significant unit cost reductions--considering timelines.

Hall and Leveen view the California survey of farms study as one designed to weigh the relative importance of technical versus allocative efficiencies. This study is said to provide evidence of technical economies of size, i.e., on the average, smaller farms lie further from the efficiency frontier than larger farms. However, allocative inefficiency is purported to be more important than technical inefficiency in causing farms to fall short in attaining the efficiency frontier.

From their study on cost-size relations based on U.S. census data, Hall and Leveen concluded that (1) economies of size, i.e., larger farms reducing their costs by spreading fixed machinery and labor costs over more land and output, are evident, (2) cost discounts from volume buying do not appear to contribute significantly to the overall advantages of large farms, (3) premium selling prices may be available to large volume producers, and because of market access, they may be able to sell more of their output--especially fruit and vegetable producers, and (4) unit costs in relation to size continue to decline rather sharply throughout the full size range, i.e., up to $400,000 in sales.

Hall and Leveen's overall conclusions are: (1) LRAC is relatively flat after declining rapidly initially, (2) the costs of highly mechanized crops generally continue to decrease throughout the full range of survey farm sizes--an observation that does not apply to fruit and vegetable farms after an initial sharp decrease in unit costs, (3) while the technical basis for economies of size is significant, other factors such as management, resource quality and overall institutional structure are even more important, and (4) a paucity of data sources from which to draw exists.

Hall and Leveen's review raises some points that may be worthwhile to consider separately. They distinguish between technical and allocative efficiency; they define the former as associated with physical economies of scale and the latter associated with adjusting factor use and output mix to relative prices. In farm size studies with the objective of describing "what is", it is next to impossible to separate these effects and, hence, one cannot know what technical economies do exist. In economic-engineering studies, technical efficiencies or inefficiencies can be isolated. Hall and Leveen say that deterministic (the authors use the term), non-parametric economic-engineering analyses are not designed to explain actual farm behavior nor to estimate all possible economic advantages and disadvantages of size.[3/] True, but they do lend themselves very well to estimating technical economies of size.

In their study on cost-size relations based on census data, Hall and Leveen charged farm operator labor at $20,000 per year for full-time work for all farm sizes. Basis for the figure is that of a full-time hired manager's salary on large farms. The underlying assumption is that the operator's main work, even on the smallest farm, is supervision and management. They argue that census data support their position. From census data, they conclude that small farms are as dependent on short-term hired labor as large farms, and that large farms employ considerably more long-term laborers whose functions tend toward management and supervision. The argument in other size-of-farm studies has been that the proportion of a farm operator's time spent in management and supervision increases with increases in farm size. Possibly more attention needs to be given to placing a value on operator labor as farms of different sizes and types are studied in various areas. Hall and Leveen excluded all land costs in their cost-size study based on census data. They argue that land costs are not independent of other production costs and play a different role in the determination of prices and profits than do other input costs. That does not seem like a very cogent argument in my mind, and in an economies of size study pursued to provide guidelines for long-run planning, I can think of no argument that logically can view any resource as free. In the long-run, farm land has either or both alternative uses in farming and off-farm uses--uses which have value.

Scott Matulich (1978) used an economic-engineering approach in his study on "Efficiencies in Large-Scale Dairying: Incentives for Future Structural

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[3/] According to Hall and Leveen, these analyses show the relationships between production costs and size if certain assumptions are met, such as identical factor prices, product prices, and soil productivity for all farm sizes. If these assumptions are not met, according to the authors, the resulting cost curves will not be realistic representations of the minimum cost curve.

Change." Large-scale herds, ranging from 375 to 3,600 cows, were studied. Alternative technologies for milking, feeding, and housing were involved. Management was not considered homogeneous; quality differentials required for alternative herd sizes were reflected in observed wage structure differences. His study showed unit cost reductions up to 750 cows; beyond this size, the LRAC was essentially flat. Eighty to 85 percent of the annual unit costs were invariant with respect to herd size; these included feed, herd replacement, land and miscellaneous costs. Feed accounted for 60 to 65 percent of all dairy production costs.

In his presidential address in 1978, B. F. Stanton gave his "Perspective on Farm Size." Below are the more salient points for our current and future consideration.

Stanton asks and answers the question of why farm size has continued to be of interest to so many for so long. His answer suggests reasons why we as agricultural economists have done and do these studies: (1) to alleviate poverty or low incomes in rural areas and to assure some minimum level of income for farm people, (2) to improve business management by identifying resource combinations that are productive, (3) to increase resource efficiency by identifying least cost ways of using given bundles of resources, and (4) to determine existing resource and income distribution.

Stanton views farm size as a policy question--the focus can be either on individual farmers and their welfare or on society as a whole, i.e., who gains and who loses with changes in farm structure over time.

According to Stanton, agricultural economists have given much more attention to economies of size than to diseconomies of size. Empirically, we certainly are in a better position to answer the question of whether economies of size exist than where the LRAC turns up. Stanton does set forth some hypotheses on the internal and external diseconomies purported to limit farm size: (1) the management resource, (2) risk and uncertainty growing out of weather, prices, disease, pests and other natural hazards, (3) labor and management supervision, and (4) costs of assembly and distribution over ever larger areas and increasing costs of waste disposal with increased concentrations of production. However, we have very little empirical evidence to support or negate these hypotheses. Stanton explains the why of this paucity by saying that simulating problems of expansion and trying to establish the reason for cost increases or constraints to added capacity requires coefficients that are not available. Stanton adds that we as a profession have not been very imaginative in studying large farms that have failed and the reasons for their failure. Stanton does refer to the Heady and Krenz study as one of the few studies that attempted to quantify diseconomies associated with untimeliness of operations from increased size.[4/] Their envelope curve indicated rapidly increasing per unit costs at farm sizes above 800 crop acres. Moreover, when they considered weather and yield variations over a five-year period, Heady and Krenz estimated optimum farm size as 12 to 22 percent smaller than the average giving minimum per unit costs, and 27 to 37 percent smaller than the optimum farm size assuming the equation of marginal costs and revenues under acreage expansion. Stanton raises the question of what is

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[4/] See Heady, E. O. and R. D. Krenz, Farm Size and Cost Relationships in Relation to Recent Machine Technology, Iowa Agricultural Experiment Station Bulletin 504, May 1962.

behind farmers' drive to increase farm size if most of the real gains in efficiency and reduction in production costs have been achieved by the time a farmer generates $100,000 cash sales. He lists as possible explanations: (1) more volume equals larger net incomes unless unit costs rise very rapidly, (2) farm real estate as a high return investment, (3) labor-saving equipment and increased capacity to get operations done on time are associated with larger businesses, (4) status in the community, (5) easy access to investment capital, and (6) growth of business and new investment is the social and business norm of our society. Stanton says we need research so that we can make improved judgments on trade-offs between production efficiency and equity, noting that agricultural economists generally have had more interest in increasing farm incomes and production efficiency in agriculture than in controlling the upper end of the size distribution of farms.

Stanton concludes his article by saying that if there are diseconomies to increased farm size, given current technology, let us seek to discover and measure them. Alas! as Stanton knows, that is not an easy task.

In his article on "Economies of Size and the 160-Acre Limitation: Fact and Fancy," Martin (1978) stated that it was impossible to avoid the conclusion that economies of size exist in farming and that these economies, whether technical or pecuniary, have been a driving force toward larger and fewer farming units in the United States, especially in the irrigated West. Martin had reviewed a number of studies. He pointed to Dean and Carter's study of cash crop farms done in 1960 which showed that 600 to 800-acre farms appeared to compete on a unit cost and profit basis with larger farms.[5/] He cited Johnston's study in the Imperial Valley which showed that costs decline rapidly to about 700 acres, then by only 5 or 6 cents per dollar of total revenue to the minimum at 2,000 acres.[6/] Martin also referenced the Faris, Armstrong, and Moore study in the Westlands District, California, which showed that technical economies for cash-crop farms were exhausted at about 800 to 1,000 acres.[7/]

Holland (1978) discussed Martin's article. He questioned the credence that Martin placed on the economies of size studies that he reviewed. Holland felt that the studies quoted were dated and that most of the available work was flawed both methodologically and empirically. Holland argued that most studies of multiple crop farms had become so enamoured of economic-engineering models that they failed to spend the time in the field necessary to corroborate the critical assumptions underlying the models. Holland stated that nearly every study with which he was familiar assumed that yields were invariant with size of farm--an assumption that Holland questioned. Holland felt that another problem that has plagued previous economies of size studies is the assumption of a fixed machinery complement which Holland claimed incorporates

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[5/] Dean, Gerald W. and Harold O. Carter, Cost-Size Relationships for Cash Crop Farms in Yolo County, California, Giannini Foundation Mimeographed Report No. 238, University of California, Davis, 1960.

[6/] Johnston, Warren E., Economies of Size and Imported Values of Farmland in the Imperial Valley of California, Giannini Foundation Research Report No. 314, University of California, Davis, 1971.

[7/] Faris, J. Edwin and David L. Armstrong, Economies Associated with Size, Kern County Cash Crop Farms, Giannini Foundation Research Report No. 269, University of California, Davis, 1963.

a strong upward bias into the cost estimates at the lower end of the operating range since it effectively precludes the option of crop specialization for smaller acreages. Holland remained unconvinced that technical economies of size are very important in agriculture and ended with a plea for new and vigorous work to firm up our understanding of economies and diseconomies of size in farming.

Many agricultural economists would agree with that plea, but Holland is likely to receive less agreement on the sweeping criticism of past economies of size studies when saying that most available work is flawed both methodologically and empirically. Moreover, in research one does not necessarily corroborate a study's assumptions empirically. Assumptions are often made for the purpose of narrowing the study so as to examine those relationships that at the time are of interest to the analyst. Thus, if the analyst wishes to isolate and study technical economies of size, then it becomes important to hold other variables constant that may influence that relationship, unless the analytical framework can identify other variables that influence cost-size relations and measure their effects. It would be helpful to know what Holland means by a "fixed machinery complement" and why that means precluding crop specialization for smaller acreages. If, by that statement, he means that in a study of technical economies of size we should have small farms rent rather than own their machinery and equipment, then I would argue he is introducing a variable into the analysis precluding any accurate measurement of technical economies of size. However, once technical economies of size have been measured, then an analyst may very well wish to determine whether small farms can reduce their unit costs by renting rather than owning their machinery considering some yield losses due to lack of timeliness.

In 1980, Carter and Johnston came out with their publication, "Farm-Size Relationships, With an Emphasis on California." The primary objectives of this report were (1) to explore the "state-of-the-art" knowledge about cost-size relationships in California agriculture and (2) specify the potential economic research, empirical and conceptual, that would enhance the knowledge of cost-size relationships in California.

In exploring the first objective, Carter and Johnston state that their review of past studies does not portray accurately the current economic conditions since data for nearly all of the studies were collected from 1956 through 1966. However, they consider the review of value in examining the technical economies of scale usually associated with increasing farm size. They also mention that most of the studies reviewed used an "economic engineering" approach with survey data.

In summarizing their review of California crop studies, they conclude that the common element among all these studies is the primary importance of technical economies of size due to the spreading of fixed machinery and equipment investments over increasingly large-sized farm operations. In general, significant economies (reductions in cost per dollar of revenue) were reported for "medium sized" compared with "small farms," i.e., the cost-revenue ratios generally fall sharply over the first one or two smallest farm sizes and then level off. Very few of the crop studies tried to measure market economies to size. The Carter-Johnston review also revealed substantial economies to size in livestock production--cattle feeding, turkey and dairy production. Again, most of these studies focused on technical economies to size, but some also reported other economies such as market economies and economies in acquisition of information.

In their study of the influence of government policies on farm size, Carter and Johnston conclude that most government policies and regulations were probably formulated with little attention to their likely effect on various sizes of farms, but that their net effect probably has been to increase farm size. A very small amount of research has been directed to answering questions about the impact of government policies on changing farm size relations.

Carter and Johnston review studies on taxation as a factor in economies of size. Very little empirical analysis has been done. What is known about the relationship between farm structure and taxes (income, real estate, and estate) is based primarily on budgeted examples and theoretical models. Data are a problem, empirically, in separating the effects of tax provisions from other factors.

Carter and Johnston explored the impacts of the product marketing system on farm size. They identified (1) increased purchases by processors directly from farmers, (2) increased use of contractual arrangements, and (3) decline of terminal markets as major changes in the marketing system in recent years. They conclude that these changes influenced farm size mainly by reducing access of smaller farms to markets and, thereby, forcing them to incur higher per unit marketing costs.

Carter and Johnston also reviewed what is known on the relationship between risk bearing, unit labor costs, and rising energy costs and farm size. They conclude that research in these areas is only at the beginning stages.

On the primary objective of their report, namely, to explore the state of knowledge about cost-size relationships in California agriculture, Carter and Johnston conclude that there is no single, simple explanation for the trend toward larger firms. They note that considerable evidence suggests that there is a significant technical basis for economies to size in farming. Cost savings tend to level off on a medium size of unit, with the least cost point varying widely by type of farm. Beyond this point, they suggest that farm expansion is the product of many other influences, such as government policies, tax structure, product marketing system, risk environment, labor and energy costs.

In reference to their second primary objective, i.e., potential research that would add to our knowledge on cost-size relationships in farming, Carter and Johnston suggest: (1) research to determine the minimum cost size of farms under current conditions and to determine whether the general findings in this report, based largely on data for the mid-50s to mid-60s, still hold for the 1980s, (2) studies on government policy-farm size relations to determine whether large farms benefit more on a per acre basis unintentionally encouraging farm-size expansion, (3) empirical research to explore the relationship between farm size and various tax provisions, (4) research on how marketing costs and returns are affected by factors such as volume of farm production, assembly distance, sales outlets and institutional and structural characteristics of the markets, (5) study of the possible relationships between risk-bearing and farm size, (6) empirical studies of the relationship between unit labor costs and increased energy costs and farm size, and (7) research on the effects of increasing farm size on the rural community.

In 1981, Miller, et. al., National Economic Division, Economics and Statistics Service, USDA, came out with a research report entitled, "Economies of Size in U.S. Field Crop Farming." The objectives of the report were (1) to determine the importance of technical economies of size (costs per dollar of gross income) in seven major U.S. field crop producing regions, (2) investigate the role that these economies play in the process of structural change in farming, and (3) explore the impact of farm-size limit policies. The review here is limited to the first of these objectives.

The method of study is an economic-engineering approach. A linear programming model was used, a format that determines the least cost mix of enterprises to produce specified levels of output (gross income). The average costs associated with each level of output form the estimated SRAC curve. The main fixed resources for the farm in the short-run were the time constraints associated with the specified machinery complement.

The primary source of data was the 1978 Firm Enterprise Data System cost of production survey conducted by the USDA.

Three LRAC curves were developed. $LRAC_1$ excludes all land, operator and family labor, taxes and insurance costs. $LRAC_2$ includes an opportunity cost for operator and family labor of $4.50 per hour, and "leaves equity capital, land, management, and entrepreneurship as residual claimants." $LRAC_3$ includes long-run average cash costs, operator and family labor costs and economic rent; the low point on this curve is the point where revenues just equal costs and all factors are estimated to be earning a normal return (economic rent).

The authors conclude that technical economies exist, but that they are not large. Small or medium-sized farms, they say, are nearly as efficient as large farms.

In a long-run cost study such as this, one may wonder about the rationale of estimating $LRAC_1$ and $LRAC_2$ that are estimated without attaching costs to all resources. For a long-run commitment of resources, one logically expects that these resources will earn at least as much in the use to which they are to be committed as in the next best alternative. Moreover, when economies to size of farm are being estimated, it seems preferable not to confound the analysis with the introduction of other variables such as part-time farming. Small farms in this study are viewed as "goods and service" firms, which see the small farm firm as a producer of goods and services, such as custom work, and off-farm employment and as having the possibility of hiring various resource services in amounts needed, as well as owning and operating durable resources. In addition, this study estimated costs on the small farms on the basis of older, used machinery and equipment. The authors say that their LRAC curves are relatively flat, and one might hypothesize the reason is that this flatness has been built into the analysis because of the introduction of the several variables listed above, and as a result, we may not have obtained a realistic estimate of what the technical economies to size in farming are.

Past Orientation of Economies of Size Studies

The textbook model is a pure returns to scale model relating changes in output to proportional changes in inputs. Thus, if all inputs are doubled and the corresponding output more than doubles, then increasing returns to scale exists. When all inputs are doubled and the corresponding output also doubles, then constant returns to scale exists. When all inputs are doubled and the corresponding output fails to double, then decreasing returns to scale are present. The typical textbook model of pure returns to scale shows increasing returns to scale over some initial range of increases in output, followed by decreasing returns to scale over further increases in output.

In the real world, agricultural economists hold that inputs are not increased in constant proportions as plant size is varied and, therefore, they speak of economies and diseconomies of size.

The list of usual explanations of or sources for economies of size are:

1. Ability to spread total fixed costs (costs that do not vary with output) over larger outputs.

2. Volume sufficient to justify the substitution of mechanization and automation for labor.

3. More proficient management from concentration on one or few production activities--specialization.

4. More skillful workers as a result of training for specialized rather than diversified tasks--division of labor.

5. New technology that changes the substitution relationships among inputs and creates a difference in the returns to resources and costs per unit of output as output is increased. Some of the durable inputs that make up the plant wear out and are replaced by more efficient inputs. Increasing size of plant with these new and more efficient durables results in lower unit costs for the larger outputs.

6. Marketing economies due to lower input prices stemming from volume buying and/or due to higher product prices resulting from larger volume sales or from bypassing some intermediate stage(s) in the marketing process.

7. External economies in the form of improved transportation facilities; ready access to banking and credit institutions; publicly supported research and education output; improvements in machinery, equipment, chemicals and computer technology and stability in government programs favoring larger farming units. (Obviously, some overlapping exists between this explanation and some of the others since all the others are not purely internal economies.)

Samuelson appears to place major emphasis on technological change over a relatively long period of time for explaining increasing returns to scale.[8/]

8/ See Samuelson, Paul A., "Economics", 10th Edition, McGraw-Hill Book Co., 1976, p. 28.

He says, "Increasing returns to scale or so-called economies of mass production are often associated with one of the following advances: (1) use of non-human and non-animal power sources (water and wind power, electricity, turbines and internal combustion engines, internal nuclear energy), (2) the use of automatic, self-adjusting mechanisms (lathes, jigs, servomechanisms), (3) the use of standardized, interchangeable parts, (4) the breakdown of complex processes into simple, repetitive operations, (5) the specialization of function and division of labor, and many other technological factors as well. The auto production assembly line and historical development of textile spinning and weaving exemplify these diverse factors." Samuelson adds that enough has to be produced to make it worthwhile to establish a rather elaborate production organization.

One implication of Samuelson's remarks is that our approach in empirical studies on scale economies or economies of size should be to construct these studies in a longer-run setting that allows for development through time of more efficient or superior technology. In a primitive agriculture, whose production technology is limited to man and hoe, constant returns to scale or size should be expected. On the other hand, if we studied economies of size in our own dairy farming as it has evolved through time from small herds fed and milked by hand, cream separated from the milk and sold, with the skim milk fed to the swine, to large herds of several hundred cows where tasks are mostly automated and specialized (essentially milk producing factories), increasing returns could be expected. In empirical studies on economies of size, agricultural economists have not utilized this long-run (historical) approach which permits technology to change over time. Such an approach could reveal much information on the changes in technology and in unit costs that have occurred over time in cash grain, beef, hog, dairy and other production. But, it would not reveal the economies of size within a particular planning or operating period.

In the neo-classical model, decreasing returns to scale or decreasing economies of size are usually assumed to occur at some size because of loss in effective coordination and supervision by management. In a recent article, Stanton set forth hypotheses on internal and external diseconomies purported to limit farm size.[9/]

Economies of size studies as guides for farm planning could perhaps be improved by giving more thought to constructing the plants whose components are characterized by durables. Studies that separate the effects of the size of the durables and other technological improvements in durables can provide more information than studies that do not. Thus, economies of size in corn-soybean farming can determine what these economies are as a result of changing only the <u>size</u> of tractors, combines and other machinery; size economies can also be estimated by not only changing <u>size</u> of machinery in defining plants, but also by incorporating other changes that have come along to improve the technical efficiency of the machines, such as combines that not only are larger, but also reduce field losses, or tractors that not only have more horsepower, but also use less fuel or cheaper fuel per horsepower hour.

[9/] See earlier section of Review of Literature, p. 6.

Who Gains from Changes in Technology and Associated Changes in Farm Size?

It is sometimes assumed that both farmers and society realize monetary gains from economies of size in farming. However, the net effects are not always that clear. Much of the technological change in agriculture has been of the labor-saving type--larger machinery and equipment that substitute capital for labor.

Labor-saving technology is considered to be primarily output neutral in the aggregate; hence, associated commodity prices are not affected. However, since more acres or more units of livestock can be managed with larger machinery or equipment operated with the same labor, incentives exist for increasing the size of farming units. As farm size increases, incomes of individual farm units also rise, but the total income to the farming sector is unchanged. Any reduction in non-land unit costs can be expected eventually to be capitalized into the price of land, since in the aggregate, farm land is largely fixed. Hence, landowners can be expected to capture the gains from labor-saving technology. Consumers generally would not be expected to gain from lower food prices, but they could gain when the labor released from agriculture becomes gainfully employed in off-farm production and services, making goods and services available that were not produced before or making these consumption goods available at lower prices.

Land-saving innovations (fertilizer, chemicals, improved seed), on the other hand, are total output increasing. In an open competitive market and a relatively inelastic product demand, held to be characteristic of agricultural products, an increase in total output leads to a decrease in unit price of the products. Hence, land-saving innovations can be expected to benefit early-adopting farmers in the short run and consumers in lower unit prices in the longer run.

Neo-Classical Theoretical Models--Short-Run and Long-Run[10]

The following diagram shows the familiar short-run U-shaped cost curves for an individual firm assuming a fixed plant. The plant can be thought of as the assemblage of all durables owned by the firm, such as land, machinery, equipment and buildings. An increase in any one of the durables increases the plant size. Prices of the factors are not influenced by the firm's own adjustments to different outputs.

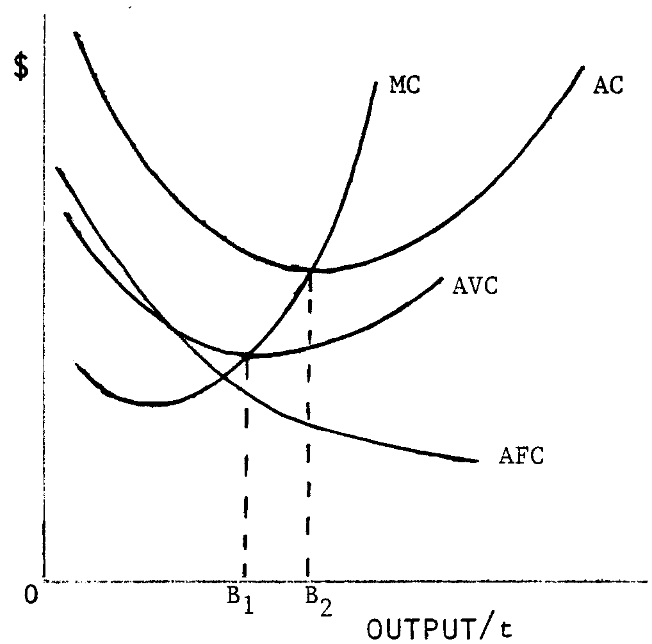

Figure 1. Short-run Average and Marginal Cost Curves.

Up to OB_2 output, returns to the plant are increasing. Within OB_1, both AVC and AFC are decreasing because of a rising average product and because total fixed costs (a constant) are being divided by increasingly larger outputs. Hence, AC declines at a relatively rapid rate. Between OB_1 and OB_2 output, AVC are increasing, but AFC continue to decrease. Since AFC decreases at a faster rate than AVC are increasing, AC continues to decline. Beyond OB_2, AC increases since AVC now increases at a rate that more than offsets the decline in AFC.

Once the plant has been built, its manager is interested in the optimum way of utilizing the plant. The optimal output occurs where the MC is equal to marginal revenue (MR) or the selling price (SP). The manager hopes that this equality will occur at a selling price high enough so that he will at least meet his AC. But even though AC may not be covered every year,

[10] Neo-classical economics is assumed here to begin with Alfred Marshall's Principles of Economics.

he is better off producing than not producing as long as he can, in any one year, and at least meet his AVC. In the long run, he is not likely to continue to produce if he is unable to meet AC.

Similar sets of short-run cost curves can be drawn for each aggregate of fixed factors or durables called "plant." In fact, if we were to describe fully the cost conditions under which, say wheat or milk were produced on a sample of farms, AC curves would need to be developed for each farm plant in the sample. Figure 2 illustrates a possible distribution of AC curves from say a small subsample of such plants. Each AC reflects a set of factor prices and production techniques associated with a particular plant. The aggregate of durables that define each plant and the prices paid for these durables differ because the time span over which a sample of farms is built characterizes a time period over which both production techniques and factor prices can be expected to change. Thus, AC_2 and AC_4 may reflect long-run optimal conditions for plants built in the forepart of the time span in which the entire sample of farms was built. AC_1, AC_3 and AC_5 can then be considered to reflect the optimal conditions (factor prices and production techniques) for plants in a later part of that time span. As the plants underlying AC_2 and AC_4 wear out, they presumably will be replaced with more efficient plants, such as AC_1, AC_3 or AC_5. We have here then a description of average cost curves for a sample of plants built at different times and thus reflecting different production techniques and different factor prices. The research analyst, depending on his objective, can follow one of two approaches. If his objective is to demonstrate how technology and factor prices have changed through time, the sample data can contribute to a long-run historical analysis. But if his objective is to develop guidelines for choice of plant, he can convert historical costs to replacement costs so that all plant assets are uniformly valued.

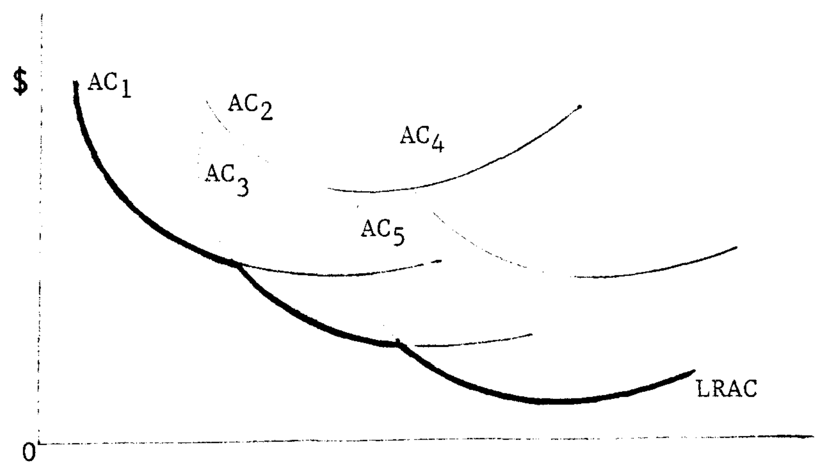

Figure 2. A Distribution of Short-run Average Cost Curves.

At this point, we can move into the long-run planning situation that allows plant replacement to more efficient plants of the same or of a different size. The long-run planning situation, hence, involves variations in output along given plant cost curves which contribute to the LRAC curve (the scalloped darkened portions of AC_1, AC_3 and AC_5, Figure 2); in dynamic analysis, it involves changes in factor and product prices and production techniques which redefine plant cost curves and, consequently, the LRAC curve itself. In the neo-classical model of the LRAC curve, the plant possibilities are typically considered so numerous that only small segments of the individual plant cost curves contribute to the LRAC curve, thus giving rise to a smooth envelope curve such as portrayed in Figure 3. However, Figure 3 shows only three of a theoretically infinite number of plant cost curves. Under the conditions of continuity, any small movement along the LRAC curve involves a change in plant, together with the variable factors that go with it. In other words, all of the factors, and their proportions to each other are continuously variable. As indicated earlier, short-run analysis shows the optimal manner of utilizing a given plant, whereas the LRAC curve shows the optimal way of producing given outputs. Thus, AC_1, AC_2 and AC_3 reflect the plants that are best adapted to producing OR, OS, and OT outputs, respectively.

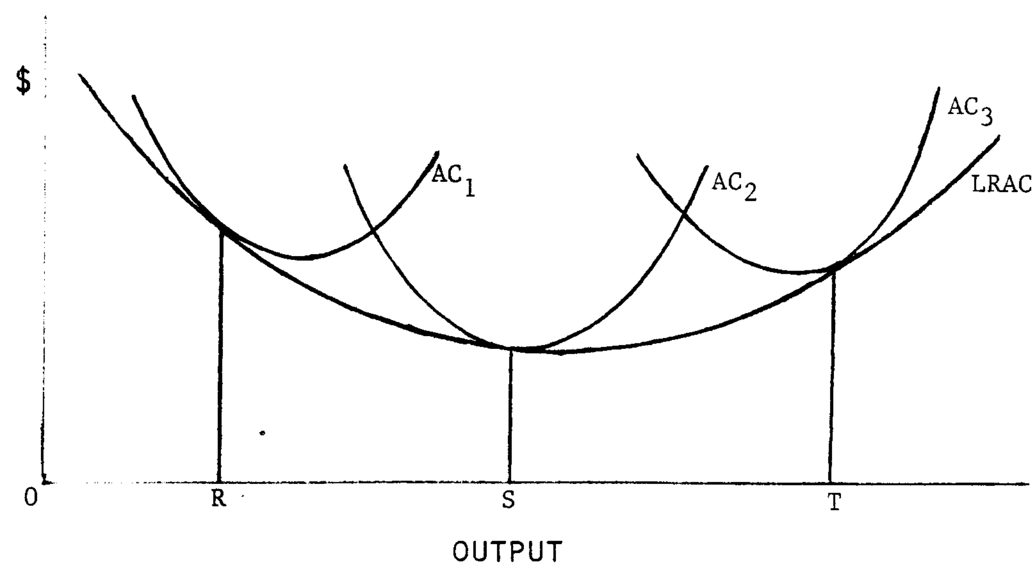

Figure 3. Short-run and Long-run Cost Curves.

As shown in Figure 3, the neo-classical LRAC curve has a falling phase and a rising phase giving it the typical U-shape. The primary explanations for the falling phase are (1) the increased specialization made possible by the increasingly larger aggregations of resources and by the extent of the market that provides profitable marketing opportunities and (2) the qualitatively different and technologically more efficient factors, particularly machinery and equipment, selected from the increased technical possibilities that become available for consideration because of the larger aggregates of resources. These two explanations are not necessarily independent, but often overlap, such as changes in machinery or facilities that characterize further specialization in the capital factor. Some examples will illustrate the point: the grain combine is a further specialization of the grain binder and the threshing machine; the combine with cornhead is a further specialization of the small-grain combine, the corn-picker and the corn-sheller. The declining phase of the LRAC curve thus involves more efficient plants and efficient utilization of those plants. This phase is also known as the output range characterized by increasing returns to size of plant or firm.

The rising phase of the LRAC curve follows the successively higher minima of the SRAC curves of a series of increasingly larger plants. This rising phase is explained by the greater complexity of the producing unit as it increases in size, making coordination and management increasingly difficult. To identify the minimum point on the LRAC curve as the place where problems of coordination and management necessarily emerge would be incorrect. When such problems emerge will depend on the product(s) being produced and the techniques and circumstances under which it is being produced at different times and places and, of course, it will depend on the level of managerial ability. Problems of coordination and management may appear in the declining phase of the LRAC curve, but they are more than offset by the unit cost reductions stemming from further specialization and use of more efficient techniques. But the gains from further specialization and more efficient techniques are believed eventually to exhaust themselves with increasingly larger plants while complexity continues to increase. The forces making for economies and diseconomies are considered to be in balance at the minimum point on the LRAC curve. To the right of that point, the forces making for diseconomies have increasingly more effect on unit costs. The theory holds that no most efficient proportion of factors exist independent of output. Hence, the proportion of factors that corresponds to the minimum point on the LRAC curve is not the best proportion of factors, but only the best for that particular output.

Long-run analysis of costs in relation to size can also be illustrated with use of iso-cost lines and iso-product contours (Figure 4).

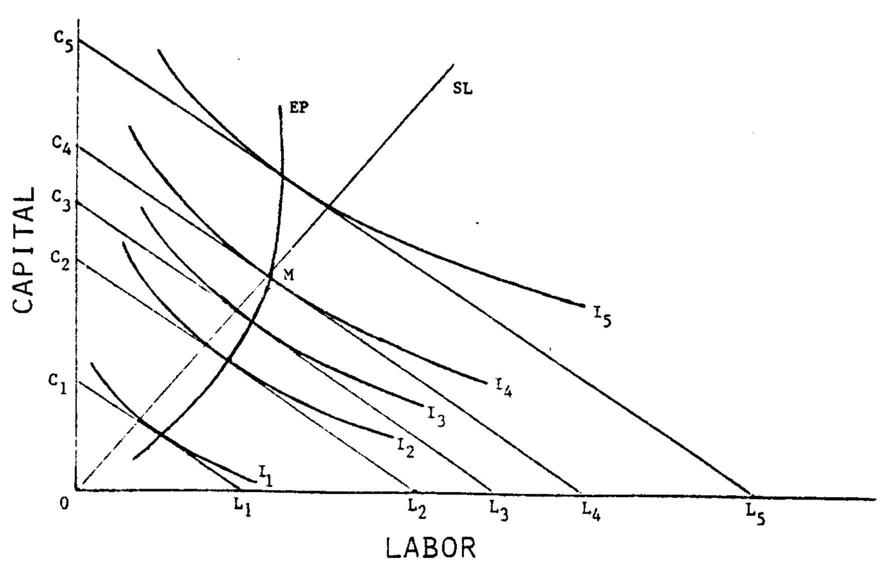

Figure 4. Long-run Cost-Size Relations Portrayed with Use of a Production Surface.

The scale line (SL) is not only a straight line, but it also passes through the origin indicating that capital and labor are being combined in fixed proportions in the plane denoted by SL.

The expansion path (EP) follows the points of tangency between the iso-cost lines and the iso-product contours. At points of tangency, the total product is at a maximum for the cost outlay, and the total cost is at a minimum for the output in question; unit costs are at a minimum for the cost outlay, as well as the product. Any other point on a "given" iso-cost line yields a smaller product for the same outlay, and any other point on the iso-product contour tangent to that "given" iso-cost line yields the same product for a larger cost outlay.

Each tangency point corresponds to a point on the LRAC curve and the line denoted by EP (expansion path) corresponds to the LRAC curve. Following the expansion path from its origin and upward, we can determine the optimum combination of factor inputs (capital and labor) to use in producing different levels of output. EP does not begin at zero since some amounts of capital and labor are needed to produce any product at all.

In Figure 4, EP bends toward the capital axis indicating that the relative marginal productivities of labor and capital are changing as they are used in increasingly larger quantities. The course followed by EP suggests that the marginal productivity of capital increases relative to that of labor and, hence, more of it should be used relative to labor. The iso-product contours in Figure 4 have been drawn to suggest that initially we have cost economies to size followed by diseconomies to size. The minimum point on the LRAC curve is assumed to occur at M; the exact minimum cannot be determined without prices and quantities.

In economies of size studies using an economic-engineering-mathematical programming approach, the average cost curve for the plant does not turn up as it does in neo-classical theory.

In Figure 5, the declining portion of the average cost curve is due to decreasing fixed unit costs, e.g., the spreading of the fixed overhead costs of machinery, equipment, and other plant facilities over more units of output and to increases in the marginal physical product from variable inputs, such as fertilizer, seed, and water. The rising portion of the average cost curve is due to decreasing returns to the variable inputs, giving rise to declining average and marginal physical products and to the fact that increases in average variable costs more than offset decreases in average fixed costs.

Figure 6 shows the short-run cost curves for economies to size empirical studies in which diminishing returns to the variable inputs are not built into the model. For example, fertilizer, seed, and other variable inputs per acre are held constant over the range of output. As a result, the marginal and average physical products and, in turn, the average variable costs do not change with changes in output. The decline in the average costs is entirely a function of spreading fixed costs over more output.

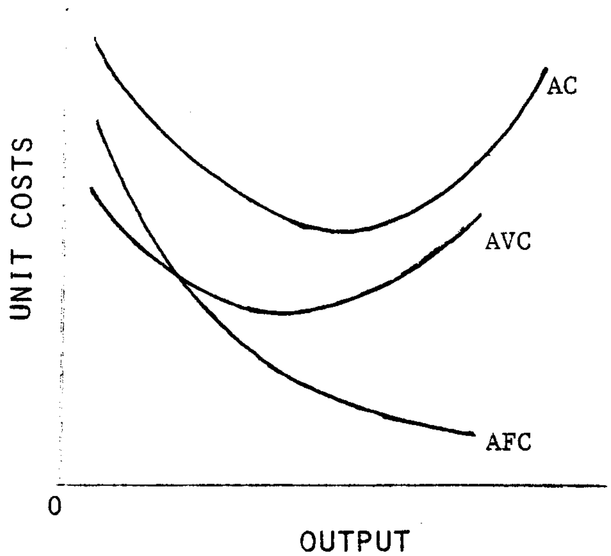

Figure 5. Neo-classical Short-run or Plant Cost Curves.

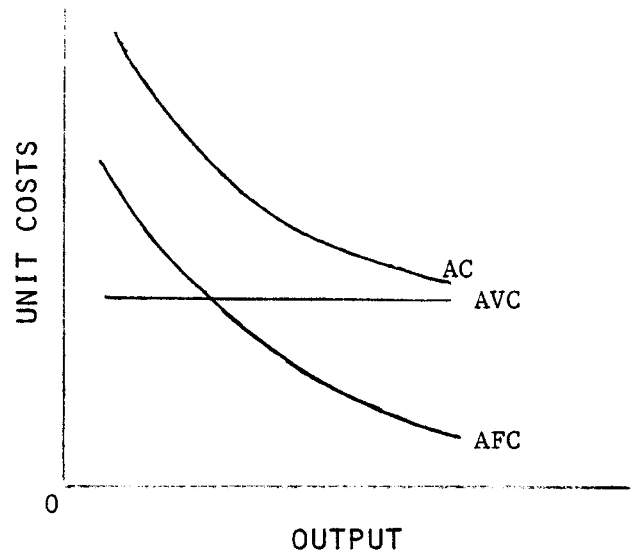

Figure 6. Short-run Average Cost Curves Based on Constant Returns to the Variable Inputs.

The differences noted above and illustrated in Figures 5 and 6 also have implications for the declining phase of the long-run average cost curve (LRAC). The average cost curves of successively larger plants in the neo-classical model trace out the LRAC as shown in Figure 7.

As noted earlier, the declining phase of the LRAC curve involves technically more efficient plants (AC_1 to AC_3) and an efficient utilization of those plants. It may also involve some problems of coordination or management as plants increase in size, but the costs associated with these problems are more than offset by further specialization and more efficient techniques.

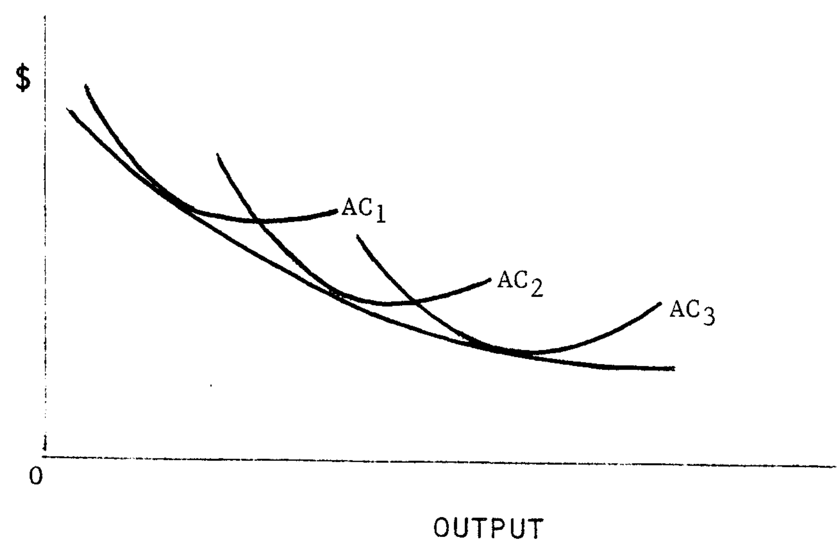

Figure 7. Neo-classical Model of Increasing Returns to Scale.

The declining phase of the LRAC curve derived by the typical economies of size study using the economic-engineering-mathematical programming approach is illustrated in Figure 8.

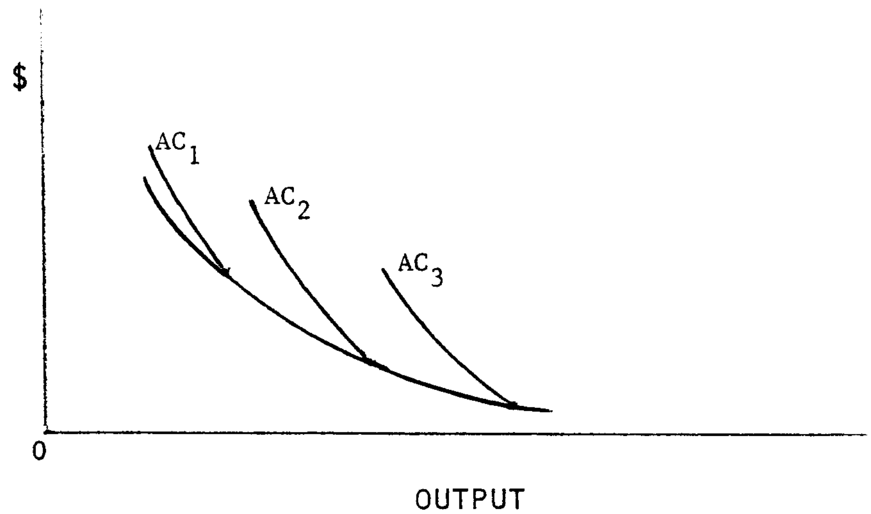

Figure 8. Illustration of Increasing Returns to Size Based on a Typical Economic-Engineering-Mathematical Programming Approach.

Because these studies do not include the costs associated with problems of coordination and management, the plant curves are a function only of further specialization and more efficient techniques. Consequently, the whole cost structure (short- and long-run) derived by the economic-engineering-mathematical programming approach will lie on a lower plane than the neo-classical model in Figure 7. Moreover, since these studies fail to allow for diminishing returns to the variable inputs, the plant curves do not have a rising portion.

As noted earlier, in the neo-classical model, the rising phase of the LRAC curve is explained by the greater complexity of the producing plant as its size is increased making coordination and management increasingly difficult. But, in the typical economies of size study illustrated in Figure 8, coordination and management are not a measured input. Hence, there is no variable(s) in the model that can cause a rising phase of the LRAC curve. Consequently, from our studies, we do not know where the minimum point of the LRAC curve is.

Problems in Modeling for Empirical Work

The kinds of empirical problems encountered depend, in part, on the goals or objectives of the study. The methodology used, it seems to me, must depend on the objectives of the study. If the objective is to describe <u>what exists</u> in terms of unit costs in relationship to farm size, then one will want to select a stratified random sample of farms--homogeneous as to type and with stratification by size. Farmers in the sample then would be interviewed to determine their unit costs in relation to output. Differences in unit costs can be expected among farmers for a number of reasons.

Differences in goals (economic and non-economic) will influence the way that they value their own and their family's labor. Economic goals can be expected to reflect opportunity costs of operator and family labor, whereas, non-economic goals will be more closely related to reservation prices.

Differences in goals will influence resource allocation, production and income. Multiple goals create problems in measuring output. Differences in vintage of machinery, equipment, and buildings will influence the annual costs of these resources and differences in technologies will influence unit costs as will differences in management. Unless one identifies all of these influences in the interviews and can measure their effects, the descriptive study will be very superficial, i.e., provide little information.

If we wish to explain why farms of different sizes exist, the model will need to be rich on content--in explanatory (including behavioral) variables, and one will need to spend a good deal of time on conceptualization and model building prior to testing it empirically.

On the other hand, if one wishes to do an economies of size study as a guide to long-run <u>planning</u> of plant size, then the approach might very well be an engineering-economic one which attempts to focus on answering the question: Are there technical economies and how are they related to size of farm? In doing such a study, however, we still have many unresolved questions. Among these are (1) how to measure inputs and their dollar value, (2) how to classify resources as fixed or as variable, and (3) how to deal with time as reflected in differences in resource flows and resource rewards over time with imperfect knowledge, risk and uncertainty.

With the inflationary rates that are characterizing our economy, perhaps we need to restructure the way that we cost out capital items or plant durables. For example, interest on average investment may have to be examined; sinking fund or capital renewal procedures may need to be looked at.

Public planning may need to be distinguished from private (farmer) planning because the costing of resources may differ between the two. Society is interested in having resources employed so that there is no incentive for moving resources out of their planned use; all resources have a cost--valued at their opportunity costs--opportunity rates of return discounted for uncertainty. For the public, land will be valued at its highest alternative use, including agricultural and non-agricultural. If no non-agricultural uses exist, then land will be valued at its highest market rental value in agriculture. For farm planning, the market rental value in agriculture will be the relevant cost base for most farmers. For farm families with non-economic, as well as economic goals, operator and family labor will be valued at its reservation price as well as it could be expected to earn in its highest alternative use.

In our usual modeling of a plant and the derivation of short-run average costs, any decrease in average costs is entirely due to spreading overhead costs over more units of output. Average variable costs are constant over the range of output. Our models are not constructed to allow for diminishing returns to the variable inputs. Hence, our SRAC curve never rises.

Problems exist in costing operator and family labor, management, and entrepreneurship. Some bases that have been suggested include (1) opportunity cost, (2) reservation price, and (3) zero price. In long-run planning, which is the nature of economies of size studies, it is difficult to see the logic of considering these resources as free. Realistically, there must be either an opportunity cost or a reservation price attached to them.

Due to changes in technology, the long-run average cost curve can be expected to shift to the right through time. Hence, cost economies of size studies must be updated periodically to provide current information for planning.

Problems exist on how to cost land. Some suggestions that have been made include (1) opportunity cost in some lower-return use like grazing, (2) cash rental rate, (3) returns to land on the most efficient-sized farm, (4) the Federal Land Bank interest rate, and (5) zero cost. Again attaching no cost to land means that it is considered a free good, which is inappropriate unless new land is available at zero cost. Implicit, as well as explicit returns (rent) enter into a full costing of production; as a farmer, even if I own land, it is mistaken logic to think that rent does not enter into cost of production. After I have paid all of my other bills, including wages to myself--at least equal to what my labor could earn elsewhere in the market--I would want an amount left over for land equal to the market net rental value of my land. I might not obtain that every year, but on the average, in the long run, if I did not obtain that amount, I'd be better off renting out my land and hiring my labor out to someone else.

Problems exist in how to <u>classify</u> operator and family labor, land, machinery, equipment, and buildings in cost analysis. These are all lumpy inputs. It is true that operator and family labor can be divided into hours, days, and months, but the fact is, it is all there whether it is used or not. Land can be divided into units of acres, but it is either purchased or rented in lumps. Hence, when developing the most efficient plant of a given size, it can be developed with land as a variable, but once the most efficient set of durables or plant of a given size has been developed, then land and other durables identifying the plant are fixed when combined with variables such as fertilizer, seed, and feed to trace out the SRAC curve. Insurance, interest on investment, and taxes on machinery, equipment and buildings are not a function of output and, hence, are classified as fixed costs. Depreciation on these assets is sometimes handled the same way. However, depreciation on machinery is quite often handled differently, especially in linear programming models; agricultural engineers provide estimates on hours of use for a machine to wear out. The amount to be depreciated is then divided by the hours to wear out to give depreciation costs per hour of use. The quotient is then multiplied by the hours per acre required to perform the machine operation on the appropriate activity to give depreciation costs per acre. This procedure considers that all the machinery depreciation is due to use and it is considered as a variable cost. As an average cost, it is constant throughout the range of output. This procedure gives different unit costs than does our short-run cost model where depreciation is part of total fixed costs, which then divided by output gives declining fixed unit costs. Classification procedure for depreciation, thus, can make considerable difference on the cost structure.

If operator and family labor and land costs are classified as variable (at constant amounts over the range of plant output) or if these resources are considered free, then the long-run average cost curves may very well be flat or near-flat and constant unit costs for the long run may be inferred. On the other hand, if operator and family labor and land costs are handled as an overhead and included in average fixed costs, the short- and long-run cost structure will differ greatly and lead to different inferences.

Questions exist on whether to cost all operator and family labor, used and unused. A Montana wheat farmer may not work as a wheat farmer every month of the year, but he is likely to work long hours at soil preparation, seeding and harvesting times. If he is idle for several months and off-farm employment is available, a social opportunity cost exists for that time. The farmer, himself, may place a high value on leisure and, therefore, has a reservation price higher than the off-farm opportunity rate of return net of the transfer costs. For social planning, the opportunity rate of return, minus transfer costs, appears to be the relevant costing approach. For farmer planning, the reservation price may be the appropriate cost.

In a cost economies of size study for long-run planning of plant size, we must deal with expectations. Yet risk or uncertainty is mostly ignored in cost economies of size studies. As a minimum, it would seem logical to include some discount for risk or uncertainty, such as using less fertilizer than the profit maximizing level, leveraging less than the maximum which credit institutions allow, and selling feeder livestock at weights less than the profit maximizing weights. Another way to make some adjustment for risk and uncertainty is to estimate variability in average costs based on output variability due to product price and yield variation, and then plan for average costs to be higher than in the most favorable years. In any adjustment for risk and uncertainty, it is important that the adjustments be applied consistently across farms.

Time enters into long-run planning, and resource service flows may differ for different sizes of plants--plants with different technological bases. Hence, it would seem logical to include a cost for tying up resources over different lengths of time.

Given the numerous problems or questions that still seem to befuddle us in economies of size research, it seems that it would be prudent to do some careful thinking and conceptualization before undertaking additional economies to size studies and before drawing implications for policy planning from either past or current studies.

Suggestions for Modeling Economies to Size Studies as Planning Guides

One general framework for proceeding with the analysis, is to conceive of two phases in decision making: one is the long-run planning phase, i.e., estimating the optimal farm size, and the other is the implementation phase, i.e., putting the plan into operation. These two phases can be considered from both private and public viewpoints. Public may differ from private goals, which may mean that public policy will develop institutional arrangements to encourage private resource use in line with public goals. For example, the public through government may vote for smaller and more numerous farms as a basis for assuring social and economic viability of rural communities, even though, say, many farms could achieve lower unit costs through enlargement. In this instance, public policy would need to provide some incentives and/or disincentives to assure that farmers who could attain lower unit costs by getting larger will be better off by staying smaller.

Thus, one broad general framework might take the form of the matrix shown below.

	Long Run	
	Planning	Implementation
Private	X	X
Public	X	X

In the planning phase, all resources are variable and the planning task is to plan plants of varying size and to select the plant estimated to have the lowest unit costs. Implementation calls for "putting into operation" the size of plant and technology selected in the first phase. Implementation may mean converting liquid assets (cash, bond, notes) into a fixed farm plant and operating capital, or it may mean enlarging an existing plant. Implementation of the plan may take one or several years depending on resource availabilities. In an empirical analysis, rather than do the long-run planning as the first step and implementation of the plan as the second, we conceivably can integrate these two phases by estimating the LRAC curve on the basis of amortized plant costs. This procedure does not address problems that may arise from variations in cash flows, but it is one way of building in some assurance that investment capital will be available for purchase of new plant facilities when the older ones wear out.

For further development of this general framework, it will be helpful to proceed from a set of assumptions, some of which can be relaxed later on. We shall assume atomistic competition among firms, no market economies, uncertainty or imperfect knowledge in a non-dynamic setting, no inflation, planning before income taxes, deal only with technical economies to size and exclude part-time farming. We shall deal first with the private sector of the matrix.

In long-run planning involving selection of the optimal size of plant, problems that will receive our attention are specifying goals, defining plant, costing and classifying resources.

The firm can have single or multiple goals, some of which compete with each other, some of which complement one another. Here we will assume that the firm is interested in allocating resources in order to increase income and to achieve other goals obtainable through income. We will also assume that the firm is interested in having ownership control over the farm resources.

Earlier, the point was made that a plant can be thought of as the assemblage of all durables owned by the firm, such as land, machinery, equipment, and buildings. In this instance, operator and family labor was not included among the fixed resources defined as plant. Operator and family labor, therefore, would vary with output and not be included in the fixed overhead costs, making the SRAC and LRAC curves flatter than they would be were operator and family labor considered part of the fixed plant and, hence, a fixed cost. In empirical studies, "plant" has been defined in a number of ways, such as:

Man years:	1-man	2-man	3-man
Acres:	160	320	640
Size of power unit:	2-plow	3-plow	4-plow

Again, how a plant is defined has implications for how resources are classified, i.e., as fixed or variable, and therefore, will affect the shape of the SRAC and LRAC curves. For example, if the plant is defined in terms of power unit and complementary equipment with land and labor as variable cost coefficients constant with output, the SRAC and LRAC curves will be much flatter than if both land and labor costs are considered part of the plant, and therefore, as fixed costs.

Perhaps if the problem of costing and classifying resources is first approached, some guidelines will emerge on how to best define plant. Clearly, the problems are interrelated.

All resources have a cost. Since uncertainty and imperfect knowledge (in a non-dynamic setting) are assumed, the relevant costs on production items, such as fertilizer, seed, feed, and herbicides, are <u>expected</u> costs. If the farmer himself is doing the planning, these expected costs are based on his expectations. They are subjective. If the research analyst is doing the planning as a resource guide to farmers, the expected costs are likely based on the research analyst's expectations. This does not make the value of the study less, because whether the expectations are formulated by the farmer or the research analyst, as long as they are applied consistently across plant sized, plant cost comparisons are still meaningful.

Under conditions of atomistic competition, market prices are the signals for resource allocation. Therefore, all non-durable inputs or factors for which markets are broadly established will be priced at their expected market prices. Within the multi-product firm, for economic efficiency, factors should be allocated on the basis of their opportunity costs, i.e., they should always be used where their returns are highest. In empirical analysis, production functions for inputs in alternative uses do not exist, except in a few instances such as for fertilizer and feed. Where such information does exist, it can be incorporated into mathematical programming formats. Otherwise, the quantities of such inputs per activity must remain constant with output changes. Although the markets for land and hired labor are not as well defined, say, as for fertilizer, markets do exist for both. For most farmers, the cost of using land is its rental price for agricultural purposes, and the cost of owning land is the amount paid on real estate tax. For fewer farms, those within urban development areas, the cost of using their land for farming is its rental price for urban use. In either case, the real cost to the farmer of farming a given acreage is the dollar amount for which it could be rented out, and for a meaningful measurement of technical economies to size as a basis for farm planning, all land across size groups should be costed out either at its opportunity rate of return in urban use or its rental value for farm use.

Hired farm labor, like land, has a market price, both by the day and by the month. Like land, its market price is not as well defined as for fertilizer. Like land, its cost to any one farmer will vary depending on what the alternative opportunities are for that labor. But, in a study set up to measure technical economies to size, the factor prices for hired farm labor, land or other resources should remain the same across farm sizes as long as resource quality (productivity) remains constant.[11] When the quality (form) of a resource changes with farm size, such as from two to four to eight-row equipment, the unit price for the equipment will, of course, change with equipment size. Also, as the form of a resource changes with farm size, such as from corn-picker to picker-shellers, the unit prices will change in going from one form of machine to another. Similarly, the form of hired labor can change with farm size requiring a change in its unit price. As plants increase in size, division and specialization of labor may take place requiring more skillful, better-trained workers. At the same time, the productivity of these workers should increase, i.e., the coefficients should reflect increases in output per unit of specialized labor--e.g., a specialist in animal nutrition and feeding should attain the same animal product from fewer resources or more animal product from the same resources when compared with a hired man unskilled in animal feeding. Some large cattle feeding farms and large dairy farms in the West, for example, do hire people trained and skilled in livestock feeds and feeding and in disease prevention and cure. However, in the North Central Region, most farms are typically not large enough to benefit from this kind of specialization and division of hired labor.

Operator and family labor will be handled at its implicit wage, i.e., at the highest expected price at which it can be sold, either to other farmers or to non-farm operators considered to provide realistic employment opportunities.

On most farms, the operator is not only a farm laborer, but he is also the manager who assumes the responsibilities of coordination, supervision, and risk bearing. It is less difficult to arrive at an expected implicit wage rate for the operator as a farm laborer than it is to arrive at an implicit wage rate for him as a manager because the market for hired labor is a more active market than the market for farm managers. On larger farms where, say, three or more farm laborers are hired, the farm operator will

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[11]Actually, insofar as the land resource is concerned, it should be of uniform quality across farm sizes. Otherwise, differences in inherent quality of farm land from one farm size to another will distort measurement of technical economies due to changes in the technological coefficients of production.

need to spend less time as a laborer and more time as a supervisor if he is going to do the supervising. As a minimum, the operator's value as a part-time supervisor should be worth at least the increase in wage that would be required to get his "best" hired man to do the supervision plus the cost of the additional labor that would need to be hired because of work time allocation to supervision.

The need for coordination grows out of change and imperfect knowledge about these changes--in weather, in production coefficients, in prices, in institutions, and in people with whom the operator must deal. To cope with these changes, he must formulate expectations about the future; he must develop and decide on a plan of production and he must implement the plan. The problem is now one of costing out these functions that have been conceived of as coordination or higher-level management for the operator who also spends time as a farm laborer and as a supervisor. One approach is to impute a value equal to what it would cost to hire a commercial farm management service to perform the coordination or high-level management function.

The farm owner-operator also performs the risk-bearing function. In planning the optimal farm size, a potential farmer's risk is really limited to the probability of error in estimating the short-run average cost curves from which the LRAC curve is estimated. Some probability will always exist that the planned or estimated costs will differ from what they turn out to be in reality. To minimize the probability of error in measuring technical economies to size for farm planning, variables such as type-of-farming, debt-to-asset ratio, soil type, weather conditions, yield (unless, e.g., a function of specialization of labor), and product price expectations should not vary with farm size. Neither should factor price expectations for homogeneous resources. Yet errors in estimation may enter in. One way of handling that risk is for the prospective farm owner-operator to put aside a reserve fund as an insurance against such a risk.

On large farms, a farm owner may hire farm laborers, a work supervisor(s) and utilize all of his time in coordination. The real cost of the farm owner-manager, in this situation, is what he could earn as a full-time coordinator-manager on another farm. In contrast to the previous situation where laborer, work supervisor, and coordinator-manager are all embodied in the farm operator, this situation can be regarded as a change in the form of the factor or a technological change.

The title for this section of the report, "Suggestions for Modeling Economies to Size Studies," makes no mention of diseconomies to size. Perhaps that is a reflection of the fact that empirical studies have not been modeled to include measurement of diseconomies, and for good reason, because no satisfactory way of measuring the phenomena giving rise to diseconomies have been found.

The section on "Neo-classical Theoretical Models" suggested that the rising phase of the LRAC curve may be explained by the increased complexity of the producing unit as it grows larger making coordination and management increasingly difficult. It was also pointed out that problems of coordination and management may appear, as well, in the declining phase of the LRAC curve, but that any resulting unit cost increases are more than offset by unit cost reductions stemming from further specialization and more efficient techniques. Moreover, when such problems emerge, it very likely depends on the product(s) being produced, the techniques and circumstances under which it is produced, and the level of managerial ability. If problems of coordination and management indeed do occur in the declining phase of the LRAC curve, the decreases in unit costs will be measured with error whenever the effects of these problems are not entered as part of the costs.

Moreover, as long as a model is wanting in variables (and measurement of these variables) that will cause an upturn in the LRAC curve, as analysts we should not mislead ourselves and our readers by suggesting that after an initial declining phase in long-run average costs, we have a wide range of output over which unit costs are constant or near constant. The fact is, we simply do not know at what point in an empirical study diseconomies to size set in. That, as mentioned above, will vary with time, place, and circumstances including managerial ability.

Costing out durables, such as machinery, equipment, and buildings, includes depreciation, interest, property taxes where levied, and insurance. In addition, there are costs of repair or upkeep, and for power units, the costs of fuel, oil, grease, antifreeze, and electricity. Since a non-inflationary setting is assumed, current prices of new durable assets will be assumed in arriving at their costs for all farm sizes. Were some rate of inflation assumed for planning, then expected replacement cost rather than current investment is a more appropriate basis.[12/] The investment cost of durables, such as machinery, equipment, and buildings will be their amortized costs--amortized over their estimated life time (or if shorter, over the length of the planning period assumed by the farmer or research analyst) at the real opportunity rate of return on current investment costs. This procedure takes care of depreciation and interest costs on durables.

Besides costing out resources, private long-run planning also involves defining the "plant," which requires classifying resources and factor costs. Whether a person is about ready to start farming or is already farming, the plant or SRAC curves and the LRAC curve derived from them can be helpful guides to selecting the optimal size. The person about ready to start farming can view the array of plant curves, their unit costs, capital requirements and annual costs as information in selecting the plant to implement. The person, however, who already has a farm plant has the choice of adding more variables to the existing plant or of increasing plant size, if the array of plant curves suggest that he may be able to reduce his unit costs by increasing plant size. In either case, they can utilize planning information as a basis for deciding on plant size prior to implementation of a complete plant or the expansion of an existing one.

A search of the literature reveals a number of concepts or terms that bear upon the problem of classifying resources and costs and in arriving at a definition of "plant." However, none have the specificity needed for empirical analysis, but then that is asking too much of general concepts. Nevertheless, let us review some of these terms or concepts to see what they have to offer.

12/Use of replacement costs for valuing assets is the appropriate way, not only under conditions of inflation, but also for constant and increasing cost industries. But for a decreasing cost industry, replacement costs would overstate the value of existing assets.

Time is involved in the term "length of run." Short run is distinguished from long run in a general way. In the long run, all factors are variable; while in the short run, one or more factors is fixed.[13] Nothing is said about how much time the short run encompasses, and nothing is said about the nature (monoperiod, polyperiod, stock, flow) of the factors that are fixed.

Time is also related to the term "production period," which can be defined as the amount of time for a resource(s) to be completely transformed into product. But many resources are used in producing farm products, some of which are transformed into product within the year, some in two years, and some in 40 or 50 years.

The term "cost function" and its underlying production function, relate to a specific time period, a particular technology, homogeneous product and factors. Hence, the definition of a cost function and its underlying production function suggests that the findings of an economies of size study will be considerably easier to interpret if it is based on a specific time period, a homogeneous product, and homogeneous factors. The matter of technology will be addressed later.

Perhaps in a conceptual, as well as an empirical analysis, little is gained by becoming greatly concerned about the element of time. For a farmer who already owns and operates a plant, at some time in the future, some of the resources defined as plant will wear out or become obsolete, and he will want to think about replacing part of the plant or building a new one. A person ready to start farming, on the other hand, can evaluate a full array of plant sizes before committing any resources, but once he has built a plant, he is in the same situation as the farmer who already owns and operates a plant. Empirically though, as a basis for estimating costs for polyperiod resources, it is useful to specify a time period in which the plant is expected to pay for itself. Thus, the analyst may assume that the resources making up the plant must pay for themselves in 10 years. Actually, this time length will vary depending on changes in technology, prices, yields, and the particular farmer or analyst. Hence, the analysis can be made with different assumptions. Also, because of the seasonality of production and accounting systems used, a calendar year may be the most appropriate time period for short-run cost analysis.

Definitions of "plant" appear to revolve more around resource fixity than the element of time. Earlier, the statement was made that "plant" can be thought of as the assemblage of all durables owned by the firm, such as land, machinery, equipment, and buildings, and that an increase in any one

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[13] Viner defines the short run as "...a period which is long enough to permit of any desired change of output technologically possible without altering the scale of plant, but which is not long enough to permit of any adjustment in scale of plant." He defines the long run as "...a period long enough to permit each producer to make such technologically possible changes in the scale of his plant as he desired and, thus, vary his output by a more or less intensive utilization of existing plant or by varying the scale of his plant, or by some combination of these methods." See pp. 202 and 205 in Jacob Viner, Cost Curves and Supply Curves, pp. 198-232, Chapter 10 in American Economic Association Readings in Price Theory, Vol. VI, G. J. Stigler and K. E. Boulding, editors.

of these durables increases plant size. A more general definition of "plant" is simply a fixed aggregate of factors.[14/] This definition does not specify these factors as durables, but since theory holds that the plant cannot be varied in the short run, and since seasonality of production and accounting systems seem consistent with a year designated as short run, and since durables or polyperiod resources cannot readily be varied from one season to the next as economic conditions dictate, defining "plant" as an assemblage of all durables seems to be consistent with foregoing conditions.

The question then is how do we arrive at this assemblage of all durables that we call plant? Fortunately, techniques do exist for arriving at a near most efficient, if not the most efficient combination of durables. Theory holds that the units of factors should be chosen so as to achieve maximum efficiency. Given the lumpiness of durables, such a maximum may not be completely attainable. However, mathematical programming is a powerful technique for determining the collection of durables for consideration as the optimum plant size for a given output. For example, a dairy farm situation can be programmed with full-time labor, type of housing for dairy cows, size and type of milking parlor, size of field machinery, and type of forage feeding program fixed. This fixed aggregate of resources than can be combined with varying levels of other resources, such as supporting dairy facilities, acres of land, cows, and money capital to arrive at a set of fixed factors to be considered as one of a number of plants that may minimize costs for a given output.[15/] The reason that there may be other plants or fixed aggregates or resources that give lower costs for the same output is the units of the factors chosen may not have been chosen to achieve maximum efficiency. Thus, a different size of the milking parlor and size of field machinery may yield greater efficiency.

Once the assemblage of fixed factors or "plant" considered to be the most efficient for a given output has been determined, then that plant or set of fixed factors can be combined with varying levels of factors, such as fertilizer, herbicides, water for irrigation or grain for livestock, to trace out the short-run cost curve for that plant. Other plant sizes and their associated short-run cost curves can then be developed following the same procedures.

The reason why it is important to trace out the short-run cost curves for each plant size is illustrated in Figure 9. Figure 9 shows alternative ways of estimating the LRAC curve. One LRAC curve is estimated from the tangency points with the SRAC curves which is the correct way. The other

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[14/] Glenn Johnson's fixed asset theory is analogous in some respects. It does not distinguish between durables and non-durables as variables. It simply says that an asset is variable if its marginal value product is above its acquisition cost or below its salvage value. But neither does the theory address the question of short run versus long run. Moreover, since mvp's are difficult to estimate for most assets, its application is somewhat limited.

[15/] Land is a variable in this instance, but only as a means of arriving at the "most" efficient set of durables or plant. Once that has been determined, then acres of land is fixed for that set of durables.

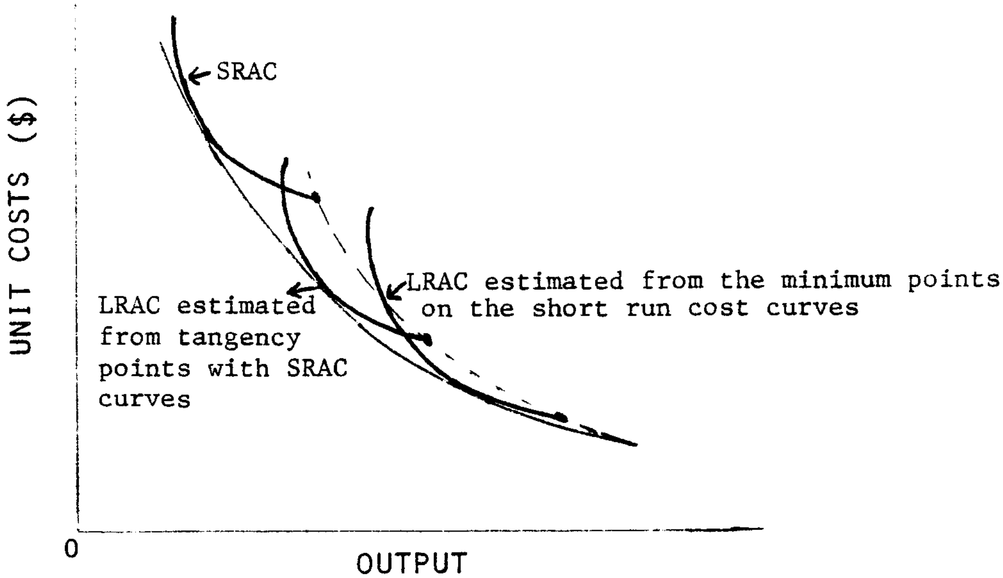

Figure 9. Alternative Ways of Estimating Long-run Cost Curves.

is estimated from the minimum points on the SRAC curves. Economies of size studies using mathematical programming actually may not develop information other than the minimum points on the SRAC curves for estimating the LRAC curve. But these minimum points have no long-run significance, except when the minimum points of the plant curves are used to estimate the LRAC curve. As Figure 9 shows, a LRAC curve constructed from the minimum points on the SRAC curves may incorporate sizable estimation errors. The tangency points between the SRAC curves and the LRAC curve are the optimum ways of producing a given output in a planning context, whereas the minimum points on the SRAC curves are relevant to the optimum way of utilizing each plant.

Figure 10 shows short- and long-run cost relations, again illustrating the significance of constructing the LRAC curve from points on the SRAC curves tangent to the LRAC curve. Figure 10-I has a set of iso-cost lines and a set of iso-product contours. An expansion path (EP) is drawn through the tangency points between the iso-cost lines and the iso-product contours. Each tangency point corresponds to a point on the LRAC curve. For example, tangency point B, Figure 10-I corresponds to tangency point B' in Figure 10-H. Figure 10-I also shows the increase in output when X_2 resources (a plant) are fixed at 0_x and and X_1 resources are increased to R to S to T. Corresponding levels of output from this fixed plant are U on Y_1, B on Y_2, and W on Y_3. U' and W' in Figure 10-H correspond to U and W in Figure 10-I. U' and W' are not on the LRAC curve.

To do short-run analysis, we are still left with the problem of how to classify costs. To approach this problem, let us draw on the concepts of fixed and variable costs along with the concepts of flow and stock resources.

At the outset, it may be well to remind ourselves that how we classify costs, i.e., as fixed or variable, gives rise to differences in SRAC curves

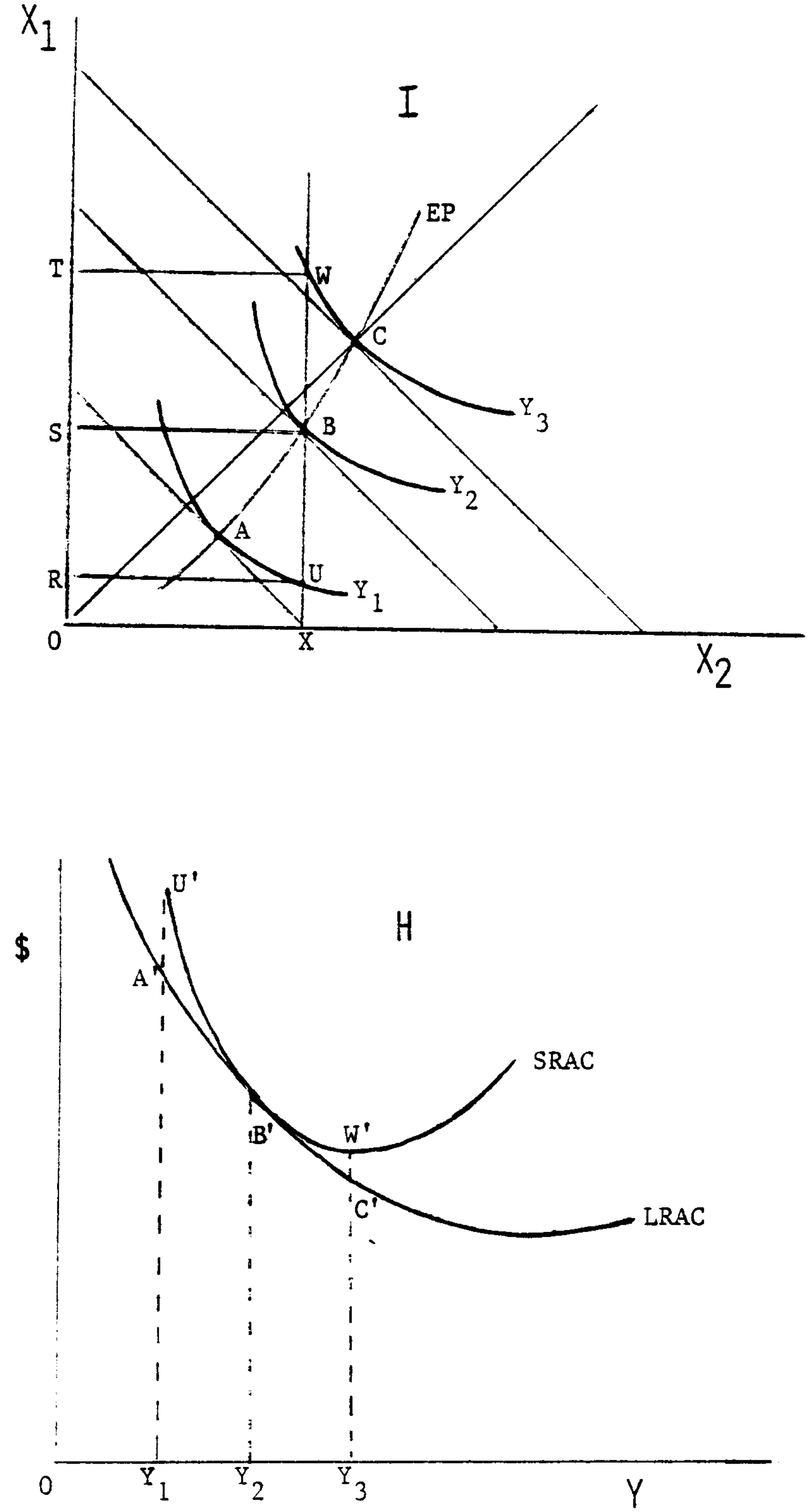

Figure 10. Short- and Long-run Cost Relationships.

and will give rise to different LRAC curves unless the LRAC curve is based on the minimum points of the SRAC curves. Table 1-a and Figure 11 show a firm's short-run costs with family labor as a variable cost, while Table 1-b and Figure 12 show a firm's short-run costs with family labor as a fixed cost. In both instances, production functions are identical and the same prices are charged for all factor services. In both instances, total average costs are the same at maximum output or where all labor is utilized. Thus, a LRAC curve derived from the minimum points of the SRAC curves would be identical irrespective of how costs were classified. However, the LRAC curve derived from the tangency points with a family of SRAC curves with, say family labor as a fixed cost, will be quite different from one where family labor is considered as a variable cost. The latter will be considerably flatter than the former.

In the literature, fixed costs are defined as those costs that do not vary with output during the production period. Hence, the categories of costs falling into this classification include (1) franchise costs, such as real estate taxes, (2) contractual costs, such as rent, annual wages for a full-time wage earner, interest on capital on resources that are fixed for a specified time, and (3) the value of the flow services from fixed resources that are given off or lost during the production period, regardless of the level of production, such as depreciation due to weather or deterioration and obsolescence and unpaid operator and family labor. Under full-time farming, operator and family labor, a flow service resource that is not storable, is on the farm whether used or not.

Variable costs, on the other hand, vary with or are a function of output during the period of production. They include the value of stock services from either monoperiod or polyperiod resources used up in the production period. When not used in one production period, they can be stored for another period. Examples are fertilizer, feed, chemicals, repairs, oil, grease, and depreciation due to use.[16/]

Once the long-run planning is completed, i.e., the type of farming, the plant size and technology have been identified, then the plan or some modification of it must be implemented. We will now relax the assumption of full-time farming and allow part-time farming. Implementation will be addressed first to the person who is ready to start farming. If he has ample capital to finance the size of plant that exhausts the technical economies of size, he can build that size of plant. Given his yield and price expectations for the year ahead, he then must decide at what level of output at which to operate the plant. At this time, he may also wish to consider what precautions, if any, he may want to set up as protection against risk or uncertainty, including consideration of whether as a manager he is capable of managing the plant size that exhausts the existing technical economies. Once these issues have been resolved, he can then begin to operate the plant.

But if the person ready to start farming is limited on capital, several years may elapse before he will have the means to implement the size of plant that exhausts the technical economies of size. He may have to implement a

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[16/] Due to the difficulty of estimating depreciation due to obsolescence, depreciation in empirical analysis is typically not divided into that due to obsolescence and that due to use.

Table 1-a. A Firm's Short-Run Costs with Family Labor Considered as a Variable Cost.[1/]

Y	TFC Without Family Labor	AFC Without Family Labor	V_1 Labor Input	Cost V_1 at $4	V_2 Other Variable Input	Cost of V_2 at $4	Total Variable Costs $V_1 + V_2$	AVC with Labor as Variable	Total Average Costs
10	$20	$2.00	2	$ 8	2	$ 8	$16	$1.60	$3.60
20	$20	$1.00	4	$16	4	$16	$32	$1.60	$2.60
30	$20	$0.67	6	$24	6	$24	$48	$1.60	$2.27
40	$20	$0.50	8	$32	8	$32	$64	$1.60	$2.10
50	$20	$0.40	10	$40	10	$40	$80	$1.60	$2.00
60	$20	$0.33	12	$48	12	$48	$96	$1.60	$1.93
70	$20	$0.29	14	$56	14	$56	$112	$1.60	$1.89

[1/] With identical production functions and the same prices for all factor services, both firms will have identical total average costs at maximum output or where all the labor is utilized.

Table 1-b. A Firm's Short-Run Costs with Family Labor as a Fixed Cost.[1]

Y or Output	TFC With Family Labor	AFC With Family Labor	V_2 Other Variable Input	Cost V_2 at $4	AVC With Labor Fixed	Total Average Costs
10	$76	$7.60	2	$ 8	$0.80	$8.40
20	$76	$3.80	4	$16	$0.80	$4.60
30	$76	$2.53	6	$24	$0.80	$3.33
40	$76	$1.90	8	$32	$0.80	$2.70
50	$76	$1.52	10	$40	$0.80	$2.32
60	$76	$1.27	12	$48	$0.80	$2.07
70	$76	$1.09	14	$56	$0.80	$1.89

[1] With identical production functions and the same prices for all factor services, both firms will have identical total average costs at maximum output or where all the labor is utilized.

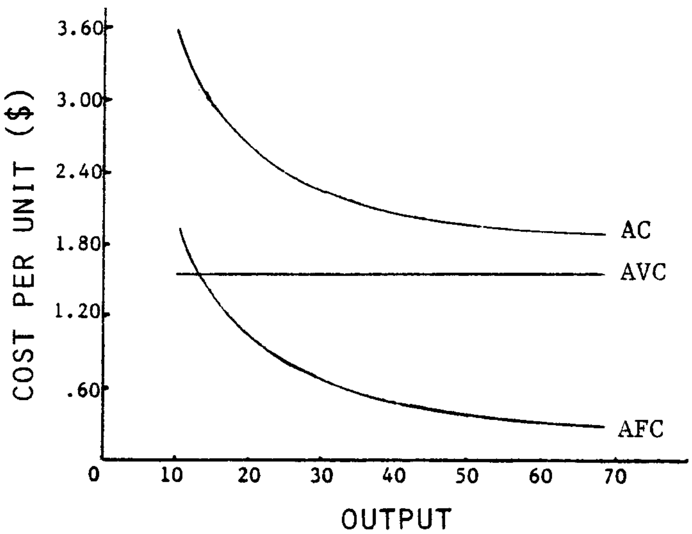

Figure 11. Short-run Average Cost Curves with Family Labor as a Variable Cost.

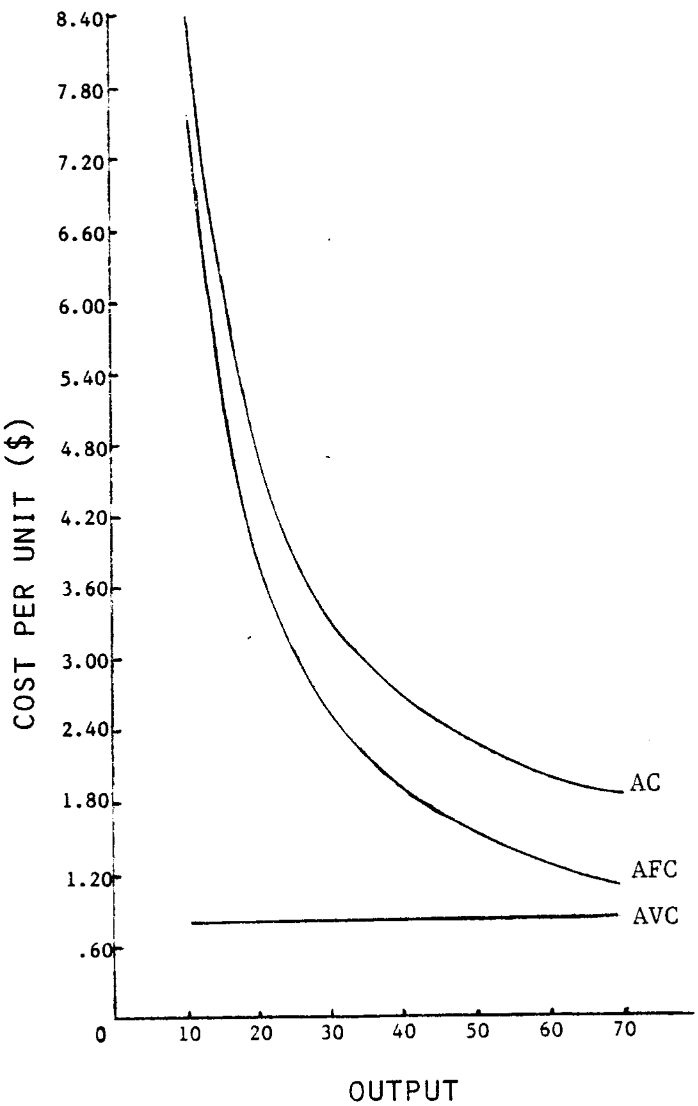

Figure 12. Short-run Average Cost Curves with Family Labor as a Fixed Cost.

smaller, higher cost plant, and eventually as he accumulates more capital, grow into a larger and lower-cost plant. For the first few years, with the smaller plant, his own labor may not be fully utilized in farming, and if his reservation price for leisure isn't too high, he may decide to work part time off the farm doing non-farm work or doing custom work for other farmers.

On the other hand, the person already owning and operating a farm has an existing plant which, on the basis of current studies and information, may be too small or partly or totally obsolete in use of technology. Since empirical studies have been unable to measure the diseconomies of size due to the increased difficulty of coordination that stems from the greater complexity of the producing unit as it grows in size, these studies are not likely to help him on the question of whether his existing plant is too large. But empirical studies should be able to help him answer the question of whether his plant is too small to take advantage of the cost reductions that are available with larger plants and alternative technologies. But again, studies may not provide much help in determining whether he has the managerial ability to exploit the technologies associated with larger and more efficient plants. If the future looks very uncertain to the person already owning and operating a farm, he may decide to expand output by adding more variable resources to his existing plant, rather than to increase size of plant, even if it appears too small to take advantage of existing technical economies of size.

This section of the report began with a general framework for long-run planning and implementation in the private and public sectors. We have now dealt with some suggestions for the private sector. The following page is devoted to public long-run planning of optimal farm sizes and their implementations.

Society is interested in having resources employed in such a manner that no incentive exists for moving resources out of their planned use. Planned use presumably rests on societal goals which in a democracy are expressed through the constitution, legislation, and legal rulings. A democratic society will have a number of goals such as an efficient use of resources, currently and over time--including some level of soil and water conservation, job opportunities for its work force, pollution control, equity for its citizens, some level of security for its people, viable communities in which people can live and develop, educational opportunities to assure a living democracy, and provision of services not readily nor efficiently provided by the private sector.

When private goals conflict with societal goals, private goals can be brought into harmony with public goals through incentives and/or disincentives.

Society presumably is interested in promoting technological developments that will assure an adequate supply of food for its constituents. In addition, society may be interested in food production as an element in international trade and as a buffer against starvation or inadequate nutritive levels in other countries. In producing its planned food needs, society supposedly is interested in an agriculture that is organized to take advantage of technical economies of size. At the same time, if such a structure destroys the social and political viability of rural communities, and catches some rural families in the backwash of technological change so that they are stranded as rural poor without the means to adjust, then society may want to take steps to create viable rural communities either through restructuring agriculture (even at some cost in technical efficiency) or in restructuring rural community organization.

All resources have a cost to society. Their real cost in their present use is what they could earn in their next best alternative. Hence, all resources in social planning should be valued at their long-run expected opportunity rates of return; expectations here are formulated by social planners, and these are formulated, ordinarily, for a longer time period than in the private sector--a difference that can bring public and private resource use into sharp conflict.

Once society has decided on the optimal plant sizes in agriculture, it must then develop a set of policy instruments to guide resource use toward these optima. Since we have assumed private farm ownership and a representative form of government, then the option of state owned farms is excluded for consideration. Hence, the policy instruments open to society for arriving at what it considers optimal plant sizes for agriculture are: (1) use of incentives for enlargement for farms smaller than optimal, (2) use of disincentives for reduction in size for farms larger than optimal, and (3) let technological development in agriculture take a free and uninhibited course as well as lending it public support because food is basic to its people's nutritive needs, to a favorable balance of trade and to stability among nations. As an extension of the last option, society may decide to let farms adjust freely to technological change; given this option, it would seem then that society might be obligated to assume some responsibility for guiding and easing resource adjustments needed because of technological change. Finally, society may decide to place upper (or lower) limits on farm size in order to assure that other societal goals are met.

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