Study of economies of scale in the savings and loan industry

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A STUDY OF ECONOMIES OF SCALE IN THE
SAVINGS AND LOAN INDUSTRY

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B.S., Michigan State University, 1973

Presented in partial fulfillment of the requirements for
the degree of

Master of Business Administration

UNIVERSITY OF MONTANA

1977

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ACKNOWLEDGMENTS

I wish to thank the United States League of Savings Associations for their financial aid, which allowed me to greatly increase the scope of this study. I am also indebted to those individuals who aided me in the analyzing of data and in the writing of this study. Finally, I would like to express my appreciation to the savings and loan associations which provided the required data.
CHAPTER I

A STUDY OF ECONOMIES OF SCALE IN THE

SAVINGS AND LOAN INDUSTRY

Savings and loan associations (S&L's) belong to a group of financial institutions known as intermediaries. Intermediaries receive savings from consumers and reinvest these in various interest producing loans and investments. The interest from these investments is used by the associations for returning interest to savers and to cover operating expenses.

As a financial intermediary, S&L's belong to a group which includes commercial banks, credit unions and various other organizations. Within this group, savings associations have been increasing what is already a substantial market share. At the end of 1974, savings associations held 14.9 percent of all assets of financial intermediaries, second only to commercial banks. The associations took in 32.6 percent of all over-the-counter savings in that year. From this, associations provided 48.1 percent of all mortgages for one to four family homes.¹ Because of this and because of public sector control of the industry, it is important to understand the various cost relationships for such institutions.


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It was the purpose of this study to investigate potential economies of scale in savings and loan associations. In the study an attempt was made to determine whether such economies of scale exist (and if so to what extent), and to determine what factors affect the cost structure of individual savings and loans, and the industry.

The study utilized data from S&L's in the Twelfth Federal Home Loan Bank District headquartered in Seattle, Washington. District 12 consists of 157 S&L's in Alaska, Hawaii, Guam, Idaho, Montana, Oregon, Utah, Washington and Wyoming. Alaska, Hawaii and Guam S&L's were not used, bringing the number of S&Ls to 128. This is because economic and demographic conditions in these three subareas are atypical in comparison with national and regional norms and therefore would distort the results. The data from individual associations were obtained from a survey of S&L's in the portion of the twelfth district defined above.

Various techniques are utilized to analyze the data. Economies of scale, the relationship between the rate of optimum output which a unit is designed for and its long run average costs, has its basis in microeconomic theory. For that reason this branch of economic theory provides the main conceptual basis for the study.

The empirical analysis utilized two techniques, standard regression analysis and the frontier frame method. The frontier frame is a line connecting the minimum actual costs of the sample institutions at various levels of output. This line then represents minimum average costs for the industry for a given technology. The frontier frame

approach is relatively new, but has been used in some analysis of other types of financial intermediaries.

The primary focus of this study was on average costs as the dependent variable, although total cost is used as the dependent variable for some regression estimates. Independent variables will consist of various characteristics of the institutions in the sample, and the environments in which they operate. These include measures of assets, savings, profitability, and local competition. The basic model will assume that there is a relationship between the variable types in the form of:

\[ AC = f(x_1, x_2, x_3, \ldots, s_n) \]

Where AC is the average costs and the \( x_i \)'s are the various institutional attributes described by the independent variables.

Regression techniques are used to attempt to fit specific equations representing the model to data for the twelfth FHLBB district. These include:

- Linear multiple regression equation:
  \[ AC = a_0 + a_1 x_1 + a_2 x_2 + \ldots + a_n x_n \]

- Curvilinear regression equation:
  \[ AC = b_0 + b_1 x + b_2 x^2 + b_3 x^3 \]

- Multiplicative multiple regression equation:
  \[ AC = c_0 x_1 c_2 x_2 \ldots c_n x_n \]

The independent variables are various output proxies such as assets, savings volume, income, and numbers of accounts.

In presenting the results of the study, the paper is divided into four main sections. The second chapter investigates the theory
of economies of scale and related empirical work. The literature review in Chapter II begins with the 1947 study of economies of scale in different industries by Joe S. Bain. This study has been the basis for most studies of this type since its publication. An example of related studies to be reviewed is a study of financial institutions and economies of scale by George J. Benston. This study represents a major contribution to the present knowledge of economies in financial institutions. A study by R. Alton Gilbert and Lionel Kalish, III, which is one of the few studies of economies of scale in financial institutions which utilize the frontier frame method, is also included in this review.

The third chapter presents the various forms of the model which are to be tested. This includes the different variables or combinations of variables used, the reason for their inclusion, interrelationships between variables and expected results.

The fourth chapter analyzes the statistical results of various alternative model forms. Hypothesis testing is utilized to evaluate the statistical significance of various results and assumptions. For the regression results one tailed "t" tests are used for individual coefficients, and the F ratio and R-squared statistics are used in evaluating the regression equations. Of particular importance here is the

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comparison of actual results to expected results and the comparisons of the results of various alternative model forms.

The fifth chapter presents the conclusions of the study and the implications resulting from these conclusions. As noted earlier the determination of the existence of economies of scale, and the effect they cause, has an important impact on management and regulatory agencies in the savings and loan industry. The best alternative model forms are selected and the implications of these forms for managers and regulatory agencies are examined.
CHAPTER II

SURVEY OF RELATED LITERATURE

Interest in economies of scale has existed almost as long as modern economies. In his book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith commented on this topic.¹ By increasing the size of the organization, and therefore the division of labor, Smith believed that certain economic advantages could be obtained. These advantages are based primarily on increased worker efficiency. Thus, by increasing the division of labor greater output could be achieved with the same inputs.

The concept of economies of scale is based on this relationship between inputs and outputs. Specifically, economies of scale may be defined as the relationship between scale, the rate of optimum output which the plant or company is designed for, and its long run average costs.² The discussion in this chapter begins with the basic concepts of economies of scale and related topics, such as industry concentration and barriers to entry in an industry. This is followed by a discussion of measurement techniques used in studies of economies of scale. Three


²Joe S. Bain, *Barriers to New Competition*, p. 56.
representative studies of economies of scale which illustrate many of the concepts presented conclude this chapter.

Basic Concepts

As stated above, economies of scale are defined as the relation between optimum output and long run average costs (LRAC). Several assumptions are implicit in this definition. First, long run average costs are used meaning that all inputs are variable. This includes capital investments like machines or buildings, as well as short term changes in materials and labor. The principle of economies of scale should not be confused with the law of diminishing returns, in which some of the inputs are fixed and some are variable. Second, it assumes optimum output, (i.e., minimum costs), by the unit, (unit meaning plant or company). This is different from technical efficiency which compares unit production costs at any output to minimum attainable costs. The importance of the difference is that each unit contributes one point toward an industry long run average cost curve used in economy of scale computations. But, since a firm rarely operates at its optimum, or even knows where this point is, economy of scale computations are estimates at best. This also means that economies of scale cannot be calculated by information on a single unit, and data on a plant or company has meaning only in relation to the industry or some other group of data. Finally, the word "economies" is used; it can be replaced with

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3 Ibid., pp. 53-56.

diseconomies. Economies of scale arise when long run average costs fall with increasing output. Diseconomies of scale are just the opposite, raising average costs with increasing output.

The long run average cost curve is the basis of many studies on economies of scale. This curve shows the relation of long run average costs (LRAC) to a range of outputs with all inputs variable. This means that the company is not restricted by its present personnel, equipment or facilities. The curve shows the lowest average costs of producing units at different rates of output. The curve can be used for the planning of additional facilities or equipment, but it assumes that the units of production are added independently. If they were not added independently, lower costs would be present.

The exact shape of the curve is dependent on various market and production factors of the economic activity under investigation. Generally it is believed that the LRAC curve is U-shaped. There are three segments of importance on the curve (See Figure 1). The first segment has decreasing costs at low levels of output. At the upper end of this segment is what economists refer to as the minimum optimum scale (MOS) of production. The MOS is defined as the smallest level of output that will allow the unit to obtain minimum long run average costs. Firms can exist at lower levels of output, but the number of such firms is dependent on the slope of this segment. The more negative it is the less likely there will be many small units.

Fig. 1.-LRAC Curve

Segment 1
Segment 2
Segment 3
Output

LRAC
The second segment of the LRAC is greatly dependent on the environment within the industry in question. If there is only one minimum cost level of output, this segment converges to a point since the LRAC would have a positive slope beyond that minimum point. It is more likely that there will be a range of outputs with the same minimum cost. Meaning that firms with minimum costs for an industry may be scattered over a range of levels of output.

The final segment of the curve is the most controversial. At high levels of output this portion of the curve shows rising LRAC, or diseconomies of scale. To date, most studies of various industries have failed to show the existence of increasing LRAC. It is possible that industries have not grown to sufficient size, or that multi-plant systems have nullified this effect to an extent. The theoretical explanation for the rising segment of LRAC curves is that as the firm grows, administrative systems and fixed quantities of management tend to cause increased costs. The growth may also be accompanied by shortages of raw materials and increased transportation costs for a single facility unit. This topic is discussed below to a greater extent in studies of economies of scale and related concepts.

Real economies of scale, as noted earlier, represent the relationship between the rate of optimum output for which the producing unit was designed and LRAC. Included within real economies of scale are economies due to the specialization and division of labor, indivisibility of inputs,

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Specialization and division of labor are at the heart of the present assembly line operations. Such operations have brought lower costs and higher rates of output. Much of this is based on increased worker efficiency and is very much like it was described by Adam Smith.

The factor of indivisibility of inputs is of greater importance because of its economic basis. These indivisibilities affect the purchasing, production, marketing, financial, and possibly the research and development, services required by a business. For example, machines should be run at an optimum rate. At speeds above that rate there may be a decrease in the quality of output and an increase in maintenance requirements. At a slower rate, fixed costs must be spread over fewer units causing higher average costs. A company purchasing a machine may be required to buy more capacity than really required. Because of this any increase in output, up to the optimum rate, will lower average costs, resulting in economies of scale. Similar relationships occur for marketing and financial operations with respect to fixed costs involved. It has been proposed by some that a similar relation is present for research and development operations, but no concrete evidence of this is available.

Human administration, or management, is thought to have an indivisibility relationship to output similar to that of machines. It is assumed that managers come in discrete units, so that some over-purchase may be required. Another aspect of human administration is the effect of the learning curve. The learning curve indicates that a worker

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can increase his proficiency at a task as he repeats it. Thus, a worker would be able to produce more efficiently as he gains more experience. There are diminishing returns related to this phenomenon. The effect of the learning curve on the long run average cost curve would be a downward shift in the entire curve, since it is taken at a point in time. The same relationship can also be applied to technology.

Besides real economies of scale there are also pecuniary economies of scale. Pecuniary economies can be defined as the minimizing of costs through the use of market power. Such economies are not related to the position of the LRAC curve due to production, but to the relative strength of the company within the market. Lower costs are obtained because the company can obtain capital, high talent labor and other inputs at lower prices by threatening to do business elsewhere. Such economies are not achieved by greater efficiency, but are really transfers of profits from one unit to another. Real economies of scale are of benefit to society because of increased efficiency. Pecuniary economies of scale are not based on efficiency and are a potential problem in that they transfer earnings from one sector of the economy to another based on market power rather than competition.

Two schools of thought have developed with respect to the relative importance of real and pecuniary economies of scale. The schools are called American and British, reflecting the general policies of the governments of these two countries. The American school of thought

9Ibid., pp. 98-100.
10Joe S. Bain, Barriers to New Competition, pp. 59-61.
states that large firms are bad, reflecting this country's long history of anti-trust legislation. It is believed that economies of scale are largely pecuniary in nature and that the dangers from monopolies, which may result, are greater than the advantages of efficiency so gained. The British school of thought is the opposite; that large firms do obtain real economies of scale and increased efficiency, and that this is generally to the good of society. Business legislation in Great Britain therefore, does not inhibit large firms to as great an extent as American laws. An ideal position would probably be in the middle ground.

Before proceeding further in a discussion of economies of scale several related topics should be addressed. These are concentration, barriers to entry, and firm's growth, size and profitability. Each of these is discussed individually and related to the concepts of economies of scale as presented above.

Concentration is defined as the number and the size distribution of buyers and sellers in a market. Initially it was assumed that concentration was related only to pecuniary economies of scale (market power). Various ratios utilizing accounting data of a cross section of industries have been used unsuccessfully in attempts to prove this relationship existed. ¹¹

On the other hand, seller concentration can be meaningfully related to real economies of scale and the minimum optimum scale. A measure of this relation is the minimum degree of seller concentration, which is the reciprocal of the MOS (which is calculated as a fraction of the total market). This measure indicates the number of producing

¹¹James V. Koch, Industrial Organization and Prices, p. 145.
units of the minimum optimum scale which could exist in the market. Obviously there may be larger units in the market, meaning greater concentration. On the other hand, there may be units which are smaller than the MOS. The number of firms in this group is determined by the shape of the LRAC curve. The steeper the negative slope of the curve segment at outputs less than the MOS, the greater the cost disadvantage for the smaller units. With greater cost disadvantages it is likely that fewer small units will be present. Being dependent on so many other factors, such as product differentiation, government regulations and other environmental factors, this index of concentration is an estimate at best.

The effect of the lower end of the LRAC curve on concentration can also be related, at least theoretically, to the high output end of the LRAC. In some industries a maximum optimal scale has been estimated at two or three times the MOS. The maximum optimal scale would restrict maximum concentration in a manner similar to MOS, but this is not confirmed. 12

In the past, growth of a firm has generally meant horizontal growth of the company. Many companies unable to grow in this manner have turned to vertical growth. 13 It may be possible for a firm to

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12 Ibid., p. 146.

13 Horizontal growth is accomplished by expanding on the same level of production which the firm presently operates in. This can be accomplished by either expansion of present facilities or by the acquisition of competing firms. Vertical growth is growth by a firm into a different level of production. The firm becomes its own supplier or customer. See James F. Tucker, Essentials of Economics, (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1975), p. 44.
grow vertically because of technically complementary operations or because of better coordination, allowing lower inventories and transportation charges. It is possible for a firm to grow vertically and not increase its market share in any individual industry. Further, such growth does not necessarily mean that they will have lower costs in that industry.

Each portion of a vertically integrated firm has its own MOS. For the firm to be most efficient, and assuming no diseconomies of large scale operations exist, the MOS for the entire firm is the largest MOS of its segments. Should diseconomies of scale occur there must be trade-offs between the segments. The importance of this is that a large vertically integrated firm does not necessarily dominate all the industries it is in. Smaller firms of higher profitability may exist in an industry because it competes against a segment of a vertically integrated firm which must produce a non-optimum output due to other operations within the company.

Development of large units of production in an industry will also be affected by the existence of barriers to entry. The barrier problem is related in part to the MOS, and in much the same way as concentration. For the company wishing to enter a new market a study should be made to determine the shape of the industry LRAC curve, what the MOS is, and the expected reactions of present producers to new competition. If the newcomer wishes to operate with a minimum of costs, it must produce at the

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MOS or greater. The problem is that the MOS may be a significant percentage of the total market. If this is the case, and present producers do not lower output, a significant drop in the price may occur, making the new operation unprofitable. The newcomer can also choose to enter at less than the MOS with a loss in profits and hope for growth. The amount of loss is dependent on the small output portion of the LRAC curve. A third course of action would be for the entrant to accept a larger loss if it thinks the other producers will reduce output while maintaining prices. The hope is that the other producers will accept the entrant in the future and will reduce output, or that the new firm can draw customers from the competition, making its business more profitable. In any case the low output segment of the LRAC curve may provide a significant barrier.

For the existing producers within an industry actions can be taken to increase the size of these barriers. A maximum limit price can be set above competitive levels which would be allowed to drop with the additional output of a new entrant. The drop in price would bring a new price less than the average unit cost of the new entrant, but high enough for present producers to survive. The size of the difference over competitive levels is affected by other barriers to entry. These other barriers include absolute levels of investment and the amount of product differentiation. An increase in either of these would allow a higher limit price.

Segment two on the LRAC curve indicates constant (or slightly increasing) costs. Constant costs have an effect on the growth of firms

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and is based on Gibrat's Law.\textsuperscript{17} Gibrat's Law states that the probability of growth is independent of firm size and that the variability of the growth rate is constant over the entire range of outputs. Field studies have verified the first part of this but not the second. The reason for the probability of growth rate being independent of output is that while smaller firms are affected by lack of capital and profitability, larger firms (with respect to their industry) are bothered by the possibility of anti-trust actions, effects of their own market power and possible diseconomies of scale. Each has about the same effect on its size group. Growth rates are not of constant variability over all rates of output. This is because of smaller firms which have a greater chance of failure (i.e., negative growth to zero output) or to grow at a higher rate relative to their size.

Attempts have been made to connect profitability to size and growth. These have met with little success due to the wide variety of factors affecting profitability, including various supply and demand requirements.

To determine the effect of concentration and barriers to entry, it is necessary to calculate the MOS and the shape of the LRAC curve. There are four main requirements for the methods used in these calculations.\textsuperscript{18} First, measurements should be over short enough periods of time that they are not averages. Second, costs should be closely connected with output. Third, wide ranges of outputs should be used.

\textsuperscript{17}James V. Koch, \textit{Industrial Organization and Prices}, p. 135.

\textsuperscript{18}Ibid., p. 101.
Finally, the effects of factors not of interest to the study should be minimized and accounted for.

A problem of considerable importance at the start of a study of economies of scale is the determination of the appropriate unit of output. For manufacturing, the physical output can be utilized with some modifications. The modifications should standardize output with respect to inputs. For example, products differ in their capital and labor content. There should be modification to make equivalent units of uniform value. The problem of dimensioning service output is one of determining what a unit of output is. Measures of output may include turnover (intensity) of service, number of types of service, or even the number of shops utilized. More than likely some combination of intensity and size of transaction should be used. This problem of identifying the appropriate unit of output is especially important in studying economies of scale in thrift institutions such as savings and loan associations.

Measurement Techniques

There are two main methods of studying economies of scale, time series and cross-sectional analysis. Time series follows one or several study subjects through a period of time. Problems of changing methods or technology can affect this type of study. Cross-sectional analysis uses a number of subjects with data gathered at one point in time. This type of data and method can be influenced by differences not directly of interest to the study if care is not taken to adjust for such differences.

These two forms of analysis are the basis of four types of studies which have been used in the past. These types of studies are profit rate tests, survivor tests, statistical studies and engineering studies.  

Profit rate studies, as indicated by their name, try to relate the amount of profit to the size of the firm. One obvious problem with this method is that profitability may be the result of economies of scale in total, in part, or not at all, since profitability is affected by many factors.

The second, and more widely used, method is survivor testing, which uses a combination of time series and cross-sectional analysis. Survivor tests are based on the assumption that competition will weed out inefficient or non-optimal production units. This method divides firms into size groups. At a point in time, data is taken and the percent of the market held by each group is calculated. At a later time the calculations are repeated using the same groups. It is assumed that through competition those that are more efficient will increase their market share, while those that are less efficient will decrease their share. Problems with this method are that there are no solid relations between efficiency and growth or decline in market share. This method gives the general shape of the LRAC curve, but since few, if any, firms operate with minimum costs for their output, the curve will show higher costs.

The third method is statistical studies which are much like profit rate tests. The primary differences are the use of varying dimensions of output and different sources of data. The final method, engineering studies, is an extension of the statistical studies. In engineering

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studies, data are used to form a mathematical relationship between costs and output.

An example of the engineering method is the .6 rule. The rule states that:

\[ C_2 = C_1 \left( \frac{X_1}{X_2} \right)^{.6} \]

Where: \( C_1, C_2 \) are costs at output levels 1 and 2

\( X_1, X_2 \) are output at levels 1 and 2

The mathematical relationship is based on the relationship between surface area and volume of a solid object. In the equation given above, cost is a proxy for surface area and output is substituted for volume. From the relation it can be shown that costs do not increase proportionally to output, meaning that economies of scale should exist. For example, if output were increased by 10 percent, \( \left( \frac{X_1}{X_2} = 1.1 \right) \), then costs would increase by 5.89 percent, \( \left( \frac{C_1}{C_2} = (1.1)^{.6} = 1.0589 \right) \). This equation is not universally applicable. It is most useful for units which use a single type of machinery and increase output by purchasing more of that type of machinery.

**Literature Review**

The remainder of this chapter is devoted to an examination of actual studies of economies of scale. The three studies presented use different methods to obtain LRAC curves and the MOS. The first study to be presented is the classic analysis by Joe S. Bain which analyzed

\[ ^{21}\text{Ibid., p. 107.} \]
economies of scale in various industries for the year 1947. This has been the basis for many studies of economies of scale since its original publication in 1954. Bain used statistical methods to study industry structures and barriers to entry. The second study is by George J. Benston, in which he investigates economies of scale and other cost relationships within financial institutions using regression analysis techniques. This study has contributed much to the areas of economies of scale in financial institutions. The last study, by R. Alton Gilbert and Lionel Kalish, III, also studies cost relationships and economies of scale in the financial services industry. It is presented here because it utilizes a relatively new statistical method, the frontier frame.

As stated above, Bain's study investigated the structure of selected industries and barriers to entry in those industries. Major considerations included the calculation of the MOS for firms, and plants, relative to their total market, the shape of the LRAC curve at outputs less than the MOS, and absolute capital requirements for entry.

Large amounts of data were required on selected industries, to conduct this study. For this reason, prior to actual data gathering, preliminary studies were made to determine which industries had sufficient data available in published and unpublished documents. From these

studies, 20 industries, considered to be representative of the American economy as a whole, were selected for evaluation. There were 8 consumer goods industries, 8 in producer goods, and 4 in both. These industries used a wide range of techniques and processes. It was found, though, that this sample was biased toward moderate to high levels of concentration.

Data on these industries were obtained from the 1947 Census of Manufacturers, and supplemented with data from surveys of industry executives. Specific data included the number of employees (which was used as an indicator of size), value added (which represented output), and some cost information. From the data, calculations of concentration were made using the maximum percentage of industry output supplied by a single plant or firm as the measure of concentration for the industry. This value was considered as a maximum because it was calculated as the average of the four largest producing units in the industry. In evaluating these concentration figures it was assumed that the units could expand to any size their management desired. Therefore, where concentration was greatest, (the largest units), there should be the greatest economies of scale.

In analyzing concentration values, Bain found that economies of scale varied greatly among the industries studied. He found that of the 20 industries, nine, primarily involved with natural resources, had slight economies. On the other hand, five industries, mostly in manufacturing, showed significant economies of scale.

A great amount of variation was found in the shape of LRAC curves of the industries studied. Of the 20 industries, four had nearly horizontal curves over the entire range of output and in nine cases data were
not available for this determination. In the remaining seven industries, two showed minor economies (1 percent higher costs if output were reduced to 50 percent of MOS), three showed moderate economies (3 percent higher costs if output were reduced to 50 percent of MOS), and two had major economies (7 percent higher costs if output were reduced to 50 percent of MOS).

In analyzing the results, Bain believed that by using the national market, concentrations on regional markets would be understated. To evaluate this belief he performed the same calculations with respect to the smallest and largest submarkets of the 20 industries. These submarkets were defined along product and geographical areas. The results indicated that increased concentrations would cause higher barriers to entry to new firms in those industries, indicating the importance of defining the scope of the market in such studies.

In evaluating the absolute amount of capital required for entry into an industry, Bain found that it was significant in all cases. When combining capital requirements with the degree of economies of scale present, the effect on the individual industry varied. In some cases they reinforced each other, in others they neutralized each other.

The importance of the Bain study cannot be overestimated. While it used relatively simple statistical methods, it provided a basis for subsequent studies. The information presented here is only representative of the total work, but several significant points can be made. It was the first study to evaluate the shape of the LRAC curve and to estimate the value of a MOS. It was also the first to investigate concentration and barriers to entry relative to economies of scale. It has made a major contribution to studies of economies of scale.
The study by George J. Benston is more narrow in scope. It investigated whether economies of scale exist in the financial services industry, and how this affects management and regulation of the industry. This study's investigation of the financial services industry included commercial banks and savings and loan associations.

Multiple regression techniques were used to determine the quantitative relationships between cost and output. The basic cost function was:

\[ C = b_0 Q^{b_1} H^{b_2} P^{b_3} U^{b_4} \]

Where:
- \( C \) = Total operating costs
- \( Q \) = Rate of output
- \( H \) = Several variables presented individually in the regression equation which equalize the output mix of producing units
- \( P \) = Several variables presented individually which account for factor prices, organizational structure, and management characteristics
- \( U \) = Unspecified factors
- \( b_0, \ldots, b_4 \) = Regression coefficients

Several assumptions are implicit in this relationship. First, output is exogenously determined, which is a valid assumption in a regulated industry. Second, it is assumed that individual firms will attempt to minimize cost, which seems reasonable for private companies. Finally, it is assumed that technological advances are available to all, which is quite hard to justify. The sample used in this study contains a

\[ 26 \] George J. Benston, "Economies of Scale in Financial Institutions," pp. 312-341.
wide range of asset sizes ($2.8 million to $801 million for commercial banks). Units near the top of the asset range will probably be using data processing equipment and be highly automated. Smaller units in this sample will probably be restricted to more labor intensive operations.

Costs, the dependent variable in the regression equation, has several components. Included within this variable are most operating expenses including salaries and wages, and the operating costs of machinery. In addition to these direct costs are indirect costs, including administrative costs, business development (promotional) costs, and occupancy expenses. Depreciation and the cost of capital are not included. Depreciation is not included because it does not reflect the true value of services provided by the depreciated item, and it is usually a minor item. Capital costs are considered constant in this study.

Output in the financial services industry cannot be defined as easily as in manufacturing. This difficulty is because the industry produces services and is multi-product by nature. For this reason, output was divided into five areas; demand deposits, time deposits, real estate loans, business loans, and securities. Each of these was analyzed separately with regression techniques relative to direct costs and each of the three types of indirect costs. The output variables included account size, account activity and the type of account.

In addition to output and cost variables, many descriptive variables were used. For the analysis of the direct costs of commercial banks, descriptive variables included the riskiness of accounts, where applicable, relative wage indices, and structural variables which measure branching. Indirect cost variables centered on the description of the
composition of bank business, such as the relative amounts of various
types of assets and liabilities.

The analysis of commercial banks was accomplished utilizing
accounting data from banks in the Boston Federal Reserve District for
the years 1959 to 1961. Approximately 80 banks were in the sample for
each of the three years, covering a wide range of asset sizes and num­
bers of accounts.

Regression analysis indicated the presence of economies of
scale in most areas of bank operations. Economies were significant in
the area of demand deposits and were present, though less significant,
in the areas of time deposits, business loans, and installment loans.
For all bank operations the cost elasticity was .93, meaning that a
10 percent increase in output would bring a 9.3 percent increase in
costs.

In describing the operations of savings and loan associations,
different variables were required. Some of the difference in variables
was necessary because of the difficulties in separating loan output
from savings account output. To alleviate this they were not separated.
Cost variables included salaries and wages, occupancy costs and miscel­
laneous costs. Taxes, interest, and advertising expenses were not
included because they could not be directly related to output. Descrip­
tive variables included the size and activity of accounts, individual
association characteristics (such as the number of branches and indivi­
dual efficiency), and factor prices indices.

Data for savings and loans were obtained from the reports of
1,986 S&L's to the Federal Home Loan Bank Board for the years 1962 to
1966. From the study data, an average cost elasticity of .923 was
calculated for all S&L operations. It is interesting that elasticities for comparable bank and S&L operations were nearly equal.

Benston's study arrived at several conclusions which are significant for further study in this area. First, while economies of scale are present, they are not so large that they will tend to eliminate smaller banks and therefore lessen competition. Second, branch banks can serve a community at lower costs than a small unit bank. Third, marginal costs decline over all observed output levels.

As in the Bain study, all the results of this study are not reviewed herein. However, its use of regression analysis and variable selection make it a significant contribution in the measurement of economies of scale in thrift institutions. Further, the conclusions of the study have made a great impact on studies of economies of scale, as well as management and regulatory aspects of the financial services industry.

A third study, by R. Alton Gilbert and Lionel Kalish, III, is presented to show a different technique in estimating economies of scale. This study attempted to plot the LRAC curve using the frontier frame method.

As stated above, the LRAC curve represents various units operating at the most efficient level for a given output. Positions on the curve indicate the relative technical efficiency of various output levels. Lower average costs mean greater technical efficiency. Since few, if any, units operate at minimum levels, the points representing the output and costs of actual producing units will be located on or above the curve.

The distance above the curve is an indicator of operating efficiency of the individual unit. The frontier frame method connects the points representing producing units with the lowest average costs. Because it does not take into account units of lower operating efficiency, the authors believe it gives a representation closer to the actual LRAC curve.

This method was used to evaluate the efficiency and economies of scale of the three types of commercial bank: unit, branch, and holding company. A sample of 898 banks was taken from the Boston Federal Reserve District. Of the sample 51 percent were unit banks, 39 percent were branch banks, and 10 percent were holding companies.

In this study two concepts of output were used; the amount of loans and investments, and the "social revenue" of interest producing assets. The latter is defined as the sum of the interest of all categories of interest producing assets held by the bank, plus any non-lending income not including service charges. The value of the interest for each asset category was modified to take into account the relative market power of the bank. Costs, as used by Gilbert and Kalish were the total annual operating expenses of the bank.

Figure 2 indicates the LRAC curves derived from the two definitions of output. As can be seen, all six curves have the same general shape. All curves show significant economies of scale for outputs less than the MOS. Also significant is that all curves show diseconomies of scale at large outputs. Large outputs in this sample ranged up to 12 times the MOS. This study is one of very few studies to show diseconomies of scale at high levels of output.
Fig. 2.—Frontier LRAC Curves for Commercial Banks

SOURCE: R. Alton Gilbert and Lionel Kalish, III, "An Analysis of Efficiency of Scale and Organizational Form in Commercial Banking," The Journal of Industrial Economics 21 (July 1973): 300, Fig. 2 & 3.

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In analyzing the relative efficiency between the types of banks, it was found that unit banks had the greatest operating efficiency at nearly all output levels for both output definitions. This point is in direct contradiction to the conclusions of the Benston study presented earlier. The cause of this difference is the definition of operating costs used in the studies. Specifically, Benston did not include the occupancy costs of the unit, while Gilbert and Kalish did. Branch bank costs would be significantly higher due to occupancy costs. Additionally, the Gilbert and Kalish study found that branch banks were more efficient than holding companies for higher levels of output.

Since this was a new technique the authors compared the results to those of earlier studies. It was found that the Greenbaum, Alhadeff and Gramley studies showed increasing economies of scale throughout the entire output ranges.28 The frontier cost curve was significantly different in that it showed smaller economies of scale for outputs less than the MOS. More important the frontier cost curve showed diseconomies of scale at higher rates of output.

Because it showed diseconomies of scale at higher output levels, this study could have a significant impact on management and regulatory aspects of the financial services industry. The study also illustrated that the frontier frame method is a valuable tool in the study of economies of scale.

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In this chapter the basic concepts of economies of scale have been presented along with the effect these have had, or can have, on the business environment. Finally, representative studies of economies of scale have been reviewed. Such studies are necessary to determine the effects of large business on the economy and society of the United States. This is particularly important in the highly regulated industries, such as financial services, if the maximum benefits are to be obtained for society.
CHAPTER III

ALTERNATIVE MODELS TO BE USED IN THE
ANALYSIS OF ECONOMIES OF SCALE IN
THE SAVINGS AND LOAN INDUSTRY

As can be seen in the studies presented in the previous chapter some contradictions can be found between the results of different studies of economies of scale in thrift institutions. These differences can be attributed, in part, to differences in the sample data, differences in the variables and differences in the mathematical relationships used (i.e., the type of models used). It is therefore important to be very specific in defining these factors for any analysis. This chapter contains a presentation of various models to be evaluated for the savings and loan industry, and the variables to be included. The expected relationships among the variables are examined and specific hypotheses concerning the empirical results are developed.

In order to evaluate the variables included in these models it is first necessary to specify the objectives of this study. This study had two primary goals. The first was to estimate the shape of the LRAC curve for the savings and loan industry as a means of investigating the existence of economies of scale in the industry. The second goal was to analyze various factors that may influence the cost structure of savings and loans, and to determine how these factors may relate to economies of scale. To accomplish these goals 22 variables have been selected for use in the analysis process.
The variables selected for this study can be divided into four groups. First are the dependent variables, which represent alternative measures of costs. Second are variables which are related to the size of the association, which include the total assets, total net worth, the number of various types of accounts, and gross operating income. The third set of variables pertain to the internal structure of the association, which include the account structure of the association, as well as the number of employees and the number of branches. The final group of variables accounts for environmental factors, including local competition, and the population and median household income of the association's business area. Table 1 lists all of the variables and the notation used to represent each variable in the analysis.

The dependent variables used in regression equations in this study were total operating expenses and average operating expenses. Total operating expenses include the benefits, salaries and wages of association officers and employees, expenses incurred in the occupancy of the association's offices, advertising expenses, expenses due to federal insurance, audits and examinations, and the cost of real estate held for development or investment.\(^1\) Average operating expenses are calculated by dividing total operating expenses by the measure of size used as the independent variable.

The first group of independent variables are those related to size and output. These variables were used to estimate the shape of

\(^1\)This definition, and those for total assets, total savings, total net worth, total gross operating income, total cost of funds, come from the Federal Home Loan Bank Board, Management Information System, Semiannual Financial Report. For 1975 this included FHLBB Forms 775a, b, c and 775, revision October 1975, and for 1976 the December 1976 revision of these same forms.
## TABLE 1
LIST OF VARIABLES FOR ANALYSIS OF ECONOMIES OF SCALE IN THE SAVINGS AND LOAN INDUSTRY

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Operating Expenses</td>
<td>TOE</td>
</tr>
<tr>
<td>Average Operating Expenses</td>
<td>AOE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size and Output Variables:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Assets</td>
<td>TA</td>
</tr>
<tr>
<td>Total Savings Accounts</td>
<td>TSA</td>
</tr>
<tr>
<td>Total Net Worth</td>
<td>TNW</td>
</tr>
<tr>
<td>Number of Savings Accounts</td>
<td>NSA</td>
</tr>
<tr>
<td>Number of Loan Accounts</td>
<td>NLA</td>
</tr>
<tr>
<td>Total of Savings and Loan Accounts</td>
<td>TSL</td>
</tr>
<tr>
<td>Total Gross Operating Income</td>
<td>TGI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal Structure Variables:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage Change - Total Assets</td>
<td>CTA</td>
</tr>
<tr>
<td>Percentage Change - Savings Accounts</td>
<td>CSA</td>
</tr>
<tr>
<td>Percentage Change - Loan Accounts</td>
<td>CLA</td>
</tr>
<tr>
<td>Ratio of Savings Accounts to Loan Accounts</td>
<td>RSL</td>
</tr>
<tr>
<td>Ratio of Savings to Total Assets</td>
<td>STA</td>
</tr>
<tr>
<td>Total Cost of Funds</td>
<td>TCF</td>
</tr>
<tr>
<td>Average Savings Account Size</td>
<td>ASA</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>NE</td>
</tr>
<tr>
<td>Number of Branches</td>
<td>NB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Variables:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population of SMSA or County</td>
<td>POP</td>
</tr>
<tr>
<td>Median Income of SMSA or County</td>
<td>MDI</td>
</tr>
<tr>
<td>Number of S&amp;L's in SMSA or County</td>
<td>NSL</td>
</tr>
<tr>
<td>Number of Commercial Banks in SMSA or County</td>
<td>NCB</td>
</tr>
</tbody>
</table>
the LRAC curve, and as descriptive variables in the analysis of cost factors. Included in this group are total assets, total net worth, the number of savings accounts, the number of loan accounts, the sum of savings and loan accounts, and total gross operating income.

The use of total assets and total net worth as proxies for output has several advantages and disadvantages. The primary disadvantage was that these measures could not be directly related to output (i.e., those service operations which produce costs). For savings and loans the importance of this argument would depend on the amounts of non-earning assets included in the independent variable. These were usually significantly less than earning assets, and thus not terribly important. A related problem is that by grouping, an averaging effect takes place with respect to yield. This means that the "social value" of loans, as calculated by the yield, is treated the same for all loans. Such consistency would be unlikely and depends on the structure of the association's assets. The main advantage to using total assets or net worth is that these data were easy to obtain. Also, when most people think of the size of a financial organization, they think in terms of the size of its assets or net worth. These measures were included in this study for an additional reason. That is because they can be used as a basis of comparison for other measures in this group.

Total assets, as defined in this study, include a wide variety of accounts. All loans for housing, (including VA, FHA and conventional), housing improvement, education and mobile homes, are included. Investments in real estate and securities, cash, and fixed assets, such as

2George J. Benston, "Economies of Scale," p. 322.
offices, fixtures and equipment, prepayment to the Federal Savings and Loan Insurance Corporation, secured accounts receivable and goodwill are also included as total assets.

If economies of scale are present in this industry it should be expected that the total assets variable would have a negative coefficient. If the long run average cost curve has the "U-shape" common to economic theory, it would be represented by a quadratic rather than linear function with the coefficient having the signs appropriate to the "U-shape" as specified in the hypothesis below. The effect of total assets on average cost may be affected by the growth of assets. Policies of management which strive for higher rates of growth will tend to cause higher costs. Higher costs can be attributed to more expensive funds, required for an expanding loan portfolio, as well as for staff and other administrative components for the processing of these loans. On the other hand, a very small growth, or a decline, in the value of assets may indicate financial problems in the association, accompanied by higher costs. To take this effect into account a variable representing the percentage change in total assets can be included.

The statistical hypothesis implied above may be stated as follows, for a simple linear relationship between average cost and total assets the equation would be:

$$AOE = a_0 + a_1 TA$$

and the hypothesis of interest is: $H_0: a_1 = 0, H_1: a_1 < 0$. That is, the $a_1$ term is expected to be negative so a one-tailed test of significance is appropriate. For the quadratic function:

$$AOE = b_0 + b_1 TA + b_2 TA^2$$
The hypotheses are: \( H_0 : b_1 = 0 \) vs. \( H_1 : b_1 < 0 \) and \( H_0 : b_2 = 0 \) vs. \( H_1 : b_2 > 0 \).

The expected negative sign for \( b_1 \) and positive sign for \( b_2 \), appropriate to the "U-shape" curve, require the one-tailed significance tests implied by this form for the alternative hypothesis \( (H_1) \).

The value of total net worth should have a relation to average operating expenses similar to that of total assets. Total net worth includes treasury stock, surpluses, and reserves in the federal insurance fund. The statistical analysis of the functional relationship between average cost (AOE) and total net worth (TNW) is strictly analogous to that specified above for total assets.

The next three size variables (the number of savings accounts, the number of loan accounts, and their sum) may be considered superior to the previous two variables in some respects. This factor is a consideration because these variables may have a closer relationship to output and therefore to costs. The primary operations of a savings and loan consist of taking in savings and reinvesting them in loans. Costs are incurred in the processing of documents. Assuming that each savings account and each loan account have nearly constant activity, the cost of processing can be directly related to the number of accounts. There are two problems with this. First, like total assets this assumes all loans have the same "social value." Second, extremely high or low changes in the number of accounts may cause higher costs, similar to changes in total assets.\(^3\) The influence of such changes may be accounted for with the percentage change in the number of these accounts. The final measure

of size is total operating income. This includes interest on loans, service charges, income derived from real estate owned and invested, and other fees and charges (all before taxes and expenses). The main advantage of this measure is that it includes interest from all loans, and thus gives the sum of the "social value" of all association loans. Its main disadvantage is that it tends to overstate the output of larger associations. These measures of size should behave much like assets and net worth in influencing average operating costs. The statistical analysis and tests that are appropriate are therefore similar.

The next group of independent variables describe much of the internal structure of a savings and loan association. This group includes the percentage change for total assets, savings accounts and loan accounts, the ratio of savings accounts to loan accounts, the ratio of savings to total assets, total cost of funds, average savings account size and the numbers of employees and branches.

The use of the first three variables, percentage changes in total assets, savings accounts and loan accounts, has been discussed above. It is believed that very large or small changes in the number of accounts causes increased costs. A similar relationship may occur for total assets and total net worth. These variables can be said to represent management policies, since such policies are usually the cause of large changes in these variables. By including the appropriate variable, the higher expenses of units with unusually large or small changes in the output variable may be accounted for. If not accounted

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for, such units would tend to distort any absolute output level to operating expense relationship. Variables describing the change in assets, loan accounts and savings accounts were used with the variables of total assets, number of loan accounts and the number of savings accounts, respectively. In addition, the change in assets was used with the size variable for total net worth. This relationship was considered reasonable, since the amount of income for an S&L is primarily related to the size of its loan portfolio. It is expected that the change in net worth relative to the change in total assets will be negligible. For the variable representing the total number of savings and loan accounts, both the variable for the change in savings accounts and the variable for the change in loan accounts were used.

Because these variables describe changes which may be large or small, their definition and composition must be very specific. For this study, these variables represent the absolute value of the deviation from the mean of the percentage change of the variable it is related to, (i.e., total assets, number of loan accounts, etc.). The expected sign for the coefficients of these variables in multiple regression functions are positive. In other words, the greater the deviation, the greater the cost increase.

The next two variables, the ratio of the number of savings accounts to the number of loan accounts, and the ratio of savings to total assets, describe the balance sheet structure of the association. In the latter variable, total assets was used in place of the dollar value of outstanding loans. This substitution was considered legitimate since non-loan assets were a very small part of total assets, and this relation is assumed to be relatively common. Both ratio variables describe
essentially the same thing, except one does this in terms of dollars and the other in terms of numbers of accounts. By comparing results from these variables an indication of the relative measuring ability of dollar amounts of assets and liabilities, and the number of asset and liability accounts. It was expected that as an association obtains more savings it is able to make more loans with internal funds. Since the use of outside funds would not be required to as great an extent, the additional paperwork that such funds require would be lessened, meaning a decrease in costs.

The variable for the total cost of funds, (the cost of funds not being included in operating expenses), is directly related to this same phenomenon. Funds obtained externally will be more costly than those from savings collected. Therefore, the cost of funds should have an effect opposite to that of the savings to loan ratios, and should be positively related to costs.

The final variable used to describe the balance sheet structure of an association is the average size of savings accounts. From previous studies two possible arguments relating to the effect of this variable can be found. First, it has been argued that all accounts have the same intensity of activity, regardless of size, meaning that large accounts would generate the same amount of expenses as smaller accounts. This is not to mean that all accounts have the same dollar size transactions. Costs, especially in the case of savings accounts, are related to the number of transactions, not their size. Thus, two associations, with

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the same amount of savings or assets, one with larger accounts and one with a greater number of smaller accounts, would have different amounts of expenses. The association with the larger accounts would have lower expenses.

The second position is that larger accounts generate greater costs because of the special attention they receive. Larger customers of any financial organization will receive greater attention from the organization's officers than a smaller customer. This attention may include letters of credit, investment advice, or extra credit checks for loans, all of which generate additional costs.

The first of these positions seems most likely. Compared to commercial banks the services of savings and loan associations are more limited. For this reason it would seem unlikely that large investors, who would seek added services, would use savings and loan associations to a great extent. Therefore, it is expected that the variable is negatively related to average cost. This means that the larger the average size of the account, the lower the average cost.

The next descriptive variable is the number of employees in the association, including its home office and all of its branches. It is expected that the variable will have an inverse relationship to average costs. The reason for this is that as an S&L grows, its workers become more specialized. With specialization, workers with lower skill levels may be hired at lower wage rates. To illustrate this consider the small

7 Frederick W. Bell and Neil B. Murphy, Economies of Scale in Commercial Banking (Boston: Federal Reserve Board of Boston, 1967), p. 11.
S&L. The president, in addition to duties inherent in that job, must also act as the loan officer and may even have to open up new savings accounts. A larger association will have employees to handle such duties.

Branching is likely to have the opposite effect on costs. Individual branches will have duplicate services. For example, all branches must have facilities for the depositing of savings, making withdrawals and frequently have facilities for writing loans. Because of this duplication, plus problems of communication and coordination, higher average costs are likely to be present with additional branches. Thus, this variable should be expected to have a positive relation to average cost.

The obvious question is why add more branches if it may be expected to increase average costs. Additional branches allow an association to handle a greater volume of business. Economies of scale, which are derived from the increased output, are thought to more than cover the additional costs of branching. The validity of this will be tested in the empirical part of this study.

The last group of variables are those describing the environment in which the savings and loan association operates. In the statistical analysis they can be used to help control for external factors and therefore allow a better relationship between cost and size to be determined. The environment, as defined here, for urban associations is the Standard Metropolitan Statistical Area (SMSA) in which they are located. For non-urban associations the county in which it is located is considered

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8 Ibid., p. 9.
the appropriate external environment. Variables included in this group are population, median income, number of savings and loans, and the number of commercial banks.  

Changes in population or median income will cause a shift in the demand curve for all thrift institutions in the area. An increase in the population of the association's business area will mean that more savings are likely to be deposited and more loans are likely to be processed. Likewise, if median income increases, consumers will have more money to deposit or will decide to make purchases they have put off in the past. Decreases in either would cause the opposite effect, though probably to a lesser extent. Since greater demand should result in greater output, these variables should have a negative relation to average cost if economies of scale are present.

Variables for the number of savings and loan associations and the number of commercial banks measure the local competition of the individual S&L. It might be expected that increased competition would mean increased cost, particularly promotional costs. Studies of S&L's by Verbrugge and Shick, and credit unions by Keating, showed increased

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10 It is likely that if population shifts decrease the local population, that some of the departing users of the association will maintain active accounts after they leave. With respect to median income, consumer expectations will determine the decrease in demand for S&L services. If the decline is considered short term, then demand changes will be small. If longer declines are expected, then greater effects are likely to be felt.
competition brought greater efficiency and profitability. It seems, brings out the best in management. Since increases in competition can be related to reductions in cost, these variables may be expected to be inversely related to average cost. In other words, increased competition would mean lower average costs.

Although specific regression functions to be estimated and hypotheses to be tested were stated explicitly for the first sets of variables, similar statistical analysis is implied for all the relationships discussed above. There are various alternative mathematical forms that could be estimated, but the most promising are multiple linear regression, polynomial curve fitting, and multiple multiplicative regression functions. The multiple linear regression function, which assumes a linear relationship between variables, and the multiplicative multiple regression function, which assumes a non-linear relationship, will be used for evaluating possible cost related factors of S&L's. The polynomial curve fitting function will be used to estimate the LRAC curve. These functions will be used in this study in the following general forms:

Multiple linear regression function,

\[ AOE = a_0 + a_1 x_1 + a_2 x_2 + \ldots + a_n x_n \]

Multiple multiplicative regression function,

\[ AOE = b_0 \cdot b_1 \cdot b_2 \cdots \cdot b_n \]

Polynomial curve fitting function,

\[ AOE = c_0 + c_1 x_1 + c_2 x_1^2 + \ldots + c_n x_1^n \]

---

The first of these forms, multiple linear regression, is also the basis for the statistical estimation of the other two forms. It assumes that the relationship between each independent variable and the dependent variable is linear, and that the linearity of the relationship holds for the range of data in the sample used. Outside that range projections can be made with uncertainty increasing with the distance from that range.

The coefficients of the variables in this equation can be considered the marginal value, or slope, of the variable. In other words, if one unit of the independent variable were added, all other independent variables held constant, then the value of the coefficient of the changed variable would be added to the dependent variable. This fact is important in the evaluation of various cost factors. The value of the coefficient(s) of the size variable(s) can be used to determine the presence of economies of scale.

The second form of regression equation is a derivation similar to the Cobb-Douglas type of production function. The relation has several basic assumptions which were presented in the previous chapter of this study. To quickly review, these were; exogenously determined output, cost minimization employed by management, and all units in the sample have the same technology.

To utilize the Cobb-Douglas type relation, the logarithm of all variables is calculated, which allows an equation to be estimated in the form of the multiple linear regression equation, and transformed back to the multiplicative form. The coefficient of the logarithm of the variables is the power to which they are raised in the multiplicative equation. They represent the elasticity of the dependent variable relative to their
independent variable. Elasticity is defined as:

$$E_i = \frac{\partial Y}{\partial X_i} \frac{X_i}{Y}$$

For a multiplicative function the elasticities are constant and equal to the exponent of each independent variable (the $b_i$ terms). If economies of scale do exist, then the coefficient of the logarithm of the size variable (or the exponent of the size variable) should be a number less than one in the total cost equations or less than zero in average cost equations.

The final type of statistical relationship to be evaluated (a polynomial function) uses a series of functionally dependent, independent variables. By functionally dependent it is meant that each term in the relationship is a function of the same variable. For this type of relationship to work the function must be non-linear. As used in cost equations, each functionally dependent variable is a power of the size variable. Previous studies of cost equations have indicated that the quadratic form is the most valuable for average cost equations, and the cubic form is the best for total cost equations.\(^{12}\) This type of equation will be used to determine the shape of the LRAC curve, as well as the shape of total cost curve. It is well suited for this purpose, as it is particularly sensitive to the measure of size or output used.

In addition to regression analysis techniques, the frontier frame method was used to estimate the shape of the LRAC curve. To understand the concept of the frontier frame method it is necessary to review the LRAC curve.\(^{13}\)


The LRAC curve represents the minimum average costs which may be attained by producing units at various rates of output. By comparing the average costs of producing units relative to each other, and the LRAC curve, the units relative efficiency can be determined. Efficiency, as used here, may be divided into two parts, technical and operational. Technical efficiency is a function of the unit's minimum attainable costs (its LRAC curve position). The unit's operational efficiency is a function of its actual costs in relation to its minimum attainable costs (its distance above the LRAC curve).

These concepts may best be illustrated in Figure 3. In this figure, unit B has greater technical efficiency than unit A. Unit B's output level, when related to the LRAC curve, produces a lower minimum cost than unit A's, therefore it is more technically efficient. Unit C has less operational efficiency than unit B. This is indicated by C being a greater distance from the LRAC curve. But, C is more technically efficient than A, since if it were operated more efficiently C could attain lower costs.

By using these definitions the frontier frame method can estimate the LRAC curve. It does this by connecting the points representing the lowest cost units with line segments. Units with higher average costs are not taken into account, since they are obviously operationally inefficient. The curve constructed from these line segments is an estimate of the LRAC curve. In other words, the line segments connecting the lowest costs attained by units in the sample estimate the lowest attainable costs for the population (the LRAC curve).

This method is believed to provide a closer estimate of LRAC curves, because it does not average in units which are obviously
Fig. 3.—LRAC Curve and Relative Unit Efficiency

SOURCE: Adapted from R. Alton Gilbert and Lionel Kalish, III, "An Analysis of Efficiency of Scale and Organizational Form in Commercial Banking," *The Journal of Industrial Economics* 21 (July 1973): 293, Fig. 1.
inefficient. With averaging, units of lower efficiency are allowed to
effect the shape and position of the LRAC curve. Their influence can
lead to greater error in the estimate, since the LRAC, representing the
minimum attainable average costs, must include or be below the lowest
average cost units of the sample. Thus, by not including them, the
frontier frame method should provide a closer estimate of the LRAC
curve.
CHAPTER IV

EMPIRICAL RESULTS

The next step is to analyze relationships among the variables that were presented in the last chapter. The empirical results of the analysis are presented in this chapter. Included are background information on the data used in this study, and the results from regression analysis and frontier frame operations. These results are divided into two sections and are divided along the lines of the goals of this study. Results which concern the shape of the LRAC curve, including regression analysis and frontier frame results, are presented first. Analysis of cost factors and a discussion of the variables and mathematical relationships is included in the final section.

Data

Data were obtained from savings and loans (S&L's) in the Twelfth Federal Home Loan Bank Board District. This includes Idaho, Montana, Oregon, Utah, Washington, and Wyoming. Alaska, Hawaii, and Guam are also part of the twelfth district, but are not included because of economic and demographic differences which make them atypical. The area from which data were gathered currently has 128 S&L's.

The data were collected through the use of a questionnaire sent to the active S&L's. Data were requested on total assets, savings

\[1\]

\[1\] Copies of the forms utilized in the survey are provided in the appendix.
accounts, total net worth, total gross operating income, total operating expenses, and the total cost of funds for the years 1975 and 1976. This information was obtained from the FHLLB Semiannual Reports for those years. The questionnaire also requested information on the numbers of savings accounts, loan accounts, branches and employees. Additional information was obtained on the median income (median household effective buying income, HEBI), population, and the numbers of competing S&L's and commercial banks.

The initial mailing was made in the last week of December 1976 to all active S&L's. A second mailing was made during the first week of February to those S&L's which had not replied. The result of the two mailings was a sample of 86 sets of data or 67 percent of the active S&L's in the survey area.

The survey is considered to be a good basis for analysis for several reasons. First, the returns were fairly evenly distributed over

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2 This report is made on FHLLB Forms 774a, b, c and 775, Revision October 1975, for 1975, and on the December 1976 revisions of these forms for 1976. These forms include year-end values of total assets, savings accounts, and total net worth. Figures for total gross operating expenses, total gross operating income, and the total cost of funds, were for the last six months of the respective years. To compensate for this, these values were doubled. This procedure was considered acceptable since comparisons of statistics which used this data, to similar statistics from another source showed only minor differences. For the alternate source see: United States League of Savings Associations, 1976), n.p.

all the states included in the survey. Second, the sample covers a wide range of sizes. Total assets, for example, ranged from under $2 million to over $1 billion. Finally, comparisons of the sample with statistical information on the twelfth district from other sources shows only minor differences.⁴

**LRAC Curve Determination**

This section presents the results of statistical analysis to determine the best indicator of output for savings and loans, and to determine the shape of the LRAC curve using this measure. Six measures of output were used in this analysis, including total assets, value of savings accounts, total net worth, total gross operating income, the number of savings accounts, the number of loan accounts and the sum of loan and savings accounts. These measures will be evaluated by regression analysis techniques (curvilinear regression equation), and the frontier frame method. Separate analyses were run for the data for the years 1975 and 1976, and for the difference between these years.⁵

Regression analysis techniques were used to estimate total cost equations, and gave similar results for all measures of output. R-squared

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⁴United States League of Savings Associations, *Significant Ratios 1975* (Chicago: United States League of Savings Associations, 1976), n.p. Comparisons were made between decile values in this publication and for the sample, for operating expenses as a percentage of operating income and savings accounts as a percentage of total net worth. Median values were found to be extremely close, though the sample showed greater dispersion.

⁵The difference between the data for the two years was evaluated in hopes that the relationship between the measure of output and operating expenses is more direct. In other words, less bothered by carry-over costs.
values ranged from .46 to .62 for significant equations. The form of the significant equations was either linear or cubic. In only 3 of 38 regressions were quadratic forms significant. Along with the small variation between the equation forms, there was also variation between R-squared values of equivalent equations for the two years. The effect of this difference is minimized, since the difference remains relatively constant for all equation forms. Differences may be attributed to general economic conditions and other unaccounted for factors which changed between the two years.

In addition to the output variables, a branching variable (NB) was evaluated with each of the equation forms, (i.e., linear, quadratic, cubic). It was included because of the higher costs inherent in branching, which is not of interest in LRAC computations, and therefore should be isolated. The significance of this in LRAC curve computations is that larger units are more likely to have branches, and isolating the effect of branching would probably lower average costs on the high output end of the LRAC curve. It is especially important in this sample because the average number of branches was 4.31 in 1975 and 5.04 in 1976. In almost all of the results the branching variable was found to be significant and its inclusion improved the R-squared value of the output measure and equation form.

In comparing the results of the various measures of output as a predictor of total operating expenses (TOE), total assets (TA) was found

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6 Significant equations must pass three tests in this study. First, the individual components of the equation must pass the t-test at the 95 percent confidence level. Second, the entire equation must have a F statistic that is acceptable at the 95 percent confidence level.
to be the best. It has several attributes which make it superior to other indicators evaluated in this study. First, the R-squared values were consistently among the highest for each equation form and for each year. Second, the equation forms for which it was significant were in line with past studies. Finally, it was most consistent between 1975 and 1976 data.

For total cost equations, utilizing total assets as a measure of output, the greatest R-squared was found in the cubic form, with the branching variable. This equation had an R-squared value of .60 for 1975 and .57 for 1976. These are presented as equations 1 and 2 respectively.

\[
(1) \quad \text{TOE} = -0.0995 + 0.0238TA - (6.153 \times 10^{-5})TA^2 + (-0.244)(2.8354)(-2.3678) \\
(5.359 \times 10^{-8})TA^3 + 0.1916NB (2.6253) (2.693)
\]

\[
(2) \quad \text{TOE} = -0.0768 + 0.0268TA - (6.062 \times 10^{-5})TA^2 + (-0.134)(2.7715)(-2.3071) \\
(4.724 \times 10^{-8})TA^3 + 0.1771NB (2.6188) (2.1271)
\]

Where: \[\text{TA} = \text{total assets in millions of dollars}\]
\[\text{TOE} = \text{total operating expenses in millions of dollars}\]

The number in parentheses below the coefficients is the t-ratio of that coefficient. It should be noted that the value of approximately 1.98 is the 95 percent confidence level for 86 cases. Figure 4 gives the graphical representation of equations 1 and 2 for units without branches. As can be seen, the curves have segments of steadily increasing costs at

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7In both 1975 and 1976 the intercept value has an extremely low t-value. Additionally, it causes the results to be inconsistent with past studies and economic theory. For these reasons it is not used in the following figures and calculations.
Fig. 4.—Total Operating Expenses versus Total Assets, 1975 and 1976.

NOTE: Regression Equations
1975: TOE = 0.02386TA - (6.153 x 10^-3)TA^2 + (3.599 x 10^-5)TA^3 + 0.1932
1976: TOE = 0.02689TA - (6.062 x 10^-3)TA^2 + (4.726 x 10^-5)TA^3 + 0.1771

NOTE: NB = 0
both the high and low output ranges, and a middle range of nearly constant costs. This shape is typical of total cost curves.

From the total cost equation, average cost equations can be easily derived by dividing the total cost relation by the unit of output. This procedure yields equations 3 and 4.

\[
(3) \quad AOE = 0.0238 - (6.153 \times 10^{-5})TA + (5.359 \times 10^{-8})TA^2 + 0.1916NB/TA
\]

\[
(4) \quad AOE = 0.0268 - (6.062 \times 10^{-5})TA + (4.724 \times 10^{-8})TA + 0.1771NB/TA
\]

Figure 5 presents a graphical representation of equation 3 and Figure 6 presents equation 4.

Both equations have the characteristic "U-shape." Because of this there is a single minimum cost point, the MOS. The value of the MOS can be found by taking the first derivative of the LRAC equation and equating this to zero. The procedure yields a MOS of $574 million in total assets for 1975 and $641 million for 1976. For both years the range of outputs less than the MOS show considerable economies of scale. For an output of one-half the MOS the average costs are nearly 70 percent higher. Units with total assets of less than $35 million exhibit even greater economies of scale. In the range of outputs greater than the MOS, for both years, considerable diseconomies of scale were found. For a unit with total assets of twice that of the MOS, 75 percent higher costs were found. Since there are few units with assets of this size, this portion of the curve may be less accurate.

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8The MOS is defined as the smallest level of output that will allow the S&L to obtain minimum average costs. This may be a minimum cost point, or the lowest output of a range of outputs with the same minimum costs. See Roger Sherman, The Economics of Industry, p. 242.
Fig. 5.—Average Cost versus Total Assets, 1975.

NOTE: Regression Equation
1975: \( \text{AOE} = -0.0238 - (6.255 \times 10^{-5})\text{TA} + (5.359 \times 10^{-8})\text{TA}^2 + 0.1916 \text{N/T} \)

NOTE: N/B = 0

NOTE: Frontier Frame Critical Points—See Table 2
Fig. 6.—Average Cost versus Total Assets, 1976.

NOTE: Regression Equation
1976: AC = -0.0268 - (0.062 x 10^-3)TA + (0.724 x 10^-8)TA^2 + 0.1773 NA/TA

NOTE: NA = 0

NOTE: Frontier From Critical Points — See Table 3
In Figures 4, 5, and 6, the value of the branching variable was zero. For units with branches an additional fixed cost must be added. This amounted to $191,600 in 1975 and $177,100 in 1976. Since this is a fixed cost, its effect on the average cost equations varies with output. In spite of this, two important points can be made. First, certain economies of scale are present since branches come in discrete units. Full capacity for the branch, with total assets as the measure of output, is the amount of total assets which the branch is designed to process. Full capacity minimizes the value of additional average costs accounted for in the branching term. Second, if the S&L wishes to minimize average cost increases due to branching, it should only add branches when the expected percentage increase in assets is greater than the percentage increase in the number of branches. The decision must also be considered in light of the company's position on the LRAC curve.

The frontier frame method can be used to derive the LRAC curve directly from the sample data. Results obtained from the frontier frame are illustrated in Tables 2 and 3, and in Figures 5 and 6. Tables 2 and 3 give the critical points of the resulting curves. These points represent units which have minimum costs for their respective level of output, and therefore are located on the frontier curve. The slopes between adjacent critical points are also presented in Tables 2 and 3.

As can be seen in Figures 5 and 6, the LRAC curve derived by this method is considerably different from that derived by regression analysis techniques. The curve is "U-shaped," but has different slopes for high and low levels of output, and a much smaller MOS. The value of the MOS is $14 million in total assets for 1975 and $16 million in 1976. The value of MOS in 1976 was not the minimum cost point, as it was in
TABLE 2
CRITICAL POINTS FOR THE FRONTIER FRAME OF TOTAL ASSETS VERSUS TOTAL OPERATING EXPENSES - 1975

<table>
<thead>
<tr>
<th>Critical Point Number</th>
<th>S&amp;L Relative Position*</th>
<th>Total Assets (Dollars)</th>
<th>Average Operating Expenses (Dollars)</th>
<th>Slope**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1,008,180</td>
<td>.147769</td>
<td>-1.36 x 10^{-7}</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1,875,250</td>
<td>.029822</td>
<td>-1.80 x 10^{-9}</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>13,970,500</td>
<td>.007081</td>
<td>9.84 x 10^{-12}</td>
</tr>
<tr>
<td>4</td>
<td>84</td>
<td>299,954,000</td>
<td>.009897</td>
<td>9.99 x 10^{-12}</td>
</tr>
<tr>
<td>5</td>
<td>85</td>
<td>644,433,000</td>
<td>.013338</td>
<td>1.49 x 10^{-11}</td>
</tr>
<tr>
<td>6</td>
<td>86</td>
<td>995,196,000</td>
<td>.018568</td>
<td></td>
</tr>
</tbody>
</table>

*Ranking of S&L's in the sample is relative to asset size. One is the smallest.

**This is the slope between adjacent critical points.
TABLE 3

CRITICAL POINTS FOR THE FRONTIER FRAME OF TOTAL ASSETS VERSUS TOTAL OPERATING EXPENSES - 1976

<table>
<thead>
<tr>
<th>Critical Point Number</th>
<th>S&amp;L Relative Position*</th>
<th>Total Assets (Dollars)</th>
<th>Average Operating Expenses (Dollars)</th>
<th>Slope**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1,094,500</td>
<td>.146224</td>
<td>-7.84 x 10^{-8}</td>
</tr>
<tr>
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<td>2,475,820</td>
<td>.037867</td>
<td>-4.70 x 10^{-9}</td>
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<tr>
<td>3</td>
<td>4</td>
<td>5,792,000</td>
<td>.022011</td>
<td>-1.30 x 10^{-9}</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>16,345,400</td>
<td>.007568</td>
<td>-1.22 x 10^{-12}</td>
</tr>
<tr>
<td>5</td>
<td>79</td>
<td>177,983,000</td>
<td>.007370</td>
<td>1.24 x 10^{-11}</td>
</tr>
<tr>
<td>6</td>
<td>84</td>
<td>354,632,000</td>
<td>.009560</td>
<td>1.32 x 10^{-11}</td>
</tr>
<tr>
<td>7</td>
<td>85</td>
<td>740,425,000</td>
<td>.014650</td>
<td>1.71 x 10^{-11}</td>
</tr>
<tr>
<td>8</td>
<td>86</td>
<td>1,137,910,000</td>
<td>.021450</td>
<td></td>
</tr>
</tbody>
</table>

* Ranking of S&L's in the sample is relative to asset size. One is the smallest.

** This is the slope between adjacent critical points.
1975. Rather it is the point at the low output end of a segment with a very small negative slope. This slope is so small that average costs are relatively constant, and any economies of scale are negligible. For both years, the output levels which are greater than the MOS show diseconomies of scale that are significantly less than those of regression equations. For example, in the regression equations costs are 75 percent higher at twice the MOS. In the frontier frame cost curves, costs are 75 percent higher at 40 times the MOS. At output levels less than the MOS, the frontier frame indicates considerably greater economies of scale. Costs are 2.25 times greater at outputs of 50 percent of the MOS. Between critical points 1 and 2 the cost disadvantage is much greater. But, since there are few units this small the significance of this curve segment is lessened.

Much of the difference between the frontier frame and the regression curves were due to the differences in the techniques. The frontier frame utilizes only the minimum cost units of the sample, while regression analysis techniques average all of the units in the sample. Thus, for the medium cost range, $10 million to $130 million in total assets, where the bulk of the sample is located, the frontier frame will indicate lower costs. Another reason for the difference is that regression technique can isolate the effect of branching. The frontier frame is not able to do this. Thus, for the frontier frame small critical point units are less likely to have branches, while larger units probably do have branches. This would cause some curve distortion.

In attempting to choose the better of these curves it is obvious

9 Ibid.
that neither is the best for the entire range of outputs. The value of
the MOS, and output levels that are greater than this value, are likely
to be closer to those indicated by the frontier frame. This is due to
the bulk of the sample being to the right of the MOS where there are
only minor diseconomies of scale. For the regression equation the bulk
of the sample lies a considerable distance to the left of the MOS, where
there are considerable cost disadvantages. In addition, the multitude
of points at lower output levels have the greatest effect on the shape
of the regression derived LRAC curve. In doing so they dilute the effect
of the larger units on the high output end of the curve. The frontier
frame does not have this problem, since individual points are independent
of each other.

For output levels less than the MOS, the shape is probably more
like that indicated by the regression equations. Frontier frame results
in this segment are affected, to an extent, by the lack of sample points.
The lack of points makes it susceptible to units with extremely high or
low costs. If critical point 1, for both years, is omitted the frontier
frame will give similar results to the regression equations.

As noted earlier, total assets were considered to give the best
results of any of the indicators of output that were included in this
study. The total number of accounts, TSL, was the next best indicator.
The R-squared values attained by this measure were very close to those
for total assets. This regression was rejected since the variation be-
tween coefficients of the same terms in the equations for 1975 and 1976
was greater than that of total assets. Total assets is also slightly
better qualitatively. Total assets are comprised mainly of loans, the
principle output of S&L's. The number of accounts consists of savings
accounts and loan accounts, of which loans are less than half the total in most cases.

The number of savings accounts (NSA) produced R-squared values nearly as large as those produced by the total number of accounts, TSL. It was rejected on qualitative grounds, since the output of S&L's can be attributed more closely to its loan rather than its savings function. Thus making TA and TSL superior in this sense.

The total number of loans, while considered a better variable qualitatively, was rejected on quantitative grounds due to low R-squared values. These values were generally lower than those produced by previously mentioned variables. These differences were as great as .08.

Total net worth, TNW, like total assets measures the size of the organization in terms of dollars, rather than numbers of accounts. It produced R-squared values quite close to those of total assets, but was considered a poor substitute qualitatively, since its relationship to loans is tentative.

Total gross operating income is considered one of the poorest measures, since the results from its use tend to be in conflict with the results of other measures and accepted economic theory. This measure produced the highest R-squared values, (in excess of .6 in most cases), but its total cost equations were only significant in the linear and quadratic forms. The latter made it different from the other measures which rejected quadratic forms and accepted cubic forms.

The least preferable measure was the total value of savings accounts. Its R-squared values were considerably less than those of other measures. In addition, the significance of various forms of equations using this measure varied drastically from year to year.
Frontier frame curves were drawn for all of these measures for both 1975 and 1976. Even though the regression analysis equations varied considerably between the various measures and years, the frontier frame curves all had the same general shape. Like that of total assets, the curves indicated extremely large economies of scale at outputs less than the MOS. Also, the MOS is at a relatively low output and it is followed by a large range of minor diseconomies of scale. Some of this consistency may be attributed to the fact that the same units (S&L's) contributed in many of the curves, and the interrelationships of the measures of output in accounting notations. This consistency may also indicate that this method is relatively insensitive to the measure of output utilized. In any case, this is indicative of the validity of this shape of the LRAC curve.

In addition to the variables, two other assumptions were tested and rejected. The first was the change in output, from 1975 to 1976, regressed against the change in operating expenses. It was thought that using the differences in output and expenses would result in a closer relationship between these inputs and outputs. This was expected since carry-over costs would be minimized and probably cancel out. This relationship could not be substantiated. The R-squared values were relatively low, ranging from .07 to .26, and were significantly less than values from less tentative methods.

Included in some of the difference equations were percentage change variables; CTA, CLA and CSA, for total assets, the number of loan accounts and the number of savings accounts respectively. The significance of these variables varied. In general they were found to be insignificant at the 90 percent confidence level. Their t-values were usually
much less than one. For this reason these variables were not included in the cost factor section of this study. On the other hand, frontier frame curves using differences were reasonable. In all cases they exhibited the same general shape as was noted earlier.

Attempts to derive the average cost equation directly, using regression techniques, were also unsuccessful. The same measures of output, as used in total cost equations, were utilized. The regression process used various forms of the following equation:

\[ AOE = a + \frac{b}{Q} + cQ + dQ^2 + eQ^3 + fNB \]

The maximum R-squared values attained were approximately .3. The reason for the lack of success here is not known, but may be due to the inter-relationships of the variables involved. Specifically, the use of the output measure as a component of the dependent variable, as well as an independent variable may have influenced the statistical results.

Cost Factor Analysis

The analysis of various cost factors which may affect savings and loans was accomplished with regression analysis techniques. The equation forms evaluated were the multiple linear regression equation and the multiple multiplicative regression equation. Variables which were evaluated include; total cost of funds, the ratio of the number of savings accounts to the number of loan accounts, the ratio of savings to total assets, average savings account size, the number of employees, and the number of branches. Environmental variables (median income, population, the number of S&L's and the number of commercial banks) were also included. These variables and equations were evaluated for both 1975 and 1976.
Total assets was used as the measure of output, because it was found to be the superior indicator of output in LRAC estimations. It was considered the best of the measures for several reasons, including consistently high R-squared values, its consistency with past studies and its consistency between the two years evaluated.

Both the linear multiple regression equation and the multiple multiplicative regression equation were evaluated in a similar manner. This method was to regress total assets and one other independent variable, against the dependent variable. This procedure was repeated until all of the independent variables had been used. Each of the independent variables was evaluated with respect to the R-squared value of the equation in which it was included, and intercorrelations with other independent variables. The variables selected by these criteria were then permanently included in the equation, and the process was repeated with the remaining variables.

The results of analysis varied between the two forms of the regression function, (i.e., linear and multiplicative). For this reason the analysis of these forms must be on an individual basis.

Significant results were obtained from the multiple linear regression equation with up to four independent variables. The resulting equation for 1976 had an R-squared value of .58 (and the F-ratio and t-values of individual coefficients were significant at the 90 percent confidence level), and was in the following form:

\[
(5) \ TOE = 3.2678 + 0.01675TA + 0.1559NB - 1.3456 \times 10^{-6} \text{POP} - 2.1749 \\
3.1195\text{STA} \\
(-1.7302)
\]

(The values in parenthesis are the t-values of the coefficients)
Where: TOE = Total operating expenses in millions of dollars
TA = Total assets in millions of dollars
NB = Number of branches
POP = Population of the SMSA or county
STA = Ratio savings to total assets

In the 1975 computations the variable STA was found to be insignificant resulting in equation 6. This form attained an R-squared value of .58 with the same significance noted in equation 5.

\[
(6) \quad \text{TOE} = 0.52277 + 0.013526\text{TA} + 0.18111\text{NB} - (8.7755 \times 10^{-7})\text{POP} \\
(1.748) \quad (6.1992) \quad (2.841) \quad (-1.8934)
\]

These equations utilize few of the existing variables, but the variables that are used come from each of the variable groups; size and output, internal structure, and environment.

The addition of other variables was impossible if the established level of significance (95%) was to be maintained for individual coefficients. This was due, in most part, to the high intercorrelation of the independent variables. For example, the total cost of funds, showed a very high t-value, but due to its high level of correlation with total assets, it could not be included without making the total assets term insignificant. Intercorrelations between variables is discussed to a greater extent with the individual variables involved.

The first variable to be added was NB, the number of branches. This variable was found to be highly significant in all equations in which it was included. Its t-value ranged from a low of 1.5 to over 3.0. Its coefficient was positive, indicating greater costs for branching, as was expected.

The second variable to be included was the population of the county or SMSA in which the S&L is located. This variable tended to be
less significant than NB, with t-values averaging slightly less than 2.0. The coefficient of this variable was quite small, about $10^{-7}$, and was always negative. This means, if two S&L's of equal assets, and an equal number of branches, were to exist in two cities of different populations, the S&L in the larger city would have slightly lower total operating expenses. Further, since they are of equal assets, the S&L in the larger city would have a lower average operating expense. This was the expected result.

The variable POP was quite highly correlated with the variable NSL, the number of S&L's in the county or SMSA. Correlation coefficients of this relationship ranged from .8 to .9. It should be noted that a similar relationship with NCB, the number of commercial banks, did not exist. This relationship is as expected, since most towns, regardless of size, have at least one commercial bank. Savings and loans tend to be located in larger communities, where there is greater demand. This is necessary because of the more specialized function of savings and loans compared to banks.

The variable representing the ratio of savings to total assets was only significant for 1976, and then at the 90 percent confidence level. As expected, STA had a negative coefficient in the regression equation. The negative sign would mean that as the amount of savings were increased relative to the amount of assets, more internal financing would be possible, meaning lower costs. The significance of this variable was not established in 1975, probably due to the instability of the economy in that year, which tended to distort the external fund requirements of S&L's.

STA was found to be intercorrelated with ASA, average savings.
account size, with coefficients of correlation ranging from .8 to .9. This relationship could indicate that as average account size grows the ratio of savings to total assets would also increase.

The multiplicative relationship differs from the linear relationship in the number of variables included, the variables that are included, and in the value of the R-squared term. In general, the results of this equation form were not as good. The exception to this was the relatively high R-squared values.

A major problem with this relationship, as it was with the linear relationship, was the intercorrelation of variables. The effect of intercorrelation severely hampered the inclusion of additional variables. In addition, there was considerable variation between the results of the two years.

The effect of these problems was quite obvious when reviewing the results. No variable was significant in both 1975 and 1976. Further, the maximum number of independent variables included was two. Additional significant variables tended to have a negative effect on previously included variables. Equations 7 through 10 give the only significant equations found for the multiplicative form. The R-squared value for the relationship, the year of the data, and the t-value of the exponent (in parentheses), are also indicated.

\[(7) \ TOE = (5.902 \times 10^{-4})TA^{-5.51}TCF^{3.19} \quad R^2 = .71068 \]

Where: \( TA \) = Total assets in millions of dollars  
\( TOE \) = Total operating expenses in millions of dollars  
\( TCF \) = Total cost of funds in dollars
The value of the exponent of the size variable, TA, is an indicator of the presence of economies of scale. Economies are present if the exponent is less than one, and are enhanced as the value goes to zero. As can be seen there is a wide variation in the value of this term. This variation can possibly be explained by noting the strength of the relationship between the independent variable, the stronger the relationship the smaller the exponent of TA. Both NE and TCF have relatively high correlation coefficients when associated with TA, thus small values. In equations 8 and 9, STA and ASA showed relatively little correlation with TA and therefore TA has a larger exponent. The exponents in these cases, about .87, are probably the better indicator of the strength of economies of scale in the savings and loan industry.

It was also found that the behavior of additional independent variables varied greatly. For that reason these variables were analyzed individually. The total cost of funds variable (TCF) reacted as expected in regression equations, (i.e., it was positively related to total operating expenses). This would mean higher cost funds do require additional operating expenditures, even though the cost of funds was not included in operating expenses. But, this relationship only held for 1976. In
1975 the relationship was insignificant at all levels, with t-values ranging from -.6 to .32. The reason for this is probably the same as was noted for STA in the multiple linear regression equation, the instability of the economy.

While the t-values for TCF in 1976 were significant for a variety of combinations of variables, equation 7 was the only significant relationship. TCF was found to have a high value of positive correlation with total assets. Additionally, it was found to have a high positive correlation with NE, which was found to be the best independent variable after the first run. Inclusion of TCF on subsequent runs could only be made at the detriment of TA or NE. Positive correlation of TCF and TA can be accounted for, since additional assets, in the form of additional loans, would probably require increasingly more expensive external funds. Its relationship with the number of employees is more indirect. It can be explained by noting that the number of employees is also highly correlated with total assets, with correlation coefficients of .9 or greater.

This variable was not included in the multiple linear regression equation. It was rejected in that procedure due to its effect on the t-values of TA. But, the results it produced in the linear relationship gave results, t-values and intercorrelation, similar to those found in the multiplicative relationship.

Equation 8 uses the ratio of savings to total assets as an additional independent variable. Its sign and t-value and intercorrelation with other variables, differs little from the results of the multiple linear regression equation. For that reason no further analysis is presented here.

Average savings account size (ASA) was significant in only one
instance and that is equation 9. Its t-values were quite small in both multiple linear and multiplicative relationships. The sign of the coefficient varied from positive to negative from one year to another and between various equation forms. For these reasons, equation 9 can be considered atypical, and ASA to be insignificant.

The number of employees (NE) was found to be the best independent variable on the first run, with an R-squared value of .781. The large R-squared term is even more unusual because of the high correlation, .9, between NE and TA. This relationship may be the reason for the 1976 regression equation being insignificant, since inclusion of NE in that equation gave a very small t-value for the coefficient of TA. The only explanation for this is that the number of employees and the size of assets would both be positively correlated to size, and therefore tend to complement each other.

The results of NE from the regression equations was as expected. It was presumed to have a positive coefficient and indicate the use of lower cost labor for more specialized jobs in larger associations. If both sides of equation 10 are divided by NE, then NE becomes inversely related to average operating expenses per employee. Thus, the addition of an employee reduces the average cost per employee and would tend to support the original hypothesis.

The multiple linear regression equation did not include NE. It was excluded due to its high correlation with total assets and the number of branches. Both TA and NB were included in the second and subsequent runs in the linear equation, making NE insignificant as an additional independent variable.

Population and the number of branches were included in the linear
relationship, but rejected in the multiplicative relationship. They were rejected because they were inconsistent with respect to sign, and usually insignificant. T-values for these variables had a wide range of values, both positive and negative in multiplicative equations. In any case, population was again found to be highly intercorrelated with the number of savings and loans.

In addition to the variables included in one or both of the regression equations, four variables were completely rejected. These variables were, the ratio of the number of savings accounts to the number of loan accounts (RSL), median income (MDI), the number of savings and loans in the SMSA or county (NSL), and the number of commercial banks in the SMSA or county (NCB).

RSL was rejected because of low t-values, which made it statistically insignificant. It was noted in Chapter III that STA and RSL describe similar relationships. The difference being that RSL uses the number of asset and liability accounts, while STA uses the dollar values of these accounts. Since STA was found to be significant for both equation forms, dollars would seem to be the superior measures of internal characteristics.

Median income was rejected for both model forms because of inconsistent and insignificant t-values. These values varied widely in value and in sign, making it impossible to estimate the effect of this on S&L's.

The measures of local competition faced by the individual S&L, NCB and NSL, were both found to be poor descriptive variables. In multiple linear regression equations both variables had low t-values, usually less than one, and were inconsistent with respect to sign.
These variables reacted slightly better in the multiplicative relationship. NSL had a negative coefficient in most regressions in which it was significant. The negative sign was as expected, since it was hypothesized that greater competition meant greater efficiency and decreased costs. NCB was also significant in multiplicative relationships, but like NSL, caused the total assets variable to become insignificant. Unlike NSL, NCB had a positive coefficient when it was significant. This sign is the opposite of what was expected and may indicate a significant difference in how the management of an S&L handles competition from commercial banks and savings and loans, or that the banks dilute the market forcing firms (S&L's) to higher costs at outputs less than the MOS.

The variables were intercorrelated with each other and, as noted earlier, NSL is intercorrelated with population. The result of these two relationships is that savings and loans seem to be located in areas of high demand, unlike commercial banks which are located nearly everywhere.

In conclusion, a large amount of information was produced by this analysis. It was found that total assets was the best measure of output in describing the shape of the LRAC curve. Use of total assets showed the LRAC curve to be "U-shaped" for both regression analysis and frontier frame methods. The regression results showed great economies of scale at low outputs and large diseconomies of scale at high outputs. Frontier frame results showed large economies of scale at low outputs, but only minor diseconomies at higher outputs. The true LRAC curve is believed to be a combination of both.

In the analysis of cost factors the results were generally as
expected. Both the multiple linear regression equation and the multiplicative equation were restricted in the number of independent variables that could be included. This was due in part to the high levels of inter-correlation between independent variables. Finally, the variables that were significant varied between model forms and over time.
CHAPTER V

RECOMMENDATIONS AND CONCLUSIONS

This chapter analyzes the empirical results in light of real world operations and the limitations of this study. As in previous chapters, the results are analyzed in two parts. The first covers the determination of the LRAC curve shape of the savings and loan industry, and the resulting economies of scale and branching factors. The second half is used to present conclusions on cost factors.

Two methods have been used to determine the shape of the long run average cost curve. The regression analysis and frontier frame methods gave quite different results. Regression results showed large diseconomies of scale at low levels of output and equally large diseconomies at high levels of output. The frontier frame method showed great economies of scale up to a smaller MOS, minimum optimum scale, but showed only minor diseconomies of scale at larger outputs. These differences in results are large enough to have a significant effect on policy implications for the industry.

The focal point in analyzing the difference in the curves is the MOS. For 1976, the frontier frame cost curve had an MOS of $16 million compared to $641 million for the MOS in the regression equation. It was noted in Chapter IV that the value of $641 million for the MOS would seem unlikely, since the bulk of the sample has outputs considerably less than this. On the other hand, the value of $16 million seems
quite low, because this would mean only 3 of the 86 units observed had outputs less than the MOS. A middle ground answer would seem likely.

To determine a value for the MOS which compromises the extremes of the frontier frame and regression equation estimates, an analysis of the distribution of S&L's with respect to output is necessary. From this analysis, the range of 40 to 70 million dollars is the best estimate for the MOS. A value for the MOS in this range fits in well with the distribution of sample units for three reasons.

First, this estimate for the MOS will result in a greater number of units, approximately 20, which have outputs less than the MOS. This number seems likely due to the population distribution of this region. Low population densities, particularly in Idaho, Wyoming and Montana, limit the demand for the services of savings and loans, and may confine the units operating in these areas to an output which is less than the MOS. Such units survive at these low levels of output because they do not face any competition from other S&L's. Approximately 10 percent of the 128 S&L's in the sample region have no competition from other units. It is assumed that such units can pass along the price disadvantages of their level of output to consumers with greater ease than units with competition. This is done by limiting the services they provide, their hours of operation, and their facilities.

The second reason for this estimation of the MOS is the high concentration of units within $20 million of the estimated interval. Approximately one-fourth of the units in the sample lie in this range. Most of these units are in cities with populations of 50 to 100 thousand and face a limited number of competing S&L's. Since they must face competition, unlike the associations mentioned above, the cost disadvantages
of lower outputs are critical. Thus, these associations must grow to attain a size where such disadvantages are minimized. Growth is continued until it is limited by the demand for S&L services in the local area and by the market share of competing units, usually resulting in an output near the MOS. Approximately half of the associations in the sample face such conditions and most of these have outputs within $20 million of the estimated MOS interval.

Finally, the average costs of units within the estimated interval containing the MOS are lower than units in adjacent intervals of the same range of outputs. To analyze this it is necessary to use the definitions of technical efficiency (the unit's position on the LRAC curve) and operating efficiency (the unit's distance above the LRAC curve).  

First, it must be assumed that the operating efficiency of units at the same output level have a relatively stable form of distribution above the LRAC curve. This seems likely since a regression equation was derived for this sample and it assumes a normal probability distribution for sample points about the regression curve. With this assumption, the relative technical efficiency of the various intervals of output can be estimated by the relative position of the bulk of the points in that interval. This method can therefore give the output level of the MOS, but not the average cost level at the MOS. Thus, since the interval of 40 to 70 million dollars has the majority of its sample units with average costs lower than adjacent intervals, it seems likely then, that the MOS is in this interval.

With the MOS estimated in the 40 to 70 million dollar range, economies of scale can be analyzed, and they would definitely appear to be present in the savings and loan industry. The only question is the extent of this presence. For the high output range a large amount of variation was found between the two approaches. Both were hampered by the lack of available points and comparisons were hurt by the high value of the MOS derived from the regression equations. Because the frontier frame curve stays closer to the units present in the high output range, as scarce as they are, its representation would seem more likely to be representative. This would mean 15 percent higher costs for outputs at twice the MOS. Another reason for rejecting the regression equation is that it is affected to a greater extent by the concentration of points at lower outputs and fewer points at higher levels of output.

For the low range of firm size, the presence of economies of scale seems definite. Again, the only question being the extent of its presence. At lower outputs, the shape of the LRAC curve tends to be closer to that represented by the regression equation. This would indicate 75 percent higher costs at half the MOS. The graphical representation of a composite curve, as compared to curves derived from regression and frontier frame techniques, is illustrated in Figure 7. It can be noted that this curve is a middle ground of the extremes represented by the derived curves.

With the presence of economies of scale confirmed, how may this information be used? Generally, this type of information can be used in regulatory decisions and decisions by individual association managements on branching. Regulatory decisions are usually concerned with the cost advantage of larger firms over smaller ones and the number of firms to
The curves represent relationships where the branching term is zero.

Fig. 7.—LRAC Curves for the Savings and Loan Industry
permit in a given area. Such decisions in the Twelfth Federal Home Loan Bank Board District are likely to center on whether a large savings and loan will be allowed to branch into a smaller community which can be served by a smaller unit savings and loan. Decisions such as this are likely in the twelfth district where most of the population centers are already covered by one or more S&L's, thus any growth would probably be into smaller towns. In deciding on the best way for a smaller community to be served (i.e., a branch or small unit association), a regulatory agency must consider a number of factors. These factors include the amount of demand for services in the community, the type of services demanded, and the relative costs of the alternatives. The extent of the services demanded, as noted earlier, is sometimes a limitation for smaller associations because they use limited services as a way to make up for the cost disadvantages of lower levels of output. In most cases, though, the main consideration is cost.

To illustrate the many aspects of the cost portion of this type of regulatory decision, consider a community with an estimated demand for 20 million dollars in loans. The alternatives for this decision are the formation of a new S&L, or to allow an association with $120 million in assets, and two branches (1976), to expand into the community. In this analysis the composite curve in Figure 7 is used. First, consider the small unit association. It will have total assets which are about half of the MOS, the point at which it can attain minimum costs. According to the LRAC curve its costs will be 75 percent greater than the minimum attainable costs or about .012 dollars per dollar of assets. Compared to the smaller association, the larger unit which operates at twice the MOS, has costs which are 15 percent greater than minimum attainable
costs (.008 dollars per dollar of assets), or about two-thirds of that of the smaller association. But this cost does not include the additional costs of branching, (Figure 7 is for zero branches). The additional cost is represented in the average cost equation by the branching term:

\[(\text{constant})(\frac{\text{NB}}{\text{TA}})\]

Where: \(\text{NB} = \) the number of branches

\(\text{TA} = \) total assets in millions of dollars

The constant is the coefficient of this term in the regression equation (i.e., .1916 in 1975 and .1771 in 1976). With its present two branches the average costs of the larger association increase to .011 or 91 percent of the average cost of the other alternative. With the addition of the proposed new branch the average costs increase to .0118 dollars per dollar of assets, which makes the difference between the alternatives almost negligible. Thus, the larger association's cost advantages due to LRAC curve position are negated by the costs of branching. Because of the small difference in costs the decision would probably be made on qualitative grounds such as service. Obviously, big is not always better in the savings and loan industry.

Several important points can be found in this example. First, the difference in average costs of the two alternatives is a function of both asset size (LRAC curve position) and the number of branches. Second, the additional cost due to branching is related to both the increase in assets and the increase in the number of branches. In other words, regulatory decisions must take into account the LRAC curve positions of the alternative associations, and the extent of branching by these alternatives (if applicable), in addition to qualitative items such as service.
The decision by the management of the individual savings and loans on branching follows a similar line of reasoning. Of importance to the management is the change in the average costs of the association. The decision is based on the association's expected economies of scale (or diseconomies) and the cost of the additional branch. The question of economies of scale would depend on the firm's LRAC curve position and the size of the expected shift in this position, and average costs, due to this change in output. This change, in average costs, may be either an increase or decrease. The effect of the additional branch, as noted above, is a function of the number of branches and the amount of assets. If the percentage change in branches is greater than the percentage change in total assets, then the magnitude of the contribution to average costs by the branching term will increase. If the opposite is true the contribution will decrease. This relationship is based on the fact that branches come in discrete units. Since the change in assets is important to the effect of branching on average costs, the management of an association must investigate the size of the demand for its services, and the types of services demanded. In other words, like the regulatory agency on a decision involving expansion of services, the management of the individual association must be concerned with its LRAC curve position, the potential demand of the new site, and the type of services demanded.

In concluding the analysis of the determination of the LRAC curve a few remarks on the methods used are appropriate. As noted the results of these two methods varied considerably. Much of the difference may be attributed to differences in the theory behind each of the methods. In addition, some of the difference can be attributed to the strengths
and weaknesses of the individual methods. The frontier frame has an advantage over regression techniques, in one respect, since the points which make up the resulting curve are relatively independent of one another. This problem was noted in LRAC curve computations. Regression analysis techniques are superior to the frontier frame in their ability to quantify the effect of factors which are of secondary interest in relationship under consideration. In this study, the effect of branching in LRAC curve computations was of secondary interest. The primary interest in this study was the effect of output on average costs. Since branching also affects average costs, its effect had to be accounted for. The LRAC curve derived by the frontier frame method consists of units with a varying number of branches. Finally, both methods of analysis were hampered by the lack of sample points for certain levels of output. This lack of points allowed the curves to be influenced by units with more extreme costs, which was most evident in the frontier frame method.

In the analysis of cost factors a significant amount of intercorrelation between the independent variables was uncovered. These intercorrelations were so strong that they limited the number of variables that could be included in the regression equations. This was evident when the addition of some independent variables could only be accomplished to the detriment of variables already present. Such intercorrelations were especially noticeable in the multiplicative relationship.

In spite of these problems, most variables were found to be related to costs as they were expected to be, and as noted in Chapter III. There were three areas where the results were of particular interest. These were the areas of cost of funds, number of employees and environmental factors.
The cost of funds results were significant in that they were verified by the results of a number of different variables. It was found that as the total cost of funds increases, so do operating expenses. Since the cost of funds is not included in operating expenses, it seems likely that high cost funds require greater expenditures for administration. This hypothesis was tentatively verified by the variable representing the ratio of savings to total assets, where total assets is a proxy for the amount of loans outstanding. This term showed that as savings grew, and internal financing became easier, operating costs decreased. All of this indicates that the total cost of funds is a significant factor in the operating expenses of a savings and loan.

The variable for the number of employees was of interest because labor expenses are a major expense for savings and loans. It was found that as the number of employees increased, the average cost per employee decreased. It then supports the hypothesis that as an association grows it increases the division of labor in its organizational structure, allowing the specialization of employee tasks. Which in turn allows the hiring of employees who are less skilled and therefore on a lower wage scale.

The environmental factors of interest were the number of commercial banks, the number of savings and loans, and the population, in the association's business area. It was found that the number of savings and loans had a high positive correlation with population, while the number of commercial banks did not have such a relationship. As was noted earlier, this is indicated by the fact that savings and loans are located only in larger population centers where there is greater demand, while commercial banks can be found in nearly every small town. The dependence of savings and loans on adequate demand is illustrated by this
relationship. Its importance comes because it reinforces the requirement for adequate demand which was essential to the branching decision. In analyzing the region covered by the sample it seems that most towns of larger sizes, have a S&L home office or a branch, thus limiting the number of new sites with adequate demand. Because of the possible limit on new sites, it is possible that the market area has become saturated.

In analyzing potential cost factors, two relationships, linear and multiplicative, were utilized. The multiplicative relationship explained the greatest amount of variation in the total cost equation, even though it used fewer variables. This fact would tend to indicate that the relationship between costs and the various factors which affect costs are non-linear for the savings and loan industry.

In conclusion, this study has estimated the minimum optimum scale of the savings and loan industry to be in the range of $40 to $70 million. Using the derived value of demand from the survey area this translates into one S&L for every 30,000 people, thus indicating a value for the minimum degree of concentration for the industry. This study did not find a maximum limit on concentration. Diseconomies of scale for higher levels of output were relatively minor over the range of associations in this sample, thus making the calculation of a maximum optimum scale impossible.

^The value of demand used in this calculation was derived by multiplying the sample, mean total assets per association by the sample mean number of associations per county or SMSA (NSL). This figure was divided by the sample mean population of the county or SMSA (POP). This produced a loan demand figure of approximately $1,750 per person. This figure is meant as an approximation since it does not account for many of the factors in a demand function.
APPENDIX

To gather data for this study a questionnaire was sent to the 128 active savings and loans (S&L's) in the study area. The survey consisted of two separate mailings. The first mailing was made to all S&L's in the survey area, and was mailed during the last week of December 1976. Included in the survey package was a letter of explanation (Figure 8), a questionnaire (Figure 9), and a stamped, self-addressed, return envelope. Of the 128 survey packages mailed, approximately 50 usable sets of data were returned.

A second mailing was made during the first week of February 1977 to those S&L's which had not yet replied to the first mailing. This survey package consisted of a second letter of explanation (Figure 10), a photocopy of the first letter of explanation, and a second copy of the questionnaire. By the first of March 1977, the total number of usable sets of data received was 86.
December 13, 1976

Richard W. Brown
University of Montana
School of Business
c/o Box 2272
Great Falls, Montana 59401

To complete degree requirements for the Master of Business Administration program at the University of Montana, I am writing a thesis on economies of scale in Savings and Loan Associations. To do this study I must collect data on income and expenses for individual associations.

Associations in the Twelfth Federal Home Loan Bank Board district will be used as a sample. The data desired is part of that used in the FHLBB Management Information System. The enclosed questionnaire presents the data requested according to the number of the entry, or entries, on FHLBB's reports, which contain the information desired.

All data used in this study will be strictly CONFIDENTIAL and used only for economic research and analysis. All data presented in my final report will be in an aggregate form so that individual respondents will not be identifiable. The name of your association is requested on the questionnaire solely for the purpose of combining other local economic and demographic characteristics with the data you supply.

Thank you for your cooperation. If you desire a summary of the results, please indicate this on the survey form.

Many thanks,

Richard W. Brown

P.S. As the faculty supervisor of Dick Brown's graduate research I can assure you that all the data received will be absolutely confidential. Dick is an outstanding and conscientious student, so I am sure you will be interested in a summary of his results. You can expect to receive this, if requested, during April or May. Your cooperation will be greatly appreciated.

Sincerely,

Holton Wilson
Associate Professor

Fig. 8.—Letter of Explanation for First Mailing.
SURVEY FORM


NOTE 2: THE NUMBERS IN PARENTHESES INDICATE THE ENTRY, OR ENTRIES, ON THE FHLBB MANAGEMENT INFORMATION SYSTEM FINANCIAL REPORTS. IF YOU WISH YOU MIGHT SEND A COPY OF THE YEAR END FHLBB SEMIANNUAL FINANCIAL REPORT - STATEMENT OF CONDITION FOR 1975 AND 1976, RATHER THAN ANSWERING QUESTIONS 1 THROUGH 6 DIRECTLY. IF YOU DO THIS PLEASE ANSWER QUESTIONS 7 THROUGH 12 ALSO.

<table>
<thead>
<tr>
<th>Question</th>
<th>1975</th>
<th>1976</th>
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<tbody>
<tr>
<td>1. Total Assets (Section A, #164)</td>
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<tr>
<td>2. Savings Accounts (Section B, the sum of entries 101 through 105)</td>
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<td>3. Total Net Worth (Section C, #108)</td>
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<td>4. Total Gross Operating Income (Section D, the sum of entries 100 through 113)</td>
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<td>5. Total Operating Expense (Section E, the sum of entries 100 through 121)</td>
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<td>6. Total Cost of Funds (Section E, the sum of entries 124 through 132)</td>
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<td>7. Number of Loan Accounts</td>
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<td>8. Number of Savings Accounts</td>
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<td>9. Number of Branches Included In These Data</td>
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<td>10. Number of Employees (Include Relevant Branches)</td>
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<td>11. Name of Your Association</td>
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<td>12. Please indicate your interest in receiving a summary of the results by checking the appropriate space:</td>
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<tr>
<td>Yes, I would like to see a summary of your results.</td>
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<tr>
<td>No, I do not care to have a summary of your results.</td>
<td></td>
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</table>

Please return in the envelope provided to: Richard W. Brown
University of Montana
School of Business
c/o Box 2272
Great Falls, Montana 59401

THANK YOU!

Fig. 9.—Survey Questionnaire
February 3, 1977

Richard W. Brown
University of Montana
School of Business
c/o Box 2272
Great Falls, Montana 59401

Approximately one month ago I sent you a copy of the enclosed survey form and a letter of explanation. So far I have received the cooperation of forty-seven Savings and Loan Associations in the Twelfth Federal Home Loan Bank Board District.

Your association is not currently represented by a completed survey form, perhaps due to the extra work load you already faced during January. Your help by providing the data I have requested will improve the reliability of the study, and as I have indicated I will be pleased to send you a summary of the final results.

A stamped, self-addressed envelope was enclosed with the original request. If this has been misplaced please return the questionnaire to the address on the lower right corner of the survey form. Your cooperation will be greatly appreciated.

Thank you,

Richard W. Brown

Fig. 10.—Letter of Explanation for Second Mailing.
SELECTED BIBLIOGRAPHY

BOOKS


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MAGAZINES AND JOURNALS


