Few investors would look upon agriculture as a growth industry. Demand for its products over the last two decades has been restrained by low price and income elasticities. Resource returns have been low in terms of certain traditional measures. The labor force has fled from it, in contrast to expanding industries such as office machines, television, amusement, drugs and chemicals. It has required large-scale government programs to maintain its prices and incomes in a rather long period of rapid growth in the national economy. Other characteristics and facets of the industry are those ordinarily associated with retarded or declining growth.

The industry has not, of course, been passive if we view its resource structure. While, in the last decade or so, output has been restrained by slow demand growth, with the exception of commercial exports and international food aid, it has had dynamic growth in the value of capital assets, in capital gains from investment, in adjusting its labor force and in transformation of its many forms of technological capital. But even if we were to consider the industry the antithesis of those commonly considered growth sectors, the agricultural firm can not be placed in the same category. The farm firm, particularly in some categories, has been even more dynamic and responsive than many growth industries, to resource and product price changes and to new technologies or knowledge. Previous papers in this series suggest that there are going to be even more rapid changes in the parameters that provide the decision variables of the farm firm. Some technologies of the agri-business sector are projected to provide chemicals and similar inputs at even lower real prices. Other technologies are expected to change the parameters of the farm firm's cost function; specifying both a larger and more specialized unit to survive under extended interfirm competition for resources. Increases in education and other investments of the human resource, plus the shifting of the age composition of farmers and

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family labor as suggested by cohort analysis, promises to reduce the supply quantity and increase the supply price of labor to the farm firm. A continuing and accentuated change in the resource structure of the farm firm is thus projected for the future. There will be fewer of them; they will be larger and more specialized; their resource structure will turn more to capital and less to labor and land, but more acres will be required to allow them the scale advantage and payoff from modern technology. The complexity of the scientific technology implies an advanced managerial function for them, or a set of managerial services furnished to them from the agribusiness sector.

One need not speculate about these possibilities—the trend is already here and is even quite well known by the man in the countryside whose quantitative analysis is "simply that which he sees about him." There is little chance that the direction of the trend will change; uncertainty exists only with respect to the rate of change and whether the trend lines will have increased slopes.

The transformation of the farm resource structure and economic organization is the key to many broad social and economic problems in agriculture. The extent and types of agricultural policies needed for the future will depend on the structure of farm firms, the extent that they continue or accentuate the substitution of capital for land and extend production capacity at rates exceeding demand growth, and their responsiveness to parameter changes and the corresponding supply elasticity in its relation to price and income stability. The size of firms, and hence the number, will determine how many people live in the countryside—and hence the population and business volume in village and town settlements of the non-metropolitan areas. Extended still further, these factors will also determine the number and sizes of towns needed in purely rural areas, the modifications that should take place in extent and form of public investments in roads, utilities, schools and even local governments. A sufficiently rapid transformation of the agricultural firm, for example, a reduction in numbers to the level of 50,000 to 100,000 as suggested by Ruttan, will entirely eliminate the political power of agriculture; except to the extent that the managers of the remaining firms are of a psychological nature and political orientation to initiate effective collective bargaining and market power. These transformations also will cause the worker in the urban chemical, drug or machinery factory to be substituted for the worker on the farm and in the village of the rural community; thus prolonging our attempts at solution of poverty problems in agriculture and requiring larger and more

rapid investments in vocational retraining and redirected adult education. Additionally, these changes will determine the extent to which rural institutions such as banks should organize their activities around service charges from a large number of small depositors; or around the payoff from fewer large-volume and highly commercial farm borrowers.

In short, there are few if any aspects of economic change which have such broad economic and social implications as the upcoming structure of the agricultural firm as it responds to changes in price and production coefficient parameters that are either with us or in prospect for the future. If we could count on a response in the years ahead as rapid or as great as projected by Ruttan, we would not need to hold this conference. The 50,000 to 100,000 farms would be large enough to invest in their own managerial research and aids, either individually or in small groups. Similarly, when the resource structure reduces the number of commercial farms down to this level, there will be little if any need for public investment in agricultural research and education. Farm firms with a half million to a million dollars in gross volume of sales are large enough to conduct their own applied trials and experimentation. Their results would be supplemented by or supplemental to the research conducted by the input and processing industries to sell more of their capital inputs to agriculture. Of course, public investigations might be needed for some of the more fundamental aspects of knowledge and particularly for research such as that relating to health, land use, pollution and other phenomena having little or no payoff to private industry. It also would be needed to solve the massive social and economic problems of the rural community stemming from the shift in firm resource structure necessary to allow thinning of farm numbers to this level. Obviously, the rate and extent to which the structure and organization of the farm firm brings us to any such number of farms will determine whether any public funds need to be invested in agricultural knowledge and its communication. Already, private industry invests more than the public in agriculture research, and makes substantial additional investment in the communication of this research to farmers.

Response to Changes in Factor Prices and Productivities

Projected changes in factor prices and productivities were summarized previously. In general, they favor the trends already under way in agriculture. Higher real prices for labor, brought about through greater investment in the human resources of rural areas and the resulting greater occupational mobility, minimum wage laws, an age distribution of farm operators skewed towards older persons which must give way to massive retirements and new entrants in the near future—all of these favor a continued substitution of capital for labor. The numerous
time-series and cross-section resource demand studies completed to date indicate clearly that farmers are responsive to these relative price changes for resources. Investment is made in labor substitutes as the price of capital declines relative to manpower and the quantity of labor demanded is smaller as its price increases.

Labor Substitutions

The use of more capital gives rise, of course, to cost or scale economies that specify larger and more specialized units if farming is to be profitable. During the past two decades these phenomena are reflected on an aggregate basis by the large decline in manpower and simultaneously a large increase in capital representing operating items, machinery and equipment. Over the period 1945-66, farm employment declined by 50 percent and non-real estate capital (constant dollars) advanced by 350 percent. At the same time, the average farm of the nation increased by 154 acres or 78 percent in size and the number of farms declined by 2.7 million or 45 percent. Aggregatively, this substitution is both real and obvious. But from a farm management research standpoint, the process is not so obvious. More needs to be known about it, both for purposes of guidance of individual farmers and for assessing the rate at which the set of social and economic problems mentioned earlier will face the rural community in the magnitude indicated.

Machinery, equipment and new building designs are direct substitutes for labor. Less actual labor and more substitutes for it have, therefore, shown up aggregatively in agriculture as technologies and relative prices favored the shift. Similarly, biological forms of capital such as fertilizer, insecticides, feed additives, improved varieties and others are substitutes for labor. With higher yields per acre or animal, fewer are needed and total labor requirements of the agricultural firm are lessened. Yet, in response to the changed prices of resources, the farmer does not always or typically select a new mix of capital and labor along an isoquant and change his resource structure so easily. As the prices of fertilizer or insecticides decline relative to labor, the farmer does not simply buy more of these items, put them into use and replace some of the labor contributed by him, family members or a hired man. Neither does he typically buy a machine and release some labor from the farm. While this process does happen on farms with a moderately large input of hired labor, a farm depending on family labor or even one hired man typically lessens employment intensity of the labor supply or acquires more acres and animals to allow an effective use of the machine and labor. Following the latter route, however, some labor is replaced, as acres and animals are taken over from other operators. We know little about these indirect processes of capital-labor substitution on individual farms, although their occurrences in the aggregative time-series data are obvious. Similarly, we know little about the supply conditions of resources in the restricted market, in
contrast to a state or national market, which surrounds the individual farm for land and similar resources. Hence, we cannot describe or project the rate at which these substitutions can take place in the future. We know so little about the rural mechanisms of this capital-labor substitution and local resource supplies that we are unable to project the rate of change implied for the future firm with its broad social implications for agriculture and the rural community. Likewise, we are able to give farmers little guidance on the expansion paths or isoclines they should follow in extending the resource mix to the farm size and volumes projected to be consistent with resource prices and productivities of the future. These processes and expansion on the individual farms do not unfold in the same manner as in a set of time series regression equations to provide estimates of resource demand or its changes.

**Scale Economies**

A great deal of importance to individual farmers, rural communities and agri-business firms revolves around the scale economies of the firm under current and prospective technology. While the term "scale economies" is shop-worn and old much depends on the concept, or its counterpart in cost functions of the individual farm firm, in respect to who can or should farm, the source and volume of the credit or capital supply to farmers and the institutional structure of the farm. Whether there will be 50,000 or a million farms in the future rests not on time trends that can be projected from time series data but on the nature of cost or scale economies of the farm firm. Similarly, the number of merchants and the displaced labor force of agriculture, and the retraining investment involved, hinges on these coefficients. But as of now, there is only scattered evidence of these relationships. We have no adequate inventory of research, for example, indicating the existence or even the nature of short-run and long-run cost functions, in technologies related to highly mechanized and large-volume cattle feeding or dairying operations. We can find no closely related data suggesting a feasible scale of operations under environmentally controlled livestock production. Neither are there data available to indicate whether the important cost economies relating to prospective and upcoming technology rest in the farm firm or in the input-supply firm. If it is the former, one set of decision, and even political, forces will determine the direction of agricultural and the managerial research which should be conducted in its behalf. If it is the latter, control will tend to be invested in quite a different direction and the managerial resources available for generating decisions will be much more numerous and sufficient. If the major cost economies reside at the level of farms, the machines and equipment will be owned and controlled by the traditional farm manager, upgraded as he may be. On the other hand, if the relevant scale economies are in the firms that supply inputs and if the direction of development is for these input supply firms to own and furnish the machines for farm
operations on a custom basis, quite a different financing and capital of the farm firm will result. Under these circumstances, the farm operator might be a sort of sophisticated landlord or animal tender who furnished the land or animal services while the chemical or machinery firm furnished machines and operating capital.

Whether and when either of these developments comes about depends on the scale or cost economies involved in typical field and farm operations. Needless to say, our research information on scale economies is now so scant that we can not inform the farmer whether or not he should prepare to become a sophisticated landlord or animal tender while the input firm is depended upon to furnish machines, chemicals, seeds and feeds. Neither can we decide whether the seat of management will change so drastically that we should turn our services in managerial research aids in the directions of the agribusiness firm.

We have no information, at least to our knowledge, to indicate the extent to which cost or scale economies that favor larger farms unfold from price or production functions. If such scale economies are attached largely to the elasticities of the production function, it seems rather obvious that the control, management and operation of farms would continue to reside with the farm manager. The scale or cost economies could be duplicated as easily on farms as in the input supplying industry. On the other hand, if the greater economies are reflected in the price function relating to material inputs, or the cost functions of processing firms, and if mammoth scale were necessary to realize these through the capital markets, the farm operations might more nearly pass over into the hands of the input supply firms; again leaving the farmer simply as an animal tender or as a sophisticated landlord furnishing land services. If the main scale economies were associated with elasticities of the production function, farmers might band together in group farming operations as in parts of Europe. However, if economies were mainly those relating to material inputs or the cost functions of processing firms, requiring massive scale and volume, the aristocratic landlord or the animal tender might be more in prospect.

It is obvious, of course, that as relative resource prices and productivities shift to alter the marginal rates of substitution of capital for labor, with more capital and less labor used in farming, that the fixed costs of farming increase. This is true because of the large capital investment involved and the relatively rapid obsolescence of new capital forms. Hence, larger volumes are required to attain break-even points and profit margins. Modern farmers think in terms of break-even volumes and profit margins, knowing that if scale is extended far enough profits exist and grow in a larger proportion than output. They have been made aware of these concepts and operations not only because of the large investments and high overhead costs, but also because of
the large investments and high overhead costs, but also because of the
greater cash costs even for constant-per-acre-or-animal outlays for
operating items such as seeds, chemicals and insecticides.

The concepts of scale and cost functions have been widely used and
durable and continue to be important ones for employment in research
if we are to establish sensible guides for the upcoming generation of
farmers or even if we are to have dependable estimates of the number and
sizes of farms that will exist in the future. It is rather obvious that as
few as 500,000 farms could readily produce the nation's output. Once
the number of farms had been reduced to that extent they would be so
large that few would encounter difficulties in getting capital supplies
or with financing. However, the process of moving from our present
number of farms to 50,000, involving as it does the absorption of 2
million small units and consequent expansion of those that remain,
poses restraints, particularly those related to difficulties and time
lags in financing. Hence, scale studies seem relevant to better indicate
whether we are in prospect of only 50,000 farm units or the rather easily
attainable 500,000 commercial farms.

Numerous projections on "prospective" and "possible" farm numbers,
exist. If simple trends are projected, the estimated number of farms for
1980 is around 2 million. A more realistically based projection con-
sidering the distributed lags traditionally associated with change in
farm structure would put the number at 1.5 million farms in 1980, with
half of these represented by commercial units and half represented by
nominal part-time and retirement units.2/ Of course, 750,000 commercial
farms of a very reasonable and modest size, those with sales of
$10,000 and over, already could quite easily produce the nation's
food and fiber output—with only slight expansion to take over the re-
sources and output of the other farmers. But how rapidly the number falls
and whether it approaches 50,000, 100,000 or 500,000 at a near-
equilibrium of the industry, will certainly depend on the extent and
degree of cost or scale economies, and whether it will be 50,000 or
500,000 will make a great deal of economic and social difference. It
would seem that the state of the arts in economic research has both
simple and complex tools which should throw some light on the possi-
bilities. Perhaps research on scale economies and cost functions,
as one of the older sets of concepts related to firms, seems too elemen-
tal to merit analysis in this dashing era of analytical techniques and
mathematical mechanisms. Yet the extent and degree of scale economies
in agriculture is more important, with respect to both the nature of the

2/ Earl O. Heady and A. Gordon Ball. "Economic Growth of the Farm
Firm and Projected Changes in Farming." CAED Report 24. Iowa
State University. 1965.
individual firm and the structure of the rural community than any other phenomenon relating to the individual farm. Needed in this realm of established concepts but less well accepted methodology, are measures of cost functions for farm firms with different complements of fixed resources (the large-scale enterprise or farm) and measures of scale returns for farms that represent multi-producing units under the same management (forgetting momentarily given management as a fixed input outside the "pure concept" of scale returns). Again whether increasing returns to scale prevail or not, and whether they unfold from the elasticities inherent in the technical production function or price functions which decline for resources or increase with outputs for large volumes, will determine whether there will be both many fewer farms and managers—or many fewer managers with more farm units held under their control and a large input of skilled laborers and supervisory personnel. The two possibilities, the former supposing scale economies through the production function and price functions and the latter through the price functions alone, have quite different implications in the labor force of agriculture and its management.

The range over which scale economies may exist and their degree, or simply the range over which the long-run cost function declines, also has optimal relationships to the institutional arrangements under which farm firms operate. If they are relatively restrained but still allow farms of sizes that give rise to problems of capital acquisition and accumulation to individual families, corporate forms of business may be best suited from the standpoint of taxes and "holding the unit together." But if the scale or cost economies extend even further and give rise to greater capital accordingly, group farming activities may provide the means competitive to the structure sometimes posed of farmers as sophisticated landlords or animal tenders while the field operations, chemical drugs and feeds are services provided by the input firm. In any case, the inter-relationships of scale and business form should be researched in order to provide guidance in decisions to farm managers, selecting among the many routes they can follow under a growing capitalization of agriculture such as corporate organizations to circumvent inheritance taxes or to accrue funds through the nonfarm capital market, integration with the input and processing industries, group farming, etc.

**Capital-Land Substitution**

While capital-labor substitution brings many problems of displacement of workers and families from farms and the rural community, capital-land substitutions bring mainly problems of producing capacity and the attending complexities of short-run supply elasticities and price and income levels. Almost every biological form of capital invented
for use and finding application in agriculture serves as a substitute for land (and indirectly as a substitute for labor in the sense that fewer acres need to be operated). Similarly, biological and other innovations that increase livestock output from given feed, or reduce feed input for a given livestock output, also serve as land substitutes. Less land is thus required to produce a given feed and animal output.

These substitutions have been mammoth over the past. Not only were we producing a 45 percent greater output in 1965 than in 1945, but we also were doing it with around 60,000,000 crop acres held out of production. The possibilities of these substitutions still exist, and perhaps their application in the future will be even more rapid than in the past. The theme in the base papers presented at this conference certainly point in this direction. Some of our own estimates emphasize these potentials. Even using the conservative assumption that trends in productivity gains of American agriculture will rise to 1980 at the 1954-64 rate, in contrast to the higher 1955-64 rate as the rates more nearly implied in the base papers of this set, we estimate that U.S. agriculture can produce the output needed by a 1980 domestic population of 243 million with per capita incomes of $3,300 (based on 1957-60 value of the dollar) with (a) 75 million acres shifted from crop production if exports are only equal to the 1965 level and (b) 50 million acres if exports grow to three times the 1965 levels.1/ These are still mammoth substitution possibilities which are realistic and too conservative against the propositions and projections offered in the base papers.

Individual technologies have high rates of substitution for land resources. Fitting even fertilizer substitution into a framework of

continuous land-fertilizer production functions, we estimate that the potentials in this substitution are still extremely great. Considering fertilizer alone at the rate farmers currently use it, and basing estimates on productivities derived from experimental production functions we estimate that a ton of fertilizer substitutes for 15–25 acres of land over the Corn Belt proper.

In making these estimates, we started with experimental response functions of the form:

(a) \[ Y = a + b_1 F_1 + b_2 F_2 - b_3 F_1^2 - b_4 F_2^2 + b_5 F_1 F_2 \]

where \( Y \) is yield per acre and \( F_1 \) are individual nutrients \( N, P, K \). Next we convert them to fertilizer response functions where represents quantity of the common mixes used in the regions of the experiment. Since \( \phi \) represents the combination of \( F_1 \) and \( F_2 \) in the ratio of \( F_1^* / F_2^* \) implies an optimal or conventional mix. For determination of the coefficients in the function \( Y = f(\phi) \) we let

(b) \( R_1 = F_1^* / \sum_{i=1}^{2} F_1^* \) and (c) \( R_2 = F_2^* / \sum_{i=1}^{2} F_1^* \)

and since

(d) \( \phi = \sum_{i=1}^{2} F_i^* \) therefore (e) \( F_i^* = R_i \phi \)

and

(f) \( Y = a + \alpha \phi - \beta \phi^2 \)

Now, since the function is on a per acre basis, we divide by acreage to get

(g) \( Y_a = a + \alpha \phi A^{-1} - \beta \phi^2 A^{-2} \)

Now by multiplying by \( A \) to get land in the production function, we have

(h) \( Y_t = aA + \alpha \phi - \beta \phi^2 A^{-1} \)

The equation of marginal rate of substitution from which our calculations were made is

(i) \[ \frac{\partial A}{\partial \phi} = \frac{2 \phi A - a}{a \beta \phi^2 A^{-2}} \]

and we set \( \phi \) at farm level uses, the ratio \( \phi / A \), for the calculations. The estimates are from an unpublished paper: Capital-Labor Substitution at Different Locations by Fahmi Bishay and Earl O. Heady. Iowa State University. 1966.
Add other biological capital items and the rate can be equally high for the investment. New seed varieties, insecticides, growth hormones and similar items probably have even higher marginal rates of substitution relative to the investment. Herbicides may be nearly as high.

It is, of course, these operating items of capital that are having, and will have, the greatest effect in increasing the productivity of capital. They provide much of the basis for structural change as it is effected through the total supply capacity of American agriculture. These forms of capital are, and will continue, to grow in domination over the total capital used on farms. In our projects, we find that real estate capital for agriculture in total will increase by less than 10 percent in the next 15 years; although it will more than double per farm if the number of farms is halved. The growth in total real estate capital will be very modest due to farm size expansion and the consolidation of units that does away with duplicate sets of buildings that are not always fully employed on separate units. Added investment in the total stock of machinery and equipment is projected to increase by less than 25 percent for the agricultural industry. This statement refers to the value of the inventory or stock of machinery on farms. Total purchases of machinery will exceed this, as obsolete equipment is replaced by improved models. The consolidation of farms into larger units causes a dampening down of the total supply of machinery because duplicated sets of underemployed equipment are not needed on the separate farms.

For operating capital items, however, total input is projected to double in the next 15 years. Hence, the quantity per farm would be expected to quadruple, if farm numbers were halved. A mammoth substitution of biological capital for land will thus occur, and annual outlays of $50,000 per farm for operating inputs can be quite common place for conventional but large scale family farms over the next two decades, even if the number of truly commercial farms reduces only to 700,000.

In terms of capital-land substitution, the process does not take place directly on the individual farm. The operator does not buy a ton of fertilizer, a drum of insecticide and a bag of "new variety" seed and apply them while he withdraws a corresponding acreage of land (except as this process is effected through land diversion under government programs.) Rather, he buys this mix of capital inputs and applies them over the whole acreage; with the output of the entire farm increased accordingly. Yet in this process, the same or more output can be produced with less land. Hence some farmers can realize an expansion without acquiring control of additional land which would otherwise be the case. (The fact that the land isn't withdrawn results in an overly large output and low prices in the short-run.) Yet substitution
of capital for land has taken place and land at the margin could now be shifted from particular crops to other uses and substitution has taken place in a national sense. On one individual farm, the process is simply one of using more inputs. But for the farm at the margin in a different location, the problem is one of shifting its entire organization as the substitution process takes place. We should have research which interprets these processes in the broad manner in which they take place, and pinpoint the regions of major adjustments for guidance of individual farms. This indirect and round-about substitution process, which simply adds up nationally in our ability to produce more from a given national agriculture, has quite different capital implications. The farms in the "heart of the producing regions" that apply the new biological capital have to increase their investment accordingly, but they add little or no real estate investment at the time. However, the marginal or fringe area possessing the land, for which the biological capital applied at the heart of the producing regions substitutes, is faced with mammoth capital requirements as it has to acquire more acreage and shift from row crops to grass and grazing or trees.

Firm Growth

Propositions put forward in these papers, plus other projections, suggest a much larger capital investment per farm in the next 15 years. The typical commercial farm will easily be in the farm-products-sold class of $20,000 and over by then and at some point in the future, we can be sure that the lower boundary of growing and competitive commercial farms will rise to $40,000. Some of our own projections suggest that the investment per farm even when all commercial farms reach the rather modest farm product sales level of $20,000 will be $225,000 by 1980, a 27 percent increase (in constant dollars) over 1960. Many more, of course, will approach a half million dollars. While these are projections, the "speculated possible" 50-100,000 farms would entail mammoth investments per farm.

Hence, there is an important analytic problem of firm growth in agriculture. We have never had much research on this problem even for the traditional firm of the past; when it went through a definite life cycle tied in quite closely with the life cycle of the household that attached to it. Starting from a small equity, it grew in a manner related to the surplus of income generated over living expenses and its equity-restrained capital supplies. This growth process limited greatly the capital available to it. Its capital supply increased with time as the equity and credit restraint moved up with greater family income and savings. How, now will it grow to accumulate the more massive amount of capital needed? Or will this trend be represented in growth models of the individual firm, aided by new supplies of
capital provided through different institutional mechanisms such as sale of common stock in the market, or by vertical integration with the integrating agribusiness firm tapping the general capital market in sale of stock? Or will this transition not be made by an existing generation of farms that will grow to the larger scale, but by a discrete break between generations of farm firms. As owners of present farms retire, will a new group of "swinging" managers and capitalists acquire the resources and initiate an entirely new firm structure from the outset? And what will be the growth process of the latter once it is initiated?

The growth process of existing and future firms will determine if, when and by what extent farm numbers will dwindle to economically strangle the traditional rural community. It will have other implications for which we should be readying other plans to create viable rural structures and communities. Yet we know little about these processes; partly because they are difficult to study, but partly because they simply have not been studied. Sufficient time series data in the farm accounts of many states would allow application of models resting on modern growth theory. Also, many interesting normative-type analyses could be applied through dynamic and nonlinear programming models.

There has been continuous pressure during recent years for the farmer to increase his size of business. Previous papers of this conference and projections from other sources suggest that much larger farm businesses are in prospect for the future. Many of our present farmers, however, are already trapped in a situation of "forced savings" because of the competitive pressures to increase the size of their farm business. Such farmers actually lower their current living standards in order to accumulate money to invest in their business. The element of "forced savings" in agriculture together with the inflation in land values over the past decade have resulted in a situation where many farmers have acquired a relatively large net worth in their business in spite of the fact that their net farm income has been relatively low.

A recent study reported that the average per family net worth of farm people in 1962 was $51,600. While the average net worth for the non-farm family was estimated to be $11,581, and at the same time the average income for farmers was $1,430, as compared to $2,440 for non-farm families.5/

Many important problems are associated with the methods by which capital is accumulated in the agricultural industry. The high degree of dependence on their own savings has forced many farmers, particularly young farmers, to operate units well below an optimum or even satisfactory size. Since capital accumulation is an essential element in the growth of the firm, limits and obstacles to the process will have substantial effects on which farm firms survive, the firm organization and so on.

The desire to have complete ownership of the farm capital by the time of retirement has forced an unduly high rate of savings on the farmer. Should farmers be encouraged to sacrifice consumption standards during most of their lifetime in order to complete ownership of all farm capital before retirement? These and other problems relating to financing the farm and to its growth will increase in number, severity and complexity. Entirely new methods of financing the farm may be required in the future.

Research is needed to determine not only the necessary and sufficient elements of firm growth in agriculture but to explore relationships on farms between current income, consumption, investments and net worth. More needs to be known on how farmers who have accumulated sizeable net worths can best contend with estate taxes associated with the transfer of the farm once every generation. What are the prospects for farmers in the future to get their capital as Lester Kellogg suggests, by selling shares to the public and through long term loans at prime rates from established financial institutions? Is it feasible for such shares to be sold directly to the public or will such financing have to come indirectly via input suppliers or output buyers with known reputations whose shares are already exchanged on the stock market? Research is needed to determine alternative methods for avoiding the discontinuities of investment and competent management in farming associated with the life cycle.

Handling Risks and Uncertainties

Farmers have always had their relatively simple strategies for dealing with risk and uncertainties. Included are strategies that are conservative or of the maximum nature, such as selecting enterprises with low income variance, diversification to provide income stability, self-restraints on capital use and others. What types of strategies and decision mechanisms become applicable under much larger and more highly specialized farm firms? In contrast to labor technology, capital intensive technology calls much more for a high degree of specialization. When labor was the main input of farming, the farmer and his family could switch their efforts relatively easily back and forth among a
few hens, a flock of geese, a dozen milk cows, a few brood sows, a small drove of feeder cattle and a mix of corn, soybeans, small grains and hay. This flexibility melts away when the resource to be switched is capital in the form of specialized machinery and equipment. A picker-sheller can hardly be switched to milk cows or convey feed in a broiler battery.

It is for this reason that changes in resource prices that favor capital inputs over labor not only bring larger farm units but also bring greater specialization. But greater specialization also poses the possibilities and actualities of wide swings in income as yields or prices fluctuate. These phenomena may themselves squeeze specialized farming operations in the direction of vertical integration and animal tenders, in order that more of the burden of risks and uncertainties are borne by very large scale agribusiness or input-furnishing firms. There are reasons in probability to provide a mathematical justification for this trend. The large firm integrated over a large number of farms and animal tenders may have a sample large enough to reduce income variance much lower than the individual farmer. With a stronger capital position, and the ability to withhold or lessen dividends to common stockholders in scattered unfavorable years, the agribusiness thus integrated also has the possibility of more observations and a greater sample in time. It may be thus better able than an individual farm manager to operate under wide fluctuations of income of a more highly specialized agriculture.

Yet there are other strategies that are used by industrial firms and may be potentials for otherwise highly specialized farms and farm managers. Industrial firms do diversify, but not by producing a smattering of several products in the same plant. Instead, they simply buy up the assets of a specialized firm at a different location producing an entirely different product. Steel firms buy up grocery chains, electric organ manufacturers buy up firms that produce work clothes and automobile manufacturers acquire the assets of firms that produce household appliances. Are these the optimal strategies in the future for highly specialized farms? Should the owner and manager of a 50,000 feed lot in the Corn Belt buy a specialized 100,000 acre wheat farm in the Great Plains and a specialized egg unit in Maryland?

Research has never been adequate on the potentials and outcomes for farmers in meeting risks and uncertainties. The new era posed in the structure of farming for the future places new importance on problems of decisions under uncertainty and gives them renewed relevance in research. What are the outcomes in the application of existing game or decision models? What adaptations and extensions in subjective and probability models can and should be made for the new generation of farms and farm managers?
Functions and Qualities of Management

Industry has always distinguished rather sharply between the types of human resources best suited as labor, supervisory roles and management. In the traditional farm, they were the same person. Yet the upcoming structure of agriculture outlined in numerous papers in this set suggests a scale of farm operations in which the same stratification of human effort now used in industry might be applicable.

If farm numbers ever reduce to the point suggested by Lester Kellogg in his paper or to the number "tabbed" as possible by Ruttan, we will certainly have farmers who specialize in the management function leaving the actual farm operation to a highly skilled foreman or other supervisory personnel. Even if commercial farms only more modestly graduate to the present economic class of sales over $40,000 and are represented by more two-and three-man farms, we expect more of this division in functions of farm manpower. Decision procedures indicating who should become managers of farm firms and who should become the skilled workers to conduct technologically advanced operations may become highly relevant. It is possible that the two should arise from entirely different training. As has been suggested by Kellogg, perhaps managers should be trained in business schools, raised in a nonfarm environment where they are associated more with individuals who have their origin in families from the chemical, drug, computer and similar firms of the nonfarm sector. It may be more nearly the skilled worker and supervisory personnel who should go through our current complement of vocational agriculture and agricultural college training--but even the latter need further restructuring to meet the type of agriculture we are discussing here. Training even at the agricultural level needs to break more away from departments and follow interdisciplinary lines; to be based more on fundamental science and decision models, and only "topped off" by the applied agricultural courses. Training at the level of vocational agriculture in high school needs to go somewhat in the opposite direction; namely away from one man departments and "general purpose instructors," to several specialists who can surround enough deep knowledge in some discipline to surpass the knowledge of operating farmers. Of course, if Ruttan's 50,000 farms are ever attained, we won't have much room for education in specialized vocational agriculture departments and agricultural colleges. The training then will come from enrollment in business, botany, biochemistry, computer programming and similar courses.

The questions that revolve around the future nature of management resources and decision procedures are large and important. They are important for determining the magnitude and nature of agricultural education, in decisions of individuals with respect to deciding who should become a farm manager, in structuring capital investments to meet
uncertainty and for many other important issues. Research relating to managerial problems and procedures will be more important for the future than the past. But we have always had too little of it.

Managerial Aids

While it is less a problem of research and more nearly one of projection and enlightened guidance, some thought needs to be given to the managerial or planning methods and decision models to be used by farmers in the future. Some analysis needs to be devoted to the extent to which and conditions under which programming and related models can improve decisions and the economic performances of the firm. On the basis of these findings, specifications need to be made relative to the institutions or organizations that can best provide these aids and services.

If, as some speculate, the farmer is to become the sophisticated and highly capitalized landlord furnishing land services, or the animal tender furnishing labor services while the agribusiness firm furnishes the other inputs and services for farm operation, no problem exists. Under these circumstances the agribusiness firm will furnish the computers and models for farm decisions. These agribusiness firms will be of a scale to merit investment in the most advanced computers for applying systems analysis as some now call it (but more nearly the conventional economic models and the newer programming and related models that are the core of firm theory and profit systems). Indeed some such firms are already moving in the direction of providing these aids to individual farmers, with the services acting to complement the inputs sold the farmer.

Even if farming never reduced to the land-furnishing and animal-tending category in integration with agribusiness, but only to the level of 50,000 commercial farms, numerous of these farmers might be able to invest in limited capacity computers for applying the more modest linear programming models consistent with specialized farms. And/or they could afford to be members of a group investing in a trained analyst to provide programming routines and interpretations. With farming reduced to these numbers, certainly the major planning would be done by programming and other more sophisticated procedures. We would expect programming models to become the basis of farm planning even if farm numbers reduced, at some reasonable point in time such as 1985 or 1990, to 500,000 truly commercial farms. In this case, services of programming and decision models, as well as farm accounting, perhaps could be best furnished by firms and organizations specialized to this purpose. Whoever performs this service, the agribusiness sector, private concerns organized for this purpose or the state agricultural extension services, will find the major leadership of commercial
farming operations falls in its hands.

As part of this complex, various models of operations research need to be researched more deeply in terms of their relevance in investments and management for large-scale, specialized farms. We can imagine that the posed Corn Belt farm that uses little field machinery but many chemicals and drugs, harvests the entire corn plant and handles feed through a specialized center with advanced storage and handling equipment, produces livestock under environmentally controlled conditions, is faced with problems of antipollution in disposing of its wastes, etc., will need courses of action and investments prescribed by queuing and inventory models, simulation techniques, critical path programming, turnpike theorems and others. More research should be initiated now to better mesh and perfect models for these purposes.

**Labor Management**

Data presented here and elsewhere indicate prospects for important changes in the farm labor market. A greater proportion of the work force on commercial farms, as they transgress through economic classes, towards the structure of Class I farms with sales of over $40,000, will be hired and family labor will continue as a declining component. Investments in education and vocational training, elimination of poverty, improved employment services, retraining of established workers and other facets of the human resource will reduce the supply and increase the supply elasticity of labor to agriculture. Minimum wage laws will raise the reservation price of labor to agriculture. "Captive" migratory labor will be in smaller supply and more of the hired labor force will live away from farms—unless some rather large upgrading of living facilities and fringe benefits takes place for farm workers. Thus the farm manager must bid against competing employers for labor drawn from local sources and which lives in the towns and villages along with the labor employment in other firms and institutions of the community. This setting is quite different from that of the past and places the farmer in a different role as employer and manager of labor. The farmer is at a disadvantage where he must recruit labor from local services for seasonal tasks but cannot offer work during the rest of the year nor provide them with competitive fringe benefits.

Traditionally, the less desirable farm jobs were performed by unskilled labor with few or no alternatives. In the future, a growing number of farm workers will be able to choose better wages and working conditions of both farm and nonfarm jobs. Two-thirds of all the hired-work force lived in nonfarm places in 1965.
Most farmers have not developed the employer skills to compete effectively as recruiters and managers of labor in this type of market. Some will respond, as rightly they should when the real price of labor rises sufficiently, by substituting more machines and capacity for workers. Yet we need to investigate the conditions under which farm managers can function effectively as employers in a changing market for labor and a changing structure of the farm work force.

**Conclusion**

We have not attempted to inventory all of the farm firm research implied for the future. Much of it will be conventional in nature and is evident in usual decision models of old or new vintage. We have tried to select the realms of research that stand out as, through the implications of previous papers, agricultural transformation continues with the further rapid injection of new technology and operating capital into the industry. Whether the research and the corresponding communication and education is accomplished by public institutions or private institutions will certainly determine the leadership of agriculture.