FACTORS ASSOCIATED WITH INNOVATIVE ADOPTION AMONG SELECTED FARMERS IN SOUTHERN BRAZIL

DISSERTATION

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Agriculture serves Brazil as the base for its rapidly growing industrial sector and urban centers. Increases in agricultural output in the past have derived primarily from the addition of new land rather than marked change in agricultural technology and productivity. Effort has been devoted during the last ten to fifteen years, however, to change this situation and to emphasize the importance of agricultural development.

Increasing agricultural output through increased productivity requires the infusion and adoption of new ideas, specialization in farm enterprises, purchase of commercialized farm inputs and non-agricultural services. Such development, in addition to available physical resources, requires that new knowledge be available, and relevant technology be accepted to overcome the traditional resistance to change by the farmers.

This study, based on a sample of farmers in southern Brazil, attempts to separate farmers or farm groups into classes on the basis of personal characteristics, command of resources, and to identify the factors associated with the variation in the behavior of farmers for adoption of new farm practices.

The farmers studied were from the municipios (counties) of Lajeado and Carazinho in Rio Grande do Sul, and Concordia and Timbo in Santa Catarina. From over a thousand farmers interviewed in 1965 and 1969 a subset of the 336 farmers who were interviewed in both periods constitutes the total sample for this study.

The central hypothesis of this study was that the adoption behavior of farmers is a function of the combined influences of individual personality characteristics, nature of the farm and structural variables. It was further hypothesized that factor scores would predict innovative adoption better than individual variables.

A component factor model, utilizing fourteen variables, was developed for analysis of the data. Through oblique rotation, three factors were extracted and identified. They are Economic Resources, Time Span, and Motivation, which together explained about 44 percent of the over-all variation in the data. The

Economic Resources factor accounted for the largest percentage of variation, 26.38, while the Time Span and Motivation factors explained 12.43 and 5.32 percent respectively.

In explaining adoption behavior the three factors together accounted for about 46 percent of the over-all variation. The Motivation factor exerted the greatest influence, accounting for 44 percent. The Economic Resources factor was second explaining about 2 percent, with Time Span, the third factor, explaining less than .2 percent.

Further statistical analysis of the characteristics of the factors and adoption groups of respondents established the identity and nature of the factors. The farmers who adopt more of the relevant new agricultural practices are highly motivated, younger and wealthier, in which the first feature accounted for the greatest influence. The use of the factor scores as data variables did not support the hypothesis about their predictive ability for adoption behavior.

The outcome of the factor analysis was undoubtedly influenced by the limitations in the selection of the sample and the availability of a range of data on variables. However, the analysis was successful to the extent that meaningful factors were identified in which

the central hypothesis concerning factors associated with adoption behavior of farmers was sustained. Before generalizations can safely be made, however, more research is needed on the factors under different conditions and with different populations.

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INTRODUCTION

More than half of Brazil's gainfully employed population in engaged in farming. Agriculture serves as the base of its rapidly growing industrial sector.

The growth of population, total and urban, and the subsequent demand along with better prices provided the impetus to the rise of agricultural production. However, the greater volume of agricultural output was obtained by the addition of new land and not by increased productivity (Celso Furtado, 1961: 273). This is because apart from the availability of extensive land, the technology of both crop and livestock production is relatively undeveloped (Nichollis, 1969: 366-368).

The growth of population and urbanization, and the relatively high income elasticity for food products, assures a fairly large demand for farm products in the present and coming decades, and hence the importance of agricultural development in Brazil.

Agricultural development could be achieved either through increased use of available resources at a given level of agricultural technology (as has been done in

Brazil in the past) or by changing the agricultural technology used by farmers. Now that the best agricultural land has at last been taken up, the first method promises little. Rather, much of the additional output to meet the increasing demand for food products in Brazil will come from the application of new knowledge and technology.

This effort of increasing productivity requires the infusion and adoption of new ideas and practices. This means specialization in farm products such as cash crops, purchase of commercialized farm inputs and non-agricultural products. The crucial and difficult problem, as Schultz (1961: 525) has observed after his survey of the economic prospects of Brazil, is how to make new knowledge of agriculture available and to get it accepted--the diffusion of farm innovations and their adoption.

The effort to spread new ideas and practices and to get them accepted encounters many problems such as availability of resources, overcoming resistance and making effective impact.

Another problem which arises early in the initiation of diffusion programs is how to reach as many farmers as possible with the limited resources of capital, extension services, etc., available and make

efficient use of these resources. One method of approach is to separate farmers or farm communities on the basis of the degree of their readiness for innovative adoption and possibly suggest different innovations and/or use different means or ways of communicating them to these groups. The degree of readiness for innovative adoption and the extent of productive and transformative capacity is a function of the combined influences of socio-economic forces: (1) personality variables, (2) the nature of farm resources and managerial skills, and (3) structural factors.

The main objective of this study is the identification of factors accounting for variation in adoption behavior of farmers on the basis of the variables mentioned above (personality variables, command of resources, and effects of structural factors). Each farm group--as well as individual variables within the groups--will then be examined to determine its significance in the adoption process. Attempts will be made to assess the level or degree of respondents' readiness for innovation-decision, predict future innovative behavior and adoption rate of relevant farm innovations.

In the effort to increase agricultural productivity in Brazil, major government policy programs have largely focused in the areas of credit, input

subsidization and price. In the southern and central parts of Brazil emphasis has been largely put in the areas of fertilizer, mechanization, production loans for basic food crops and cattle and high wheat prices (Rask, 1971: 9).

The study area, in southern Brazil, consists of the states of Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul. This study is based on about 336 detailed farm interviews done in 1965-66 and later repeated in 1969-70 for the Capital Formation Project. All of the farms are located in four municipios (counties) of Santa Catarina (Concordia and Timbo) and Rio Grande do Sul (Lageado and Carazinho). The farms are mostly small to medium in size (5-50 ha.) with only about 50 large frams 50+ ha.). They are either of crop, livestock, or mixed enterprises.

The major concern in the agriculture of southern Brazil is how to change agricultural technology and improve farm productivity. Accordingly, the theories of diffusion must deal with the spread and adoption of new knowledge and means in agriculture. Hopefully, this will be followed by the growth of supportive institutions and subsequent productive results at the farm level.

Diffusion process has been a subject of study for

a long time now. On the basis of the model used in western countries, studies have been done in Asia, Africa and Latin America. Apart from some questions on the nature of the model itself (behavioral and structural problems), one major skepticism has been how effective the model is and how relevant are the findings to be generalized, to non-western countries. It must be realized that there are important socio-cultural differences between the developed and the less developed countries. Examination of some of the studies done in less developed countries brings out some of the methodological problems encountered in the diffusion model.

Rogers' (1962) adoption model will provide a framework for the analysis of the diffusion and adoption of innovations. Careful consideration will be given to the influence of structural factors on the awareness and decision making process of the farmer (Blau, 1960; Young, 1966; Weintraub, 1970; Galjart, 1971). The effect of the availability of innovations on adoption rate (Presser, 1969) and the response of non-innovative farmers to newly created farm situations (Roling, 1970); the importance of multi-dimensionality of social behavior; and the consequences of innovativeness and adoption are some of the additional things

which will be dealt with in detail.*

It is hoped that the recognition of the existence of such problems in the diffusion model, special attention in the selection of variables relevant to the area of study, the method of analysis to be employed, and cautious interpretation of results will help surmount some of the major problems of cross-cultural comparison of the research.

The results of this research project will contribute to the findings of diffusion research, and would be of some use to extension agents, agricultural and economic planners, and all others who are involved in rural development programs in Brazil and other areas.

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*For some details of these references see the section on Review of Literature.

CHAPTER I

THE RESEARCH OF DIFFUSION OF INNOVATION

Review of Literature

The research into diffusion of innovation and the subsequent model is the result of rural sociological studies in the United States and Western Europe (Lionberger, 1960; Rogers, 1962). In spite of the volume of over a thousand empirical results of research on the diffusion of innovations (Rogers, 1970) there remains a need for a more rigorous theoretical worth.

Valkonen (1970: 162-166) points out the following major shortcomings of the existing research:

1. More attention is paid to correlation analysis than finding the causal nature of the theory which brought the observed correlations and which is theoretically more important.

2. The variables studied are often conceptually and causally intercorrelated and hence the results lack much informative value.

3. The study of only segments of a social system makes it difficult to combine the results of diffusion

research with theories of social change. The latter applies to natural social systems like communities.

The preponderant nature of the empirical findings so far from the United States and Western Europe, and the lack of much cross-national research in rural sociology, has made the theory of diffusion highly culture-bound. This restricts the universal explanatory usefulness of its propositions (Lupri, 1969: 101-102).

The diffusion and adoption of innovations model envisages a process through which innovation information gets from its origin to the potential user, and on the basis of the combinations of both the characteristics of the innovation and the user, it gets adopted or rejected. By and large, it is a communication model. Also on the basis of the time and number of innovations adopted, the model presents stages for the adoption process and categorizes individuals into distinct groups on a continuum.

As mentioned, much of the research and findings in diffusion were done in the United States and Western Europe, particularly Holland. There has been effort for some time now to apply the model to Asia, Latin America and Africa with mixed results. This may well be because of the nature of the model and/or the application methods used. Particularly in the use of

diffusion research in developing countries, a number of problems have arisen for which the model does not seem to account satisfactorily and therefore has raised questions concerning its cross-cultural use. Some of the major problems encountered by various researchers are as follows.

Problems of Interviewing.--Interviewing in many developing countires presents problems in that many people are not accustomed to expressing their opinions on public affairs to strangers, in the presence of others especially. When they do, there seems to be much courtesy bias or traditional reserve in their responses (Wilson and Armstrong, 1963: 48-58; Jones, 1963: 70-76; Portes, 1972: 32-33).

Problems of Small Sample.--Many times researchers have found that when they survey an area, there are not enough people who are aware of the innovation, let alone trying or adopting it. This raises the problems of the reliability of the study and its generalizations (Keith, 1968).

Variability of Responses.--When asked about particular innovations they have adopted as to the time and circumstances of their adoption, individual

respondents give variable responses at various times (Coughnour, 1965; Doob, 1958; Palmer, 1943). Apart from the shift in innovator category this creates, it presents a serious problem when different researchers use different innovations or different times for their researches. The variability of the responses and subsequent unreliability seems great among the less-educated groups of the society. A Brazilian study by van Es and Wilkening (1970) led them to suggest that the best approach is to select a few key variables which can be applied regardless of the people and culture in which it is administered.

Mobility of Adopters.--H. R. Presser (1969) has noted that the area under consideration makes a big difference as to the number of persons in each adopter category. If in a small area there are three innovators, their absolute number may increase if the area under consideration is made bigger, as some of the early adopters may be considered innovators in the new groupings. Similarly, the out-migration of the people in an area is likely to change the average innovativeness of the area.

Structural Effects.--The traditional procedure by which diffusion research has been done focuses on the

attitudes and activities of the individual. This has a great shortcoming in that it neglects structural factors which facilitate or infringe as the case may be on the awareness and decision-making process of the individual. The contextual factors or social environment, family structure and individual position in the social system are important determinants (Mosher, 1966: 153-161). The activities and tendencies of an individual are not only the result of the individual's personality and internalized values but also the results of the norms, values, and the social relationships of the society in which the individual lives. The norms and values could be positively or negatively aligned with the individual's. The kinds and number of innovations which come to an area are largely determined by many sectors of the society, and the emphasis so far in micro-approach only has neglected the macro factors involved (Blau, 1960: 178-193). In a larger context, Weintraub (1970: 367-376) has developed a scheme which shows how exogenous variables affect changes in rural areas. Rural areas of developing countries are not only affected by the internal organization, social positions and orientation of the rural sector; equally important is the commitment, the rural image and power

of influence of the central government; i.e., its policies and actions.

Concepts and Measurements Problems.--Apart from differences in political, economic, and social systems of the developing countries from the United States and Western Europe, the use of the model in these other societies persents methodological problems such as equivalence of meaning, concept and difficulty of translation of these concepts into local language, and cultural variability (Lurpi, 1969: 103-109). Also, Presser (1969) has pointed out that in some cases innovativeness and adoption have been confused. The former implies relative earliness while the latter is the number of innovations adopted. This makes a difference as to who is an innovator, and who is an adopter but not necessarily an innovator. This would suggest a closer scrutiny and careful definition of the population in the sample and the time considered to be relevant for the study of innovativeness.

The neglect or oversight of determining possible differences in the availability of the new innovations for all members of the study group and its effect on their categorization is explained in the same study by Presser.

The use of the basic model (Rogers' five stages) implies that the innovation involves a major investment of time, energy, and capital resources on the part of the adopter which forces the adopter more or less to pass through all the stages. If the practice, however, could be tried on a smaller scale and the results are highly visible, the stages may be fewer (Bohlen, 1967: 123). Bohlen also brings out that the relationship between subjective security and the problem of risk aversion and adoption have not yet been researched well (Ibid." 127). Furthermore, the adoption of a non-material idea such as the use of credit does not fit neatly into the model (Ibid.: 124).

Involuntary Adopters.--The emphasis of diffusion research not only has been on the individual's behavior with less attention paid to structural variables, but also it deals only with the voluntary behavior of the individual in the gathering of information, giving a trial to an innovation and the decision on the basis of evaluation to adopt or reject the innovation. It does not take account of forced situations or the "positive influence of negative forces" on potential adopters. Research in the United States shows that on the basis of the individual's subjective definition when the

situation is considered to present no alternative to adoption he accepts the innovations regardless of other pertinent factors (Havens, 1965: 164). Similarly, but of more wide implication, a study of farmers in the United States, Japan, and India has led one researcher to hypothesize that "the rate of adoption and diffusion of new techniques and of the requisite changes in farmers' values, attitudes, and practices will be in an inverse ratio to the range of available alternatives". The only feasible solution would be cutting of the less efficient choices through stringent farm management techniques and leaving only the one relevant choice (Nair, 1969: 231). Nair believes this restriction of possible alternatives to be more important than even the characteristics of the farmers or the resources at their disposal (Ibid.: 230).

Non-Adopters.--To impute adoption the evidence of continued use was the preferred method. Little or no attention is paid to the study of non-adopters or quitters (Bohlen, 1967: 71-85).

The cost of adoption is the most common obstacle preventing or delaying adoption (Bohlen, ibid.: 126; Valkonen, ibid.: 174). Thus, the correlates of non-adoption are not only ignorance and unwillingness, but

also inability (Galjart, 1971). However, research in the past has identified a lack of willingness rather than ability which limits adoption (Rogers, 1969).

In identification of potential innovators in developing countries, Mellor (1966: 174) suggests that innovations that give only modest increases in production are unlikely to be accepted by either prosperous or poor farmers. The first reason he offers is the marginal utility of the additional production is too low; a second reason is because of the high risk premiums to innovation attached they are unlikely to try new practices. Rather, it is the middle group of farmers who are the most likely group to innovate. Theodore Schultz (1964 and 1969) also suggests that the innovation must provide a very good margin of profitability at the farm level for farmers in developing countries to adopt it.

Leadership and Adoption.--The high degree of differentiation in the United States leads to less overlap of leadership; i.e., the roles that formal leaders and opinion leaders play are different (Rogers, 1962: 236-237). However, as Max Weber (1947: 341-342) has stated, leadership in traditional societies has diffused authority; i.e., the formal leaders tend to be

also opinion leaders. In this context, enough attention has not been paid to their function as intermediaries or "gate keepers" between small farmers and change agents and institutions.

A study of farmers in Brazil gives the evidence that participation in farm organizations and extension activities appears most consistently related to political participation which in turn is positively related to social participation. That is, non-land owners participate less than owners in various institutions (van Es and Whittenberger, 1970: 22-23). For a model which is patterned on communication concepts, this participation of well-to-do farmers in associations and organizations has important bearing. Nypan (1970) found that because of their diffused authority and closeness to communication centers, formal leaders in rural Tanzania have great influence in the diffusion and adoption of new farm practices. Referring to the Green Revolution in Asia, Lele and Mellor (1972: 20) found that the larger farmers not only can afford the risks of innovation, but also they have more political power over the developmental agencies which provide agricultural imputs and services. Hence, there is a definite need for exploring the concept of traditional leaders and their roles in community development of

developing countries (Fathi, 1965: 204-212).

The problems mentioned above and others raised by the research of innovation diffusion lead to questionable reliability and predictive power of the adoption model. Having said all this, however, it is important to point out that the basic model is still considered valid (Bohlen, ibid.: 123). In spite of its limitations the number and variety of results the empirical research in diffusion offers is a basis for synthesizing a more general theory of social change (Rogers, 1970: XVIII).

Diffusion research needs not only cognizance of its limitations in its present form, but also some modifications, methodological attack on the unsettled questions and a cautious interpretation of its cross-cultural generalizations. Emphasizing the importance of caution in the use of past diffusion research findings in developing countries, Francis (1971: 102) suggests the importance of identifying both social and economic constraints which are culturally specific to an area in order to analyze their implications on the adoption process. This study will try to come to grips with some of these important problems of diffusion research.

Theory and Hypotheses

To change the agricultural technology and improve farm productivity is of prime importance in the economic development of Brazil. The spread and adoption of new farm practices and inputs is of immediate importance for this endeavor. Diffusion research, as pointed out above, has often neglected some important non-sociological aspects, economic or structural variables, of the determinants of the variation in adoption behavior of farmers. However, the realization of the complexity of development has underscored the importance of a multi-dimensional study of the process.

The objective of this study is the identification of factors accounting for variation in adoption behavior of farmers. Hence, the importance and complementarity of sociocultural variables and economic indices.

The hypotheses for this study are two. The central hypothesis is that the readiness of farmers for adoption of new agricultural practices is a function of their individual characteristics, the nature of their farms and structural factors. It is also hypothesized that factor scores, data generated for each case by the factor analysis, would predict adoption better than individual variables.

CHAPTER II

METHODOLOGY

The major concern of this study involves variations among farmers in the degree of readiness for innovative adoption, and its relationship to productive and transformative capacity of their farming operations. The investigation will include primarily: (1) individual characteristics, (2) nature of the farm, and (3) structural variables, with all of which adoption behavior is believed to show a concomitant association. Impact of government policies and institutional changes, effects of market stimuli and other incentives are examples of relevant structural variables. Market accessibility and attitude toward credit use are included in this study. The history of the individual's innovativeness in terms of past adoption is one of the additional aspects that will be examined for an understanding of the multi-dimensionality of individual adoption behavior.

Consistent with the major concerns of this study, there are four methodological approaches used:

1. Identification of the major individual and structural variables associated with variations in adoption behavior among farmers;
2. The decomposition of the identified variables into smaller subsets of factors using a factor analysis model;
3. The use of factor score for prediction of adoption;
4. Evaluation of the factor model with suggestions for further refinement.

Area Description

Two factors influencing the agricultural development of the southern part of Brazil are particularly interesting in terms of the major thrust of this study. These are: (1) Considering agricultural tradition and cultural background, the South is an area settled by Europeans of German and Italian descent. They have a distinct cultural background and agricultural tradition from their Portuguese counterparts on the large plantations or from the small commercial farms of the Japanese. These immigrants established small family farms of mixed enterprises in the small enclaves of their colonies. This feature is of interest in light of the fact that diffusion is a western approach and

thus would be expected to work better in a western social environment. Farmers in southern Brazil are of European tradition and orientation, but in a different geographical setting. (2) The bulk of the agricultural production of Brazil comes from the South, and it is there that the development of modern agriculture is really "taking root". New farms are being established. Capital formation, farm mechanization and technology are advancing there in contrast to many other regions of the country. These characteristics thus provide an interesting situation for the study of diffusion and adoption of farm innovations.

Unlike the Brazilian population of Portuguese descent, which is dispersed throughout the country, southern Brazil was settled during the 1800's to the 1900's by immigrants from Germany and Italy, as mentioned. The settlement process was not haphazardly conducted by individuals but rather by deliberate programs of the Brazilian government in cooperation with the home countires which facilitated the settlement of many families in specific areas (Furtado, 1963: 136-140; Waibel, 1950: 529; Wagley, 1971: 78). These colonies tended to form small European ethnic enclaves with people having common languages, religions, and cultural patterns different from the areas surrounding them.

This led to the euphemism of southern Brazil as "another Brazil, a state within a state", a feature which the government later tried to discourage (Wagley, ibid.: 72; Waibel, ibid.: 545). The immigrants established mixed farming. Small but progressive farms were owned and operated by the families largely in the tradition of their home countries. Crops, livestock and dairy are the common enterprises on the farms. The influence of these immigrants is felt not only in the type of agriculture but also in the industrial and social structure of the area. They have successfully established wine, chemical and leather industries. On the social and political scene, they form a middle class of landholders. They occupy a position intermediate between the owners of the great cattle ranches and the poor cowboys. As they move to urban centers, they are establishing themselves in the bureaucratic and administrative posts, reducing the effects of the long tradition of political monopoly of the "Luso-Brazilian" landed class (Wagley, ibid.: 79). In comparison to the northern regions of Brazil, southern Brazil has never had the economic boom and depression that go with mining and temporary trades. Rather, because of the patterns of agriculture, the level of technology and the farm background of the people, the

area has steadily grown in prosperity.

Apart from the agriculture of the European immigrant homesteader and the Azorean agriculture on the coastal regions, the pampas of southern Brazil developed a different way of life. Here the wide expanse of grasslands led to the creation of latifundia and the formation of great cattle ranches.

Hence, in terms of its agriculture, the South includes large cattle ranches and small to medium progressive European farms. The sample of this study is limited to the latter. As Nichollis (1971) has observed, it is these farms which are the principal instruments for change in the agricultural production of the progressive South.

The economic features of southern Brazil are fascinating. Over 90 percent of the nation's farms are found in the Northeast, East and South. Since 1950, there has been a steady increase in the number of new farms, though a great proportion of the increase is small farms of usually less than five hectares. The largest proportion of these new farms is again found in the Northeast and South. This increase in farm units, however, seems to result mostly from the breakdown of existing units into smaller units (Rask, 1968: 13; Schuh, 1970: 146). In terms of area of toatl farm

land, the increase in the South was 23 percent, of which about 79 percent was put into crop land (Schuh, ibid.: 136).

Farm size in Brazil shows great variation. In the South, however, 55 percent of the farms are considered to be viable family size units. While the 10 to 100 hectare category accounts for about 58 percent of the total, the average and most common class of farm size is 50 hectares (92 hectares for the country as a whole). Farms over 10,000 hectare units include less than one percent of the total farms (Schuh, ibid.: 142-145).

Southern Brazil is leading the nation in total agricultural output and is developing a modern agriculture. While a majority of the Brazilian farmers still use traditional and less efficient farm methods and tools in their farm operation, farmers in the South, especially on the newer farms, have considerably increased their farm capital: machinery, equipment and principal inputs. The increase in farm equipment and machinery between 1950 and 1960 for Brazil as a whole is sizable. From a regional point of view, however, the southern part has experienced proportionally a more rapid rate of mechanization. For example, over half of the increase in the number of tractors and plows was in the four southern states which already had the bulk of

this equipment before 1950 (Schuh, ibid.: 153-154, 164-165). The use of farm inputs only confirms the leading position of the South. In Brazil, the use of modern farm inputs such as fertilizers, insecticides, preventive medicine for livestock is considered to be very low. But this is not universally true, since there are some places where the farm technology is very sophisticated. The South again has the lead in this regard. In Rio Grande do Sul, a rather widespread program of artificial insemination has been established. Hybrid corn has been adopted extensively in the South. The consumption of fertilizer has increased rapidly since the early 1950's in the South. It has approximately doubled in about five years since 1964 (Schuh, ibid.: 168-170). The use of credit to purchase new inputs, equipment and financing of farm operation is also of significance.

The major government policy programs of credit, input subsidization and price support have had their thrust in the central and southern parts of the nation. Thus the South presents an environment where the pace of agricultural development has been rapid and increasing steadily.

Southern Brazil consists of the states of Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul.

Based on climate, soil and altitude there are four distinct geographical regions in the area.* Moving from inland to the eastern sea coast, one finds an interior lowland plain, a high plateau, a coastal mountain range and finally the coastal plain, each with its own agricultural patterns in terms of enterprise combination, farm size, and level of farm technology used. This study includes only the two states of Rio Grande do Sul and Santa Catarina (see section on Data Sources) and is confined to regions in the high plateau and the coastal mountain range.

The high plateau encompasses the greatest area among the four regions. Its vegetation is characterized by areas of open plains and pine forests. On its eastern front, the plateau is defined by a large escarpment which separates it from the adjoining coastal mountain region, the other area of study. The plateau slopes to the west. Most of its rivers flow west, cutting across the farmlands. The expansive open plain of the high plateau traditionally has been an

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*Much of the following information is from Norman Rask, An Analysis of Agricultural Development Problems at the Farm Level--Southern Brazil: Methodology and General Farm Description, Agricultural Finance Center Research Report 120, August, 1968, pp. 10-18; and Donald M. Sorensen, "Capital Productivity and Management Performance in Small Farm Agriculture in Southern Brazil" (unpublished Ph.D. dissertation, Ohio State University, 1968), pp. 14-17.

area of livestock raising and large cattle estates. In recent years, however, there has been a shift towards mechanized grain production. In the northern part, sugar cane and coffee have been important farm products. Some areas of the high plateau, however, have farming patterns similar to those found in the coastal mountain range. Two municipios* from each of the two states are included to represent this large and important farm region: Carazinho from Rio Grande do Sul, and Concordia from Santa Catarina. Carazinho is located in an area of rolling hills on the plateau in the north central part of Rio Grande do Sul. It is an area of medium size to large farms which is in the process of transition to more specialization as a mechanized cash grain area in place of its extensive livestock tradition. Wheat, soybean and flax are the major crop products. Improved pasture is becoming important for cattle grazing. This transition from traditional livestock production to modern grain production presents a wide range of potential types and degrees of use of farm technology in the area. Concordia is located on the southern part of Santa Catarina bordering Rio Grande do Sul. Much of the municipio includes steep

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*A municipio is the basic local unit of government and corresponds somewhat to the county in the U.S.

hills and valleys, resulting in the establishment of relatively small to medium size farms which--though generally progressive--nevertheless employ little mechanized equipment. Corn, hogs and to a lesser extent poultry production are the predominant farm enterprises.

The coastal mountain range separates the high plateau from the coastal plains. This region has substantial annual rainfall and relatively fertile soils, but because of its rough topography no significant degree of mechanization or intensive cultivation is practiced (Rask, 1968: 12). Farms are characteristically small, with agricultural production being based largely on a mixture of crop and livestock enterprises. Corn and soybeans are the most important crops, and hogs the major livestock enterprise. Dairy is important in areas close to larger cities. Again two municipios, one from each state, are selected from the region of the coastal mountain range: Lajeado from Rio Grande do Sul and Timbo from Santa Catarina. Lajeado is located in the east central part of the state. It is almost entirely located within the interior mountain range that connects the low plain to the high plateau. The topography is very mountainous. Farms are small in size. Subsistence production patterns exist and hand labor has been the biggest energy source. Agriculture

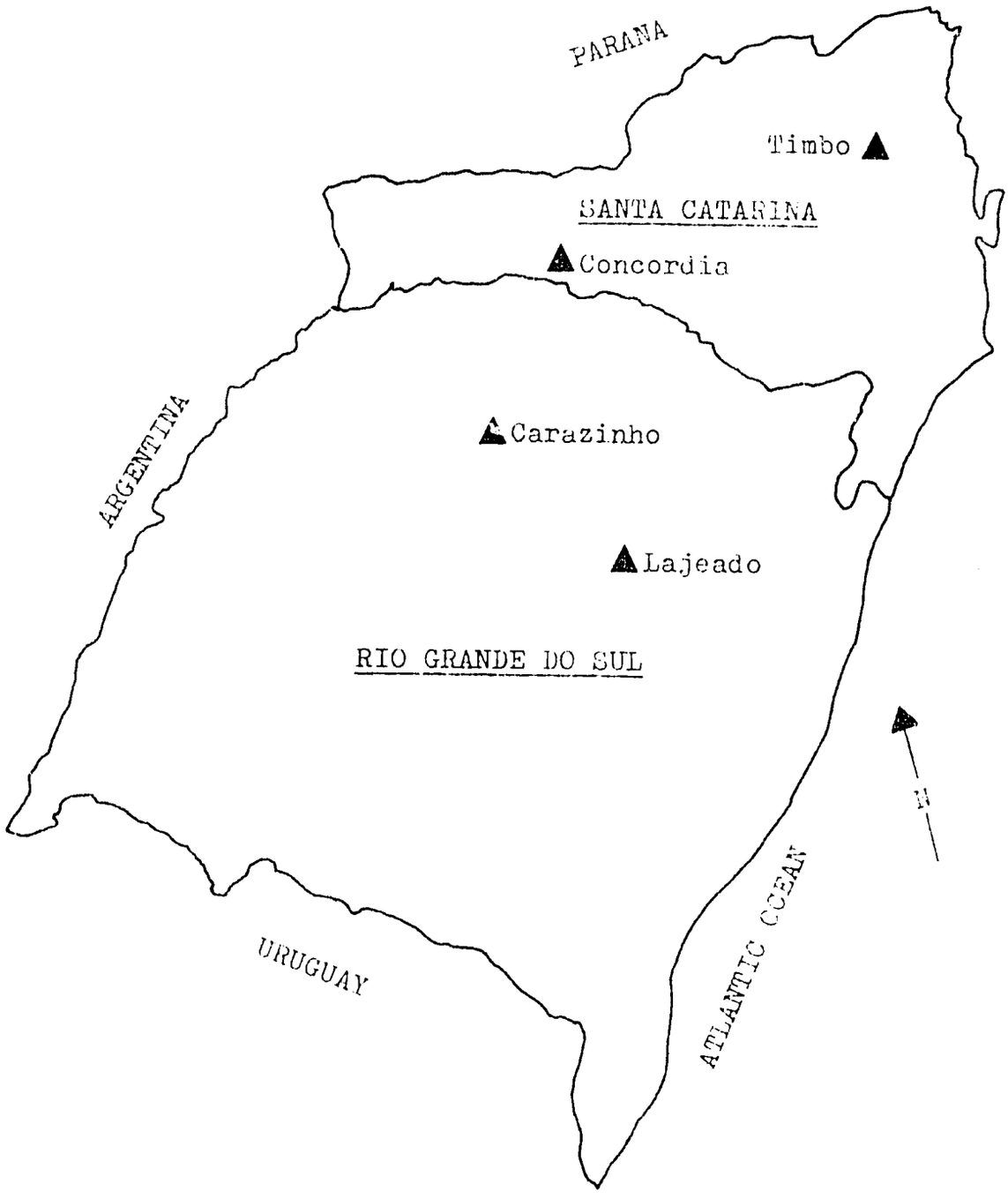

Fig. 1.--Location of the four municipios in Southern Brazil

is based on a mixture of crop and livestock enterprises. Timbo is located near the coast in the northern part of the state of Santa Catarina. Farms are generally small with mixed enterprises. Dairy and rice are two important activities in the area.

The four municipios in the two states present two dominant farm patterns even though farms generally tend to be of mixed-enterprise nature: (1) Small to medium size farms in the high plateau of Lajeado and Concordia. Dominant farm types include hog and cattle producers. (2) Medium to large farms in Carazinho, and small farms in Timbo. In both cases crop production is important.

Data Source

Data used in this study were obtained through farm interviews conducted among the same respondents in the selected municipios at two periods with an interval time of five years. The first was done in the early part of 1966, the information pertaining to the 1965 production year. The second was done in early 1970, securing data for the production year of 1969.*

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*A detailed description of the sampling procedure for both periods is found in Rask, 1968, ibid., and Norman Rask, "Analysis of Capital Formation and Technical Innovation at the Farm Level in LDC's," Economics and Sociology Occasional Paper No. 26 (Department of Agricultural Economics and Rural Sociology, Ohio State University, January, 1971); and for the first period in Sorensen, 1968, ibid.

In the 1966 survey, eight municipios including Rio Grande do Sul and Santa Catarina were sampled. Much effort was put into adjusting the random sample selection to include farms which would provide the major characteristics of each geographic region and within that of each municipio. Once the population was delimited the individual cases from each municipio population were stratified by districts in proportion to the number of farms existing within the range of size specified. The sample farms were chosen by random cluster sample from the property tax rolls of each municipio. Once the initial farms were selected by use of random numbers, they served to identify clusters of three farms, themselves and two non-adjacent neighboring properties. Thus the population for sampling included those farmers within the specified size ranges in the selected districts of the municipios included in the study. Farm interviews and coding were done by experienced Brazilian university staff. In all, 954 farms were selected of which 501 were in the four municipios of this study. Also, in terms of size, both extremes--very large and very small--were avoided in order to increase the representative nature of the observation cases. Thus the minimum and maximum size units established for the four municipios of this study reflecting

the size of farms commonly found in the areas are as follows (Rask, 1968: 21):

State	Municipio	Number of Farmers	Size in Hectares	
			Minimum	Maximum
Rio Grande do Sul				
	Lajeado	127	5	100
	Carazinho	109	20	1000
Santa Catarina				
	Concordia	133	5	100
	Timbo	132	5	100

A contract was entered into in July, 1969, between the Department of Agricultural Economics and Rural Sociology of The Ohio State University and the Agency for International Development to analyze Capital Formation and Technological Innovation in less developed countries. This contract provided a second opportunity for an extensive farm-level data collection in southern Brazil. Data were again collected from a sufficiently large cross-section of farms so that as many as possible homogeneous farm groups could be identified, reflecting the characteristics of size, type, technology, tenure, market orientations, management level, and

power in each municipio. The survey was completed in 1970.

In Rio Grande do Sul, 370 farmers were surveyed in three municipios including Lajeado and Carazinho. These interviews were conducted during January and February of 1970. Many of the farmers interviewed in 1966 in these two municipios were reinterviewed at this time. In Santa Catarina field interviews were completed at the same time for 370 farms in Concordia, Timbo and one other municipio. Again, as in Rio Grande do Sul, farmers in Concordia and Timbo who had been interviewed in 1966 were reinterviewed in 1970.

The present study has two major methodological perspectives: (1) A cross-sectional study in which variables affecting the degree of farmers' readiness for innovation adoption will be examined. Farmers will be categorized and an attempt made on the basis of this profile to identify the variable associated with adoption behavior and thus predict future innovativeness of the farmers. (2) A longitudinal approach which will make use of the five-year interval to test the accuracy of the prediction, measure discernable changes and attempt to provide some explanation for the differences noted.

This methodological approach requires having the

same observation cases from the 1966 and 1970 surveys in all of the four municipios. In the two states, 501 farmers in 1966, and 740 in 1970, were interviewed. As indicated earlier, many of the interviews done in the four municipios in 1970 were reinterviews from 1966. Hence the sample population of this study includes farms interviewed in both 1966 and 1970. A careful checking of farmers' identification based on personal information, the nature of the farm, time and geographical factors reduced the final sample size to 336 farmers distributed as follows: Lajeado, 90; Carazinho, 31; Concordia, 107; and Timbo, 108. Hence for both cross-sectional (1965 and 1969) and longitudinal (1965-1969) analysis, the 336 farm cases in the four municipios will be used.

Selection of Variables

The selection of variables for examination is based on a combination of factors. It is recognized at the outset that the analysis can be no better than the items on which it is based. As Adelman and Morris (1967: 15) experienced, there were two conflicting principles involved: those of inclusiveness--to cover the important aspects of the problem--and those of parsimony--not to include a large number of narrow indices

with limited utility. With this in mind, the following three criteria were used in narrowing down the selection of variables:

1. Previous research findings identifying the importance of specified variables associated with innovativeness and adoption, e.g. Rogers (1962), Havens (1965), Feaster (1968), Francis (1971);
2. The availability of information and data concerning the relevant variables; and
3. Judgment by the researcher as to the significance of the variables for the types of farms considered in the study.

Rogers (1962: 287-289) summarized the types of variables generally used by past studies of innovativeness as: individual attitudes, nature of the business operation, social structure, group relationships of the respondents, and communication behavior. These general headings include specific items such as age, venturesomeness, family income or level of living, farm income, individual values, mental flexibility, membership in farm organizations, farm specialization, mobility, education, information contact and others. Havens (1965: 150-165) used 16 variables to predict the time of adoption of innovations. Some of these were farm

size, attitude toward credit, social status, favorableness of the innovation, opinion leadership, and anxiety associated with adoption. He found that while 13 of the variables were positively related to the acceptance of innovation, the respondent's definition of his farm situation was the most influential factor.

In a similar approach to that of Havens, Feaster (1968) also used age, education, non-farm employment, farm goals, and contact with agricultural agents. Age, education, level of living, and extent of contact with agricultural agents were found to be significantly associated with adoption.

In his study of the adoption of improved agricultural practices in West Africa, Francis (1971: 91-92) used, among other items, sale of farm crops for cash income, age, innovativeness and ownership using factor analysis. He found farmers who had accepted farming as a permanent full-time occupation score higher on adoption than those who had other sources of income. Moulik and Khan (1967: 306) used innovation proneness, economic motivation, adoption leadership, rural life preference and closeness with extension agents to study with a factor analysis model determining factors of farmers' participation in agricultural development programs in India. Their findings indicated three

important aspects of a farmer's characteristics: the importance of the farmer's orientation to innovation, occupational or economic motivation, and leadership. Dasgupta (1968: 12-13) listed 21 variables which he found to be related to adoption. These included such items as organizational participation, education, level of living, extension and outside contact, tenure status, size of farm, degree of commercialization, and attitudes toward changes.

The review given above makes clear that there is no particular set of variables used in adoption research. Each researcher has added a few different items, but in general used a number of variables in essence--if not in nomenclature--similar to those used by others.

On the basis of the above studies and other considerations mentioned, 15 variables will be used in the analysis of the present study. They are age of farm operator, family size, farm experience, land ownership, employment for wages, adoption score, mobility, attitude toward credit use, sales of farm output for cash, operating expenditures, production efficiency, farm size, and farm income.

Consistent with past research patterns (Rogers, 1962: 287) and the concerns of this study, variables

fall into two patterns: individual characteristics (nine variables) and nature of the farm (five variables).

Age of farm operator is given in years. Education is given in the number of years spent in formal schooling. Family size includes the total number of dependents in the family, i.e., the members of the immediate family and others, e.g., relatives living in the household. Farm experience indicates the number of years the operator has worked with plants and/or animals. It helps to identify those who have put more time into farming from the "newcomers" to the business. Land ownership is important both for economic and social reasons. In terms of security for farm investment and social status, ownership of land is considered to be desirable. The measurement of land ownership is hectares. Employment for wages is indicated by the size of income from off-farm activities excluding such wources as interests on loans.

Adoption score is calculated by percentage of applicable practices adopted by the farmer, i.e., number of practices adopted by the farmer over number of practices applicable to his farm times 100. This is a widely used index of adoption (Dasgupta, 1968: 1-3) and is considered to be the best under the circumstances

when there are no data available on time of adoption. For applicability of practices to farms and production efficiency, the farmers are classified into four groups on the basis of the relative importance of various farm enterprises measured in terms of annual cash income. There are crop farms, hog farms, livestock farms, and general farms.

Crop farms and hog farms are those in which 60 percent or more of the cash income comes from the sale of crops and hogs respectively. Their numbers are 73 and 117 in that order. Livestock farms are those in which 60 percent or more of the cash income comes from the sale of cattle, sheep, dairy products, and other animal products. There are 87 of them. General farms number 59 and are those which are not specialized in crop or livestock, but have a diversified crop and livestock program. In a number of cases this category includes farms in which the non-farm income is equal to or greater than the cash income originating from livestock and crop sales.*

Mobility is measured by the number of trips taken in 1965 by the farm operator to places over 100 Kms

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*A detailed description of each of these farm types is given in Norman Rask, An Analysis of Agricultural Development Problems at the Farm Level--Southern Brazil (Ohio State University, 1968), pp. 27-30.

distance within the state. The limitation of this variable by its restriction to travels only within the state is well recognized. For attitude toward credit use for financing farm operation, farmers were scored on a scale of 0-12 constructed with the method of summated ratings, based on six questions pertinent to credit.

Sales of farm output for cash is valued in Brazilian cruzerios of farm outputs sold or stored for sale in 1965. Operating expenditure is pertinent in line with the consideration that cost is one of the major restraining factors for the adoption of new technological inputs. The expenditure list includes wage costs; crop, machinery, livestock and general expenses; and costs of credit. For the score on production efficiency index, farms are given a score of "1" for better than average and "0" for below average rating of a group of farm activities applicable to the farms as classified above. Once each farm is scored on applicable activities, a percentage index is calculated in formulating indices of adoption. For example, crop farms were scored on the yields of two crops (corn and one other depending on the municipio) for the previous two years (1964 and 1965). For hog farms, the number of pigs weaned per year per sow, age and weight of hogs

sold were used. Availability of improved pasture, breeding age of heifers, and weaning age of calves were used for livestock farms. A mixture of the activities for the livestock and crop farms were used for the general farms. The land ownership farm size is given in hectares. Farm income as given here is net farm income in cruzerios.

Initially, market accessibility for purchasing farm inputs as well as selling farm outputs was considered as a variable for the structural aspect of the study. However, further investigation showed that most of the marketing function was satisfied within one to nine kilometers from the respondents' farms. The discriminating capacity of the accessibility variable was too limited and it was therefore dropped from the analysis. Hence the number of variables used is only fourteen.

Mode of Analysis

The principal methodological tool used for this study is factor analysis.* Factor analysis can handle

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*For full explanation of factor analysis see: Benjamin Fruchter, Introduction to Factor Analysis (Princeton, New Jersey: Van Nostrand, 1954); H. H. Harman, Modern Factor Analysis (Chicago: University of Chicago Press, 1967); and J. R. Rummel, Applied Factor Analysis (Evanston, Illinois: Northwestern University Press, 1970).

a large number of social and economic variables specified numerically. The interrelationships or interdependence among a multitude of variables and their variation is the basic concern of factor analysis rather than the dependency of one variable on another or the factors accounting for the interrelationships (Rummel, 1970: 190-191).

> A basic assumption of factor analysis is that a battery of intercorrelated variables has common factors running through it and that the scores of an individual can be represented more economically in terms of those reference factors. (Fruchter, 1954: 44)

Thus using this method we can delineate, without attributing cause and effect, the underlying regularities or patterns in a complex mass of data by extracting from a large set of variables the mutual interdependence among the subsets which then comprise each factor. As Catell (1965: 190) has pointed out, this simplification may consist of a set of classificatory categories or creation of a small number of hypothetical constructs or concepts.

In terms of the immediate interest in variation in adoption behavior of farmers, Francis (1971: 88-91) suggested that the integration of adoption data with other personal and socio-economic information of individual farmers would result in a group of meaningful

factors. These factors would then represent "real" types of adopters as found in the population by strengthening the data attachment to the sample population. In this way, factor analysis can provide empirical support for hypothesized relations among variables.

Factor analysis has many uses of which the following three are very important:

1. To explore and delineate from the large socioeconomic interrelationships the patterning of variables in the data with view of a possible reduction of data and discovery of hypothetical constructs.
2. To test hypotheses of the relationship and dimensions of variables, and the independent source of data variation.
3. To use as a measuring device--for the construction of indices to be used as variables in later analysis.

As indicated above in the general methodological approach, the concerns of the study are identification of variables accounting for variations in adoption behavior among farmers, and the inference of the existence and direction of causality for the variation. Hence for the purpose of the present study all three uses of factor analysis will be employed.

The patterns among variables are viewed from the perspective of variation of characteristics. For example, the concepts innovativeness and adoption involve intercorrelated variables such as education, cosmopoliteness, farm size and ownership. Factor analysis applied to delineate patterns of variation in characteristics is called "R-factor analysis."

> R-technique is . . . an instantaneous snapshot, and as such it catches people at different state levels as well as at their trait levels. In statistical terms it includes both across-people and across-occasion variance. (Cattell, 1963: 170)

Most factor analysis on individual differences has been of this kind, and it is the method used in the present study.

The Factor Model

A linear model is the basic assumption of factor analysis (Harman, 1967: 11-15). It represents a variable Y_j in terms of several underlying factors. Within the linear framework, principal component analysis is an empirical method for the reduction of a large body of data so that a maximum variance is extracted. [1] The sample data are given in the following way:

Farm Identification Number	Variables				
	Adoption Score 1	Education Level 2	Mobility 3	. . .	Farm Size 14
1					
.					
.					
.					
.					
92					
.					
.					
.					
129					
.					
.					
.					
336					

The model for component analysis is:

[2] $Y_j = \alpha_{j1}F_1 + \alpha_{j2}F_2 + \cdots + \alpha_{jn}F_n \quad (j = 1, 2, \ldots, n)$

In the particular study at hand, it will take the following form:

[3] $Y_1 = \alpha_{11} F_1 + \alpha_{12} F_2 + \cdots + \alpha_{1n} F_n$

$Y_2 = \alpha_{21} F_1 + \alpha_{22} F_2 + \cdots + \alpha_{2n} F_n$

$Y_3 = \alpha_{31} F_1 + \alpha_{32} F_2 + \cdots + \alpha_{3n} F_n$

. . . .

. . . .

$Y_{14} = \alpha_{141}F_1 + \alpha_{142}F_2 + \cdots + \alpha_{14n}F_n$

where Y = a variable with known data

α = a constant

F = a function, f( ), of some unknown variables.

Each of the j(14) observed variables is described in a linear fashion in terms of n new uncorrelated factors, F_1, F_2,..., F_n. That is, by application to the known data on the Y variables, factor analysis defines the unknown factors. As noted above, F stands for a function of variables and not a variable. The unknown variables entering into each function, F, are related in unknown ways, although the equations relating the functions to each other are a linear combination of the j original variables (Rummel, 1967: 459). The loadings emerging from a factor analysis are the α constants. The size of each loading for each factor measures how much the specific function is related to Y. Besides determining the loadings, factor analysis will also generate data for each case on each of the α functions uncovered. These derived values for each case are called factor scores. They, along with data on Y and the equations [3] give useful and important mathematical relationships among the data as in multicorrelation equation (Rummel, 1967: 459). The mathematical principles by which each factor is formed from

the observable variables are as follows (Adelman and Dalton, 1971: 498; Kim and Nie, 1970: 217-218):

1. Those variables that are most closely intercorrelated are combined within a single factor;
2. The variables assigned to a given factor are those that are most nearly independent of the variables assigned to other factors;
3. The factor sets are derived so as to maximize the percentage of total variance attributable to each successive factor (given the inclusion of the preceding factor).

On the basis of the initial correlation matrix, a decision will be made as to how many factors to extract. Since each factor is defined as the best linear summary of variance left in the data after the previous factors are taken care of, the first m factors--usually much smaller than the number of variables in the set--may explain most of the variance in the data. For factor analysis purposes, the factors that explain at least five percent of the overall variance are retained for further rotation to arrive at the terminal solution that satisfies the theoretical and practical needs of the research problem (Kim and Nei, 1970: 211; Adelman and Dalton, 1971: 498; Harman, 1967: 15).

In summary, the following are some of the unique features of factor analysis.

Its primary purpose is to reduce the original number of explanatory variables to a smaller number of independent factors in terms of which the whole sets of variables can be understood (Adelman and Morris, 1967: 131).

Factor analysis is based on measures of association. It differs from other statistical problems in that there is no distinction between independent and dependent variables. One does not select one variable which is to be predicted or determined by the other variables. All variables are treated alike, dependent and independent in turn. It is a study of mutual interdependence (Adelman and Morris, 1967: 191; Phillips, 1971: 209; Rummel, 1970: 190-191; Thurstone, 1947: 59).

> In factor analysis the object is to discover whether the variables can be made to exhibit some underlying order that may throw light on the process that produces the individual differences shown in all the variables. (Thurstone, 1947: 61-62)

Furthermore, to point out another significant difference, in factor analysis unlike regression analysis the final explanatory factors are not observable magnitudes. They are, rather, groupings of the original

variables into a number of clusters. Each cluster consists of a linear combination of the initial variables included in the study. Finally, the merit of factor analysis lies in its power to simplify statistical data arising from complex and comparatively unexplored areas of scientific endeavor (Adelman and Morris, 1967: 141-143).

CHAPTER III

ANALYSIS OF THE DATA

Factor analysis operates with the basic assumption that the intercorrelationship of a large number of variables may be due to the presence of one or more underlying dimensions or factors which are related to the variables in varying degrees. As mentioned in the last chapter, one of the functions of factor analysis is to replace this large number of variables with a much smaller number of conceptual factors which have more theoretical significance and meaning.

We conceive of underlying factors which "really exist" but which can be only imperfectly measured by variables. The imperfect correlations among variables may be accounted for by their varying association with the underlying factors. Thus, a variable may be conceived as having several components, one component associated with the first factor, another component with the second factor, and so forth. In other words, the variable may be measuring several factors simultaneously; although it may be much more highly

correlated with one than with the others.

When factor analyzed, the variables are clustered in the sense that within any cluster of variables there is high inter-correlation whereas correlation between clusters is relatively low. The theoretical assumption is made that high inter-correlations within each cluster are due to the presence of a single factor representing the cluster. Then a second factor is associated with another cluster and so on until the last cluster has been identified. By examining the nature of the variables in each cluster we can identify what they all have in common. This common element among all the variables of the cluster is presumably the factor associated with the cluster and can be named accordingly.

The Initial Factor Matrices

The matrix of correlations indicates the correlation of each variable with every other variable (Appendix B). These are the basic data used in the factor analysis. The decomposition of the original set of variables into smaller sets of factors partitions the totality of the variables into essentially independent subgroups or factors. The first factors extracted are unrotated. The unrotated factor matrices presented in

Table 1 are actual factor results for a common factor analysis of the data. The columns of the matrix define the common factors and the rows refer to the variables. The intersection of the row and column gives the loading for the row variable on the column common factor.

In the factoring of the 14 variables the following standard procedure was used: all factors with eigenvalues of greater than zero were extracted. The number of factors was 14, with the last one having an eigenvalue of 0.0195. Factors with eigenvalues near unity (the 3rd, 4th and 5th factors) were then evaluated. On the basis of eigenvalues of one or greater and interpretability (meaningfulness) three factors were maintained. Factors beyond this "cut-off" point were considered less meaningful and dropped from the analysis since factors of eigenvalues lower than one would not help reduce the data to more comprehensive units (Cooly and Lehner, 1962: 160). The configuration of loadings of the fourth factor resulted in its rejection. The fifth factor was not used because the rotated factor structure is highly sensitive for overfactoring, thus tending to distort results beyond the first few factors (Rummel, 1970: 366). Each of the three retained factors accounts for 5 percent or more of the overall variation in the data. The total

TABLE 1

FOURTEEN VARIABLES--UNROTATED FACTOR MATRIX*

Variables	Factor I	Factor II	Factor III	Communality (h^2)
(1) Land Ownership	(0.76772)	0.07808	-0.08839	0.60330
(2) Farming Experience	-0.12283	(0.85192)	0.16586	0.76836
(3) Age	-0.08930	(0.92538)	0.00160	0.86430
(4) Education Level	0.19213	-0.16780	-0.17154	0.09449
(5) Family Size	0.04709	-0.01319	0.36917	0.13868
(6) Operating Expenditures	(0.84111)	0.06111	-0.10757	0.72277
(7) Sales of Farm Output	(0.97440)	0.09135	-0.17158	0.98724
(8) Employment for Wages	0.38850	-0.01757	-0.02195	0.15173
(9) Net Farm Income	(0.80513)	0.08666	-0.05531	0.65881
(10) Mobility	0.09639	0.01449	0.00466	0.00952
(11) Adoption Score	0.34999	-0.14298	(0.59584)	0.49796
(12) Attitude toward Credit Use	0.32579	-0.23079	0.24325	0.21858
(13) Production Efficiency	0.09938	-0.08246	0.25144	0.07024
(14) Farm Size	(0.58114)	0.15293	0.17800	0.39279
% Total Variance	26.38	12.43	5.32	44.13
% Common Variance	59.98	28.16	12.06	100.00
Eigenvalues	7.69	1.74	0.74	

*Principal axes technique. Unity was employed in the main diagonal of the correlation matrix as a communality estimate. Loadings greater than an absolute value of .30 shown in parentheses.

variation explained is 44.13 percent (26.38 + 12.43 + 5.32).

The major features of this matrix are as follows:

1. The three common factors (columns) are the largest statistically independent (orthogonal) patterns of relationship among the variables.
2. The loadings measure which variables are involved in each factor and to what degree. They are correlation coefficients which show the extent of variance in each variable that can be explained by the factor (Cattell, 1957: 896). The square of the loadings times 100 equals the precent variation that a variable has in common with the unrotated common factor. By comparing factor loadings for all factors and variables, those particular variables involved in an independent factor can be defined, and those variables most closely related to a factor can be identified. For example:

Sales of farm output (var 7) and Factor I	:	$(0.97)^2 \times 100 = 94$
Age (var 3) and Factor II	:	$(0.92)^2 \times 100 = 85$
Adoption (var 11) and Factor III	:	$(0.60)^2 \times 100 = 36$

Mobility (var 10) and Factor II : $(0.01)^2 \times 100 = .01$

Age (var 3) and Factor III : $(0.002)^2 \times 100 = .0004$

A zero factor loading, as in age on Factor III, does not indicate the absence of the factor in the variable but rather that the factor in question does not explain significantly the variance of the variable; i.e., it is not involved in the variable variance (Thurstone, 1947: 341).

3. The loading as the projection of each variable on the factor axes of the data may be employed to give a spatial representation of the findings. Each variable loading can be displayed as a vector in the factor space. As uncorrelated factors they can be represented geometrically as perpendicular or orthogonal axes. However, the factor matrix was too large in this case and hence cannot be shown.

4. For principal axes technique as employed in this analysis the amount of variation in the data explained by each factor decreases successively with each factor. In other words, the first unrotated factor delineates the most generalized patterns of relationships in the

data (26.38 percent) and hence is the strongest. The second factor delineates the next most general pattern that is orthogonal to the first (12.43 percent). The third delineates the third most general pattern orthogonal to the first and second (5.32), and is thus the weakest.

5. The column headed "Communality" displays the proportion of a variable's total variance that is accounted by all the three factors. It is the sum of the squared loadings (h^2) for each variable. For example: the percent of variance in adoption scores (var 11) accounted for by the three factors is the communality times 100: $h^2 \times 100 = (0.50) \times 100 = 50$ percent.

6. The sum of the column of communality values over the number of variables times 100 equals the percent of total variation in the data that is patterned, i.e., the total variance in the data accounted for by the factors.

$$\frac{\Sigma h^2}{14} \times 100 = \frac{6.17 \times 100}{14} = 44.13$$

We could reproduce about 44.13 percent of the total variance among the 336 respondents on the 14 variables by knowing the respondents'

scores on the three factors. This sum (44.13), therefore, measures the order, uniformity or regularity of the data.

7. Percent of total variance among the variables related to a particular common factor measures the amount of data variation in the original matrix that can be reproduced by a single factor; i.e., it measures a factor's comprehensiveness and strength. For example: the correlation of the variables with Factor I = sum of column of factor loadings = $(0.76772)^2 + (-0.12283)^2 + \ldots + (0.58114)^2 = 3.69326$= eigenvalue. The percent of total variance accounted for by Factor I is $\frac{3.69326}{14} \times 100 =$ 26.38 (Rummel, 1970: 137-145).

The initial factor matrix is produced primarily as a means of data reduction. On the basis of this matrix, the number of factors to be retained was evaluated. Even though the unrotated factors define the major clustering in the data, they do not necessarily give the major clusters of interrelationships since unrotated factors are uncorrelated with each other. Simple structure rotation does give the major clusters. (See next section.)

Factor Matrix Rotation

In factor analysis the initial factor solution (unrotated matrix) is usually altered to a solution with more desirable properties. When factors are rotated it is possible to end up with nonperpendicular (unorthogonal) "oblique" factors (linear transformation of the unrotated factors) which fit the cluster more perfectly and provide meaningful patterns of the variables. The aim of the rotation is to obtain a set of factors in which a given factor will be fairly highly correlated with some of the variables but uncorrelated with the rest. Each rotated factor can then be identified with one of the clusters of variables. Thereby the effective number of variables is reduced to several factors.

The rotation criterion used in this analysis is the one most generally applied: simple structure. The multiple factor analysis hence involves the application of principal axes to yield a preliminary solution that is rotated to simple structure. Simple structure attempts to maximize the number of high loadings on each factor, while minimizing the number of factors with high loadings for each variable. This tends to make each factor define a relatively unique configuration of the intercorrelated variables (Fruchter,

1954: 109). The advantage of the rotation is that the factor loadings are conceptually simpler than the unrotated ones since the variables will not load on as many factors as they did in the unrotated solution. Also, the loadings in the unrotated solution depend heavily on the relative number of variables being examined. The rotated factors are more stable in this respect than the unrotated ones (Kim and Nie, 1970: 222). The factors from the rotation may be interpreted as 'classifications, causative agents, basic variables or basic dimensions' of the data. Thus, this rotation technique is useful not only in reducing data to a smaller set of independent factors but also in mapping empirical concepts of a domain or test hypothesis about major sources of co-variation (Rummel, 1970: 338, 344).

Like the unrotated factors, here also, the variance contributions of the factors are decreasing. The first factor measures the most variance, the second and third decreasing proportions of variance.

For comparison, both orthogonal and oblique rotated matrices are given in Tables 2 and 3. Orthogonal rotation only defines uncorrelated factors. Oblique rotation has greater flexibility in searching out factors regardless of their correlations. For the purpose at hand--searching the patterns of

TABLE 2

ORTHOGONALLY ROTATED FACTORS*

Variables	Factor I	Factor II	Factor III
(1) Land Ownership	(0.77270)	-0.04595	0.06428
(2) Farming Experience	-0.00021	(0.87599)	-0.03161
(3) Age	0.07476	(0.90572)	-0.19592
(4) Education Level	0.18769	-0.22584	-0.09090
(5) Family Size	-0.02345	0.06367	0.36617
(6) Operating Expenditures	(0.84424)	-0.7634	0.06485
(7) Sales of Farm Output	(0.99010)	-0.07909	0.02619
(8) Employment for Wages	0.37695	-0.07327	0.06534
(9) Net Farm Income	(0.80443)	-0.03521	0.10229
(10) Mobility	0.09498	0.00229	0.02225
(11) Adoption Score	0.20612	-0.05098	(0.67296)
(12) Attitude toward Credit Use	0.23111	-0.21150	0.34704
(13) Production Efficiency	0.03997	-0.04096	0.25878
(14) Farm Size	(0.55701)	0.11064	0.26512
% Total Variance	25.18	12.43	6.53
% Common Variance	57.04	28.16	14.80
Eigenvalues	4.52	1.74	0.91

*Varimax rotation. Loadings greater than an absolute value of .50 shown in parentheses.

TABLE 5

OBLIQUE ROTATED FACTORS*

Variables	Pattern Factors			Structure Factors		
	Factor I	Factor II	Factor III	Factor I	Factor II	Factor III
1. Land Ownership	(0.78397)	0.01618	-0.02533	(0.77615)	-0.11286	0.13334
2. Farming Experience	0.07596	(0.88567)	-0.01080	-0.07301	(0.87345)	-0.02621
3. Age	0.17081	(0.92411)	-0.18543	-0.01999	(0.90225)	-0.18291
4. Education Level	0.18244	-0.21158	-0.11941	0.19325	-0.23765	-0.07499
5. Family Size	-0.05298	0.05745	0.37569	0.01581	0.05315	0.36293
6. Operating Expenditures	(0.85488)	-0.00866	-0.03377	(0.84946)	-0.14916	0.14017
7. Sales of Farm Output	(1.00811)	0.00106	-0.08994	(0.98967)	-0.16287	0.11479
8. Employment for Wages	0.37503	-0.04396	0.02088	0.38655	-0.10684	0.09858
9. Net Farm Income	(0.81392)	0.02912	0.00982	(0.81109)	-0.10610	0.17412
10. Mobility	0.09569	0.00981	0.01164	0.09643	-0.00645	0.03073
11. Adoption Score	0.14462	-0.04371	(0.65757)	0.28542	-0.09057	(0.68846)
12. Attitude toward Credit Use	0.18732	-0.19946	0.32016	0.28541	-0.24164	0.36515
13. Production Efficiency	0.01346	-0.04162	0.25689	0.07254	-0.05280	0.26107
14. Farm Size	(0.55672)	0.15398	0.20716	(0.57328)	0.05451	0.31487
Sum of Squares	5.59	1.70	0.85			

*Direct Oblimin rotation at 25 iterations. Loadings greater than an absolute value of .50 shown in parentheses.

interrelationships of the variables in the data--oblique rotation seems more fitting. In other words, by oblique simple structure it is meant that the best definition is sought of the uncorrelated and correlated factors, necessary to delineate the clusters of interrelated variables (Rummel, 1970: 147). This is more realistic because the theoretically important underlying dimensions are not assumed to be unrelated to each other (Kim and Nie, 1970: 223).

The oblique simple structure rotation takes place according to a primary axes coordinating system using the direct Oblimin criterion to simplify the pattern matrix and control the obliqueness of the solution. This way the factors will be correlated if such correlations exist in the data (Kim and Nie, 1970: 225). In applying the direct Oblimin criterion, 25 iteration cycles and a δ (delta) value of zero were used to yield factors which are more oblique (Harman, 1960: 336).

The oblique rotation produces two sets of matrices (Table 3)--the factor pattern with loadings of regression coefficients and factor structure with correlation loadings. Between the two, the first shows what variables are involved in each factor. It distinctly shows the patterns or the loadings of the variables on the factors (Rummel, 1970: 148, 479). Hence the factor

pattern is used for the identification and interpretation of the factors (Table 4).

Factor Identification

Identifying the underlying factors is one of the theoretical problems posed in factor analysis. The matrix of factor loadings not only indicates the weight of each factor in explaining the variables but also provides the basis for grouping the variables into common factors. Each variable may reasonably be identified with that factor with which it shows the closest linear relationship, i.e., the factor in which it has the highest loading (Adelman and Morris, 1967: 152-153).

Interpretation entails affixing labels to the oblique rotated factors. The configuration of the simple structure as shown below (Table 4) yields isolated constellations: the variables in each cluster are highly correlated and have very low correlations with the variables in the other clusters. In other words, each variable is a relatively pure measure of its factor (Fruchter, 1954: 111). The three factors are identified by descriptive (typological) labels which embody the patterns of interrelationships defined by the factors.

TABLE 4

ROTATED (OBLIQUE) FACTOR LOADINGS*

Variables	Factor I	Factor II	Factor III
(7) Sales of Farm Output	1.00811	0.00106	-0.08994
(6) Operating Expenditures	0.85488	-0.00866	-0.03377
(9) Net Farm Income	0.81392	0.02912	0.00982
(1) Land Ownership	0.78397	0.01618	-0.02533
(14) Farm Size	0.55672	0.15398	0.20716
(8) Employment for Wages	0.37503	-0.04396	0.02088
(10) Mobility	0.09569	0.00981	0.01164
(3) Age	0.17081	0.92411	-0.18543
(2) Farming Experience	0.07596	0.88567	-0.01080
(4) Education Level	0.18244	-0.21158	-0.11941
(11) Adoption Score	0.14462	-0.04371	0.65757
(5) Family Size	-0.05298	0.05745	0.37569
(12) Attitude toward Credit Use	0.18752	-0.19946	0.32016
(13) Production Efficiency	0.01346	-0.04162	0.25689

*Each variable is assigned to the factor pattern which has the highest loading for the variable.

Factor I.--The variables which loaded most heavily on Factor I included: sales of farm output, operating expenditures, farm income, land ownership and farm size.

Factor I, which is a group factor, may be interpreted to represent economic resources which are of both cash and fixed natures. It also points to the commercialization of the farm as reflected by the volume of sales and the net farm income. Operational expenditures indicate the importance of the availability of capital as one of the major differentiating (discriminating) variables among the total number of farmers.

In terms of non-cash resources, landholdings and farm size loaded heavily on this factor. Factor I accounts for 61 percent of the variation in ownership and 31 percent of the variation in farm size.

Off-farm income also loads significantly, though not so heavily. The loadings of non-economic resources variables on this factor, such as individual personality characteristics and sociological variables, are low. Examples included are the case with age, education level, mobility, family size and adoption. However, as shown in the table, apart from Factor III, it is on this first factor that the adoption variable loads most positively.

Factor II.--Factor II accounts for 12.43 percent of the total variance. It is based primarily on only two variables: age and farming experience expressed in years. Hence, it is a "double" factor. It accounts for 77 and 85 percent respectively of the variations in age and experience.

In Factor II education level, attitudes toward credit use, farm income, adoption score, production efficiency and operating expenditures loaded negatively. Time span is an appropriate name for this factor. It implies that in spite of more years of life and farming experience, older persons generally tend to have less capital expenditure and farm income. They also have had less school years completed. They don't have significantly favorable attitudes toward borrowed capital. Their production efficiency is lower and they score lower on adoption of new practices, too.

Factor III.--This is a specific factor with only one high loading. The only variable which loads significantly is adoption. Factor III accounts for 44 percent of the variation in adoption among the total sample.

Next to adoption, characteristics of family size, attitude toward credit use, and production efficiency

load high, though not as significantly as adoption. The positive relationship of these variables to adoption is also clear in the correlation matrix. In view of the transcendent dimension which relates these variables to each other as some sort of prerequisite to adoption, Factor III represents motivation.

Family size varies positively with adoption. This is probably because its operational definition included "all dependents in the household." The well-to-do farmers may have higher numbers of dependents or household members, thus providing their farms with a good supply of labor.

The factorial analysis of the first order oblique rotated factors using 14 variables thus led to the retention of three factors. They were:

1. economic resources,
2. time span, and
3. motivation.

These factors constituted the major variations or differences (44 percent) among the total sample. In other words, the three clusters now form the independent factors and the variables are the dependent ones.

The major hypothesis for this study was that the degree of farmers' readiness for innovative adoption is a function of the individual personal characteristics,

the nature of the farm and structural factors. In terms of the major hypothesis, the independent factors or determinants of adoption included motivation and attitude, resource endowment of the farm and age of the farm operator. The percent of variance in adoption explained by each factor was as follows:

Percent of Variance in Adoption Explained	Factor
43.56	Motivation
1.96	Economic Resources
0.16	Time Span
45.68	

About 46 percent of the variation was explained by the three factors. The implications of these findings are that farmers who adopt more practices are:

1. more highly motivated: they are more efficient producers, and are favorably oriented toward the use of borrowed capital;
2. better endowed with farm resources and are market oriented; and
3. younger in age and as a result have fewer years spent on farming.

The factorial method was used for the study of individual differences among farmers as an approach to

study the processes which underlie the differences.

The three factors--motivation, resource endowment and time span--have produced nearly 46 percent of the difference in adoption behavior of individuals. The implications of this are suggested above. This identification of the independent clusters for adoption and the examination of their nature and implications has shown the presence of the postulated parameters and, as a result, the major hypothesis is sustained.

Adoption Groups and Factor Loadings

To test the accuracy of the factors as measures of variance among the total sample, and to be in a better position to relate individual characteristics to adoption behavior, further analysis was conducted. The total sample of 336 farmers was divided into three groups on the basis of the 1965 adoption scores (percentage of practices adopted): high adopters (75.00 to 100.00), medium adopters (42.00 to 74.99), and low adopters (00.00 to 41.99). The next step was to check these groups on the three independent factors, specifically the variables which loaded high on each factor.

Statistics of variables which loaded high in Factor I (Table [illegible]) show that the five variables not only account for the major variation among the total

TABLE 5

ADOPTION GROUPS AND CHARACTERISTICS OF FACTOR I (ECONOMIC RESOURCES)

Variable	1985 Mean Scores			
	High Adopters (N = 115)	Medium Adopters (N = 102)	Low Adopters (N = 119)	Total Sample (N = 336)
Sales (NCR)[a]*	3280.14	1849.57	834.67	1979.76
Oper. Expenditures (NCR)*	1702.09	758.78	222.41	891.67
Net Farm Income (NCR)*	2100.48	1621.94	1152.27	1619.38
Land Ownership (ha.)*	49.82	39.75	22.74	37.17
Farm Size (Code)[b]*	3.00	2.69	2.26	2.74
Employment Wages (NCR)	114.20	192.52	40.97	112.04
Mobility (# Trips)	2.90	1.90	1.17	1.00

*Variables which loaded high on Factor I.

[a]NCR = New Cruzeiros.

[b]

Code	Area
0 = [illegible]5.0	to 9.9 ha.
1 = 10.0	to 14.9 ha.
2 = 15.0	to 19.9 ha.
3 = 20.0	to 29.9 ha.
4 = 30.0	to 49.9 ha.
5 = [illegible]	to [illegible] ha.
6 = 100.0	to 199.9 ha.
7 = 200.0	to 499.9 ha.
8 = 500.0	to 1499.9 ha.
9 = 1500.0	or more ha.

sample but also indicate clear patterns among adopter groups.

In translation of "real" cases, the high adopters are those who have land resources, capital for expenditures, high off-farm income, and are more commercialized. This combination results in higher net income, and vice versa for the low adopters.

The high adopters are younger in age and years spent on farming; hence the negative relation of the age factor to adoption behavior. Education does not seem to be very discriminating (Table 6).

The higher adopters were persons with favorable attitudes toward credit use (Table 7). They were found to have more family (household) members, and higher production efficiency. A further examination of the loan situation of those groups in 1965 showed that the high adopters had twice as many loans as the low adopters and a significant amount above the medium adopters. The large number of cases who had never had loans confirmed the findings. There were many who had never had a loan among medium adopters and more among the low adopters (more than twice that of the high adopters). In other words, the better adopters not only had favorable opinions toward credit use but also made more use of borrowed capital.

TABLE 6

ADOPTION GROUPS AND CHARACTERISTICS OF FACTOR II (TIME SPAN)

Variable	1965 Mean Scores			
	High Adopters (N = 115)	Medium Adopters (N = 102)	Low Adopters (N = 119)	Total Sample (N = 336)
Age (yrs.)*	40.85	43.89	44.82	43.18
Farming Experience* (yrs.)	17.22	19.31	19.11	18.52
Education (yrs. in school)	3.04	2.92	3.03	3.0

*Variables which loaded high on Factor II.

TABLE 7

ADOPTION GROUPS AND CHARACTERISTICS OF FACTOR III (MOTIVATION)

Variable	1965 Mean Scores			
	High Adopters (N = 115)	Medium Adopters (N = 102)	Low Adopters (N = 119)	Total Sample (N = 336)
Adoption Score* (%)	89.04	54.46	18.14	53.43
Family Size (No. of Dependents)	6.54	6.29	5.59	6.13
Attitude Toward Credit Use (0-12 scale)	7.12	6.38	5.57	6.35
Production Efficiency (%)	53.21	38.95	33.91	42.05

*Variable which loaded high on Factor III.

The profile of the "real" respondents--i.e., individuals in the sample population identified by the factors--was as follows. High adopters:

1. are ycunger in age;
2. have higher socio-economic status (i.e., income, land ownership);
3. have larger farm units;
4. are more market oriented;
5. have favorable attitudes toward credit use and have more loans;
6. have more capital for farm expenditures;
7. are more efficient producers;
8. have larger households;
9. have more off-farm income than low adopters;

and vice versa for the low or non-adopters.

In short, the high adopters are younger, wealthier farmers with larger farm units. Education level does not seem to produce much difference, apparently because the general education level for all of the respondents was around three years of schooling. Specialization in farm enterprise was not very discriminatory since most farms were specialized. More than 50 percent of the hog farms, however, were in the high adopter groups, while many of the cattle farmers were low adopters.

Adoption Prediction with Factor Scores

The second hypothesis of this study was that factor scores would predict adoption better than individual variables. Factor analysis was completed a second time without the adoption variable in order to better specify the relationship of adoption to the factors. From the thirteen variables, again three factors were extracted:

Factor	Eigenvalue	Percent of Variance	Cumulative Percent
1	3.624	27.88	27.88
2	1.747	13.44	41.32
3	0.488	3.75	45.08

By omitting adoption the three factors extracted explained 45.08 percent of the over-all variation in the data. This compared with 44.13 percent when fourteen variables including adoption were used, indicating considerable variability in the adoption variable (Francis, 1971: 93). Though the new factors explained more variation, they did not produce a meaningful pattern matrix without the adoption variable included.

The principal axes method was used to estimate the factors. To define the best set of factor scores, the true weighting of all variables (or the complete

estimating method) was used, whereby instead of only variables with high loadings all variables were included. Thus, some variables were simply used as suppression variables to increase the accuracy of the estimate of the given factor. In other words, each of the thirteen variables was weighted proportionally to its involvement in a factor: the more involved a variable, the higher the weight. Variables not at all related to a factor would be weighted near zero (Cattell, 1957: 290). (See Appendix E)

To determine the score for each respondent on a factor, then, the respondent's data on each variable are multiplied by the factor weight for that variable. The sum of these "weight times data products" for all the variables yields the factor score. Corresponding to the values of the variables involved with a factor the weighted summation will give respondents high or low standard scores.

The factor scores are to be interpreted as data on any variable are interpreted (Rummel, 1971: 152). Since the adoption variable was not included in getting the factor scores, they could be used for further study of adoption without risking circularity of argument (Cattell, 1957: 38).

A detailed survey of the 1969 data showed that

during the previous five-year period no particular new agricultural practices were introduced into the area. However, there was some expansion in the same set of practices which may have been new for some and a continuation for others.* Since the objective of the factor analysis was the discovery of underlying patterns rather than the mere study of individual differences, a new adoption score was calculated for 1969 for each respondent regardless of his score on some or all of the practices adopted in the past (1965). The calculation of adoption scores involved, as before, the percentage of applicable practices adopted by each respondent.

The last step taken in this analysis and in accord with the second hypothesis was to use the factor scores of the respondents as data for prediction of the 1969 adoption score. However, both the multiple regression analysis and Kendall's correlation showed that individual variables were better predictors than factor scores. This was also the finding of Francis (1971: 93) in his study of West African farmers' adoption behavior. A

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*For some details see Norman Rask, "Technological Change and the Traditional Small Farmer of Rio Grande Do Sul--Brazil," Economic and Sociological Occasional Paper No. 85, Department of Agricultural Economics and Rural Sociology, Ohio State University, June, 1972.

factor analysis of the factor scores with the 1969 adoption score confirmed this, as shown below:

TABLE 8

ROTATED MATRIX OF FACTOR SCORES WITH 1969 ADOPTION SCORE*

Variables	Factor A	Factor B
Factor Score 1	(0.54677)	-0.37400
Factor Score 2	-0.42064	-0.05382
Factor Score 3	0.08691	(0.54742)
Adoption Score (1969)	0.33100	0.08296

*Loadings greater than an absolute value of .50 shown in parentheses.

The rotated matrix showed that only the economic and motivational factor scores loaded relatively heavily, and they loaded on different factors. However, the variation in the adoption variable was explained little by the two factors and principally by the factor associated with economic resources. Hence, both the regression and factor analyses did not bear out the hypothesis that factor scores would predict adoption better than individual variables.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This research was part of a series to study the process of capital formation and technological innovation at the farm level in developing countries. The locale for this study was the two southern states of Brazil, Rio Grande do Sul and Santa Catarina. Data were collected from farmers on a purposeful random sample basis both in 1966 and 1970 for the previous years (1965 and 1969) of operation. Initially the intention was to study the factors which accounted for the differences among the individual respondents in their readiness for innovative adoption of agricultural practices. By readiness was meant having a favorable combination of individual personality characteristics. Structural as well as socio-economic features were considered which would render it possible for an individual farmer to adopt feasible and relevant farm practices. Once the sources of this variation among the respondents were established the objective was to check if major changes had occurred in the five years since,

and measure and account for the changes that took place. Accordingly much effort was put into choosing, from the over one thousand cases in the total sample, those respondents whose identity could be matched for both periods. The retained sample size was 336. A careful check of 1969 data, however, did not show new practices introduced in the area and hence, the present analysis is largely only for 1965.

The central hypothesis for this research was that the degree of farmer's readiness for innovative adoption is determined by a combination of individual personality characteristics, the nature of the farm and structural factors. This hypothesis was thought to have a better perspective than many researches done on this topic which have unduly emphasized only one or two aspects of the determinant factors (see Review of Literature).

The search for the basic underlying source of the variation in adoption behavior and the possibility of using a large number of variables to test the hypothesis lent itself to the use of factor analysis. Factor analysis can be used beneficially not only to reduce the data but also to delineate the patterns of variation in the major characteristics of the sample population.

The model used was component factor analysis. This model is concerned with all the variation in a set of variables, whether common or unique. Initially fifteen variables were selected for investigation on the basis of their theoretical importance, availability of data and the researcher's judgment of their relevance for the study. One of the variables was market accessibility--the distance farmers have to travel to sell farm outputs and/or purchase farm inputs--as a structural factor. However, a detailed survey of the data showed that most of the marketing function was done within a distance of nine kilometers (five + miles). This variable as operationally defined was thus not found to be discriminating. It was not, therefore, included. The final list of variables used in the analysis included: land ownership, farming experience, age and education of the farm operator, family size, operating expenditures of the farm, sales of farm output, employment for wages (off-farm incomes), net farm income, mobility, adoption score for 1965, attitude toward credit use, production efficiency index, and farm size.

Using principal axes and simple structure for the rotation, the factor analysis extracted three common factors from the fourteen variables. These were titled

"economic resources," "time span," and "motivation." Both Kaiser's varimax and direct oblimin methods were used respectively to extract the orthogonal and oblique rotation of the factors. Criteria of eigenvalues of one and interpretability were used for the number of factors retained.

Together the three factors explained 44.13 percent of the variance in the data. The first and strongest factor was "economic resources" including significant loadings of five of the fourteen variables. This factor which explained 26.38 percent of the variance reflected a heavy concentration of resource variables, market orientation and sales value of farm output. Capital expenditures, income and landownership were included in it.

The second factor, "time span," was a double factor with high loading by age and farming experience. It explained 12.43 percent of the over-all variance. This factor reflected the time span in age and years spent in farming. Education level as measured in years spent in school loaded negatively on this factor.

The third factor, "motivation," included a significant loading from one variable, adoption, and relatively high loading by attitude toward credit use and the production efficiency index. The percent of

variance explained by Factor III was 5.32. This factor reflected a high level of favorable attitude and readiness for adoption.

In terms of the major thrust of this study, the analysis indicated that the variation in adoption behavior of the farm respondents was more closely associated with or influenced more by attitudinal, motivational and managerial (sociological) variables than by economic ones like resource ownership.

The motivation factor explained 44 percent of the variation in adoption scores, while the economic factor explained two percent and the time span less than two-tenths of one percent. Further examination of the variables which loaded heavily on each of three factors identified those who were higher adopters to be highly motivated, well endowed with resources, market oriented and younger in age than the lower or non-adopters. This inference was also collaborated by other studies in one of the states (Rask, 1972: 2-29; Sturn and Riedle, 1972: 16-23). Moreover, in a number of respects, the characteristics of the higher adopters were similar to those of early adopters: social status (income, land ownership, . . .), farm size, competence in farm technology, market orientation, and favorable

attitude toward credit (Francis, 1971: 101; Rogers, 1971: 185-186).

For explanation of over-all variation in the data (the characteristics of the respondents) the economic factor accounted for more. But for variation in adoption score the attitudinal and motivation factor was more important.

In terms of specific variables, age and farming experience showed negative relation to adoption. Education level did not show much discriminatory capacity. The education level of respondents was mostly around three years of schooling, and having not much variation itself, it did not account for much variation explanation either in total data or in the adoption variable. Sturn and Riedle (ibid.: 19, 22) in a similar study also found this to be the case with both the education and age variables.

Mobility, defined here as the number of trips over 100 kilometers (60 miles) taken in a year by the farm operator within the state, did not load much either. Again this might be because the number of such trips was few, averaging about one in a year.

Availability of credit was an important structural influence. Those who had favorable attitudes toward the use of borrowed capital and who used more loans

were among the higher adopters. They seemed to have a positive attitude toward the adoption of other practices too (Rogers, 1971: 110).

Family size defined as the number of dependents in the household loaded relatively high on the factor associated with adoption (Factor III). This could be because of the high demand for labor on those farms which used more and varied new practices and inputs or because more people come to join higher income households (Sturn and Riedle, ibid.: 3). Rask (1972: 29) and Sorensen (1968: 151) also found that farms which had not kept pace with the general rates of income growth and technological change were limited not only in land resources but also in family labor.

The identification of the factors, interpretations of the meaning of their nature and characteristics sustained the major hypothesis postulated for variation in adoption behavior. Factor scores were generated for each respondent which were then used for prediction of the 1969 adoption score. Use of these scores as variables in multiple regression, Kendall's correlation and another factor analysis showed that individual variables are better predictors of adoption than the factor score.

It is realized that the outcome of this factor analysis was influenced by a number of conditions. Some of these were:

1) Selection of the sample

The sample, though somewhat representative, was not completely random. Furthermore, it included a wide range in the values of the variables used. Hence it was more useful for the identification of the underlying factors in adoption behavior than for generalization to the entire area of southern Brazil.

2) Type of correlation coefficient used

The most satisfactory type of correlation coefficients for continuous variables are product moment correlations, i.e., the most consistent results are obtained when distributions have been normalized. However, correlation coefficients of raw scores were used in this analysis. This should not unduly affect the result since linear relation is assumed in factor analysis and simple structure was used for factor rotation (Fruchter, 1954: 201; Thurstone, 1947: 309, 369).

3) Selection of variables

The nature of the variables accounts significantly for the emergence of unique factors. In the case of this study, the selection of the variables was obviously limited as the information was from a secondary

data source. Perhaps, had the data been more complete, more variables should have been used. If this had been the case, a factor analysis of the 1969 data would have provided more information, e.g., variables in communication behavior, and this might have influenced the factor content. One other danger was the inclusion of variables which were not independent, e.g., farm size and landownership. Each included a significant amount of the other with a possible creation of auto correlations.

4) Interpretation of factors

The factor analysis yielded three factors. An effort was made to interpret the characteristics and implications of these clusters and the kind of individual differences they produce. The factor analysis has revealed some aspects of the underlying order of adoption behavior. The factors underscored the importance for adoption of farm practices of (a) favorable attitude and motivation toward change; (b) availability of farm resources: capital, land and labor; and (c) commercialization of farm output.

In this respect, the factor study was successful, as Thurstone (1947: 179-180) suggested, to the extent that meaningful factors were identified by a proper choice of reference axes even if the factors identified

would account only for a part of the variance of the adoption variable (46 percent), leaving some considerable parts still to be identified. In other words, more research is required before generalizations can safely be made. The nature and extent of the factors could be studied as a next step by factor and nonfactor methods to determine how they vary under different conditions and with different populations.

APPENDIX A

BASIC STATISTICS OF VARIABLES

Variable	Mean	Standard Deviation	Cases
(1) Land Ownership (ha.)	37.1719	73.9329	336
(2) Farming Experience (yrs.)	18.5238	10.8339	336
(3) Age (yrs.)	43.1815	11.1511	336
(4) Education Level (yrs. of schooling completed)	3.1071	1.7655	336
(5) Family Size (total dependents in household)	6.1280	2.5495	336
(6) Operating Expenditures (NCR)*	891.6726	3062.9553	336
(7) Sales of Farm Output (NCR)*	1979.7559	4966.5156	336
(8) Employment for Wages (off-farm income) (NCR)*	112.0387	540.4795	336
(9) Net Farm Income (NCR)*	1619.3838	2189.9036	336
(10) Mobility (number of trips over 100 Kms per yr.)	1.2917	7.8962	336
(11) Adoption Score (%)	53.4318	31.8280	336
(12) Attitude toward Credit Use (0 to 12 scale)	6.3482	2.0342	336
(13) Production Efficiency Index (%)	42.0454	27.9584	336
(14) Farm Size (Code)**	2.7440	1.6963	336

*NCR = New Cruzeiros

**Code		Area		
0 =	5.0	to	9.9	ha.
1 =	10.0	to	14.9	ha.
2 =	15.0	to	19.9	ha.
3 =	20.0	to	29.9	ha.
4 =	30.0	to	49.9	ha.
5 =	50.0	to	99.9	ha.
6 =	100.0	to	199.9	ha.
7 =	200.0	to	499.9	ha.
8 =	500.0	to	1499.9	ha.
9 =	1500.0	or more		ha.

APPENDIX B

VARIABLE CORRELATION COEFFICIENTS

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Land Ownership	1.00000	-0.06215	-0.00836	0.16601	0.00263	0.65889	0.70784
(2) Farming Experience	-0.06215	1.00000	0.80729	-0.19100	0.06014	-0.07817	-0.05574
(3) Age	-0.00836	0.80729	1.00000	-0.16884	-0.06633	-0.00362	-0.00935
(4) Education Level	0.16601	-0.19100	-0.16884	1.00000	-0.09590	0.11846	0.16315
(5) Family Size	0.00263	0.06014	-0.06633	-0.09590	1.00000	-0.04990	-0.04474
(6) Operating Expenditures	0.65889	-0.07817	-0.00362	0.11846	-0.04990	1.00000	0.90730
(7) Sales of Farm Output	0.70784	-0.05574	-0.00935	0.16315	-0.04474	0.90730	1.00000
(8) Employment for Wages	0.29467	-0.06631	-0.04377	0.15170	-0.00544	0.33069	0.35343
(9) Net Farm Income	0.63252	-0.01509	-0.00935	0.17811	0.05680	0.62435	0.58069
(10) Mobility	0.06425	0.00746	0.01604	0.03158	0.07376	0.11286	0.11002
(11) Adoption Score	0.18447	-0.07465	-0.14221	-0.01537	0.20575	0.24087	0.24671
(12) Attitude toward Credit Use	0.16720	-0.17693	-0.23413	0.10678	0.10592	0.2[illegible]	0.2[illegible]
(13) Production Efficiency Index	0.02175	-0.03981	-0.08141	-0.03302	0.02075	0.07839	0.06883
(14) Farm Size	0.57059	0.06124	0.09936	0.08195	0.19189	0.44599	0.47197

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Land Ownership	0.29467	0.63252	0.06425	0.18447	0.16720	0.02175	0.57059
(2) Farming Experience	-0.06631	-0.01509	0.00746	-0.07465	-0.17693	-0.03981	0.06124
(3) Age	-0.04377	-0.00935	0.01604	-0.14221	-0.23413	-0.08141	0.09936
(4) Education Level	0.15170	0.17811	0.03158	-0.01537	0.10678	-0.03302	0.08195
(5) Family Size	-0.00544	0.05680	0.07376	0.20575	0.10592	0.02075	0.19189
(6) Operating Expenditures	0.33069	0.62435	0.11286	0.24087	0.26085	0.07839	0.44599
(7) Sales of Farm Output	0.35343	0.58069	0.11002	0.24671	0.26066	0.06883	0.47197
(8) Employment for Wages	1.00000	0.29263	0.06706	0.10191	0.18021	0.03342	0.26056
(9) Net Farm Income	0.29263	1.00000	0.05766	0.21942	0.23006	0.0[illegible]	0.44784
(10) Mobility	0.06706	0.05766	1.00000	0.02821	0.06260	-0.04174	-0.00577
(11) Adoption Score	0.10191	0.21942	0.02821	1.00000	0.32206	0.23210	0.2[illegible]73
(12) Attitude toward Credit Use	0.18021	0.23006	0.06260	0.32206	1.00000	0.11102	0.17144
(13) Production Efficiency Index	0.03342	0.0[illegible]	-0.04174	0.23210	0.11102	1.00000	0.[illegible]
(14) Farm Size	0.26056	0.44784	-0.00577	0.27273	0.17144	0.0[illegible]	1.00000

APPENDIX C

FACTOR CORRELATION MATRIX FOR
THE OBLIQUE FACTORS

	Factor I	Factor II	Factor III
Factor I	1.00000		
Factor II	-0.16572	1.00000	
Factor III	0.20311	-0.03481	1.00000

APPENDIX D

TRANSFORMATION MATRIX FOR THE ORTHOGONAL FACTORS

	Factor I	Factor II	Factor III
Factor I	0.96793	-0.13228	0.21359
Factor II	0.17450	0.96560	-0.19276
Factor III	-0.18074	0.22385	0.95772

APPENDIX E

FACTOR SCORE COEFFICIENTS

Variables	Factor I	Factor 2	Factor 3
(1) Land Ownership	0.09309	-0.01111	0.21980
(2) Farming Experience	-0.07556	0.04592	0.27944
(3) Age	0.05076	0.92958	-0.35217
(4) Education Level	0.02985	-0.02294	-0.05591
(5) Family Size	0.11580	0.03686	0.09836
(6) Operating Expenditures	-0.57289	0.05085	1.70238
(7) Sales of Farm Output	3.39429	-0.26832	-3.33979
(8) Employment for Wages	-0.00639	-0.01647	0.07515
(9) Net Farm Income	-1.32249	0.09329	1.61839
(10) Mobility	-0.03980	-0.00930	0.06634
(12) Attitude toward Credit Use	0.05053	-0.01137	0.04038
(13) Production Efficiency Index	0.00781	0.00624	0.02197
(14) Farm Size	0.22630	-0.04009	0.47325

APPENDIX F

FARM PRACTICES USED FOR CALCULATING ADOPTION SCORES--1965

Adoption Score based on Percent of Practices adopted:

$$\frac{\text{Number of Practices Adopted}}{\text{Number of Practices Applicable}} \times 100$$

For Crop Farms

1. Use of improved seeds
2. Use of fertilizer
3. Application of insecticides and fungicides

For Hog Farms

2. Raising of improved breeds
2. Use of balanced ration
3. Vaccination of hogs
4. Treatment of hogs for worms

For Livestock Farms

1. Raising of improved breeds
2. Use of vaccination
3. Treatment for ticks
4. Use of improved pasture

For General Farms

1. Raising of improved breeds
2. Use of vaccination
3. Treatment for ticks
4. Use of improved seeds
5. Use of fertilizer for crops
6. Application of insecticides and fungicides to crops
7. Use of improved pasture

APPENDIX G

ITEMS USED TO MEASURE ATTITUDE TOWARD CREDIT USE

Scale (0 to 12) constructed with the method of summated ratings:

1. Loan situation

   0 = never had a loan

   1 = has loans in preceding year but not in '65

   2 = has 1 to 4 loans in effect in 1965

   3 = has 5 to 8 or more loans in effect in 1965

2. Number of purchases on credit

   0 = none

   1 = 1

   2 = 2

3. Generally, the rural entrepreneur can increase his income by using credit

   0 = disagree

   1 = no answer or undecided

   2 = agree

4. I consider myself to take more risks than the average owner-operator

   0 = disagree

   1 = no answer or undecided

   2 = agree

5. It is better for a farmer to have the least number of loans possible

   0 = agree

   1 = no answer or undecided

   2 = disagree

6. It is more convenient for the rural entrepreneur to borrow now than before

   0 = has no opinion

   1 = has opinion

APPENDIX H

PRODUCTION EFFICIENCY INDEXES BASED ON FARM TYPES--1965

Crop Farms

Crops used in each municipio:

Lajeado	Carazinho	Concordia	Timbo
Corn	Corn	Corn	Corn
Soybean	Wheat	Wheat	Rice

$$\frac{\text{Production last year per ha. for each crop}}{\text{Normal production of the crop per ha.}} = \%$$

$$\frac{\text{Production this year per ha. for each crop}}{\text{Normal Production of the crop per ha.}} = \%$$

0 if < 100%

1 if ≥ 100%

Scale: 0 to 4 converted to percentage

Hog Farms

1. Number of pigs weaned per year per sow

   0 if < 11*

   1 if ≥ 11

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*Figures for criteria are based on means from the sample of hog farms.

2. Age in months when fattened hogs are sold

   0 if > 12*

   1 if ≤ 12

3. Average weight of hogs in Kms when sold

   0 if > 97*

   1 if ≤ 97

Scale: 0 to 3 converted to percentage

Livestock Farms

1. Age in years when heifers are first bred

   0 if > 3.0**

   1 if ≤ 3.0

2. Age in months when calves are weaned

   0 if > 3**

   1 if ≤ 3*

3. Availability of improved pasture on the farm

   0 if No

   1 if Yes

Scale: 0 to 3 converted to percentage

---

*Figures for criteria are based on means from the sample of hog farms.

**Figures based on means from the sample of livestock farms.

General Farms

1. Age in years when heifers are first bred

   0 if > 3

   1 if ≤ 3

2. Age in months when calves are weaned

   0 if > 3

   1 if ≤ 3

3. Availability of improved pasture on the farm

   0 if No

   1 if Yes

4. $\frac{\text{Production last year per ha.}}{\text{Normal Production per ha.}} = \%$

5. $\frac{\text{Production this year per ha.}}{\text{Normal Production per ha.}} = \%$

   for two crops in each municipio

Scale: 0 to 7 converted to percentage

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