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INCORPORATION OF TECHNOLOGY IN THE ARGENTINE LIVESTOCK SECTOR FROM AN INSTITUTIONAL PERSPECTIVE

By

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DEDICATION

With gratitude and appreciation to

Marta and Fabiana, and my parents.

"Y es misterio tan profundo
Lo que esta por suceder,
Que no me debo meter
A echarla aqui de adivino:
Lo que decida el destino
Después lo habran de saber."

José Hernandez
"Martin Fierro" (Poema Argentino)

ABSTRACT

INCORPORATION OF TECHNOLOGY IN THE
ARGENTINE LIVESTOCK SECTOR FROM AN
INSTITUTIONAL PERSPECTIVE

By

Roberto Mario Bocchetto

This study analyzes the use of technology in the breeding-livestock region of Argentina as a means to illustrate the role that research-extension institutions should play in inducing technological change at the farm level. Gaps exist between the potential technological levels generated by INTA (the principal public agricultural research and extension agency in Argentina) and the state of technology at the farm level. Increased compatibility between the supply and demand for technology depends on increasing communication and coordination between the government, INTA and agricultural producers.

A Model of Mutual Causation was proposed to help coordinate the behavior of these three participants in the process of technological change. This model is built on an application of the Induced Innovation Model to Argentine conditions and the Institution Building Model. The analysis of the generation of technology in the Argentine agricultural sector reveals that INTA, through its research and extension centers throughout the country, should act as the catalytic agent within the Model of Mutual Causation. INTA should provide the government with a technological diagnosis of the different productive regions, showing the main factors that limit or delay the incorporation of technology. The lack of this strategic information is one of the factors which has prevented the government from taking appropriate political decisions about the technological process.

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The main purpose of the technological diagnosis is to identify groups of farms that within a homogeneous ecological area show similar behavior in the assimilation of innovations, i.e., the actual production systems. A conceptual framework is developed to study the technological behavior of the production systems. Four basic components are recognized for analysis, i.e., the farm productive structure, producer characteristics, the technological package in use, and the interaction of farmers with their socio-economic context.

The analytical procedure covers the identification of actual production systems, a technological diagnosis, and the analysis of resource allocation by systems of production. The identification stage comprises exploration of the sample, classification of farms and characterization of the systems.

The conceptual framework was applied to a sample of livestock producers in Ayacucho County, which is located in the most important cattle breeding region in Argentina. Exploration of the sample revealed two relevant dimensions to understand the incorporation of technology in breeding-livestock enterprises, the farm size dimension and the intensity of land use dimension. These dimensions helped identify four actual production systems. The basic dissimilarities among these systems are based on farm size, the proportion of factors used, the producer's disposition toward technical change, his dedication to the farm, interaction with the rural context, technical inputs in use and extent of fattening activities.

A critical farm size must be reached before farmers are able to generate their own financial capacity. The smallest sized production system does not reach that critical level. The medium sized system devoted to fattening operations, using an intensive proportion of factors, and with high dedication of the producer and technical level, has the highest land productivity. However, profitability is the basic condition that justifies the existence of different production functions for a farm size higher than the critical level.

Structural characteristics are the basic factor affecting the technological behavior of breeding-livestock producers under existing economic policies. The interaction of farmers with their socio-economic context does not appear to be a limiting factor in the adoption process. There was not a substantial change in the conditions of breeding-livestock production between 1968 and 1977. Under the prevailing economic policies, structural conditions, and technical know-how already available at the farm level, there is little reason to expect any significant change in the state of technology of the breeding-livestock region.

Increased land productivity is an overall social goal for Argentina. However, conditions in the breeding-livestock region indicate technological heterogeneity without dominance in profitability under prevailing economic policies. Modification of these conditions requires an explicit definition of governmental policy, both at the farm level and for research-extension activities. As a result, INTA should be able to set up priorities in the planning of research and extension activities according to the structural characteristics of the production systems and market conditions. This coordination should improve the compatibility between the supply and demand for technology, and the social performance of the technological process.

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CHAPTER I

INTRODUCTION

1.1 Background and Problem Setting

It has been a common practice to divide Argentina geographically into two major agricultural regions: the Pampean Region and the rest of the country. The Pampean Region covers practically the entire Province of Buenos Aires and Entre Rios, the center and southern part of Santa Fé, the east and southern part of Córdoba and the northeastern part of the Province of La Pampa. The rest of the country is comprised of the Northeastern Region, the Northwestern Region, the Area of Cuyo (western region), and the Patagonia (southern region). This division takes into account ecological characteristics, features of the agricultural production structure and the characteristics of internal and external markets. The Pampean Region is a primary producer of grains and beef which are major export products. The rest of the country mainly produces fruit and industrial crops (sugar cane, tobacco, cotton, tung and yerba mate) which are consumed domestically.

The Pampean Region is one of the best endowed areas in the world for the growing of crops and the grazing of livestock, having excellent soils and climate for agricultural production. However, during the present century the agricultural output of the Pampean Region has suffered decreasing rates of growth, showing in some periods actual declines in production.

Until 1920 production grew rapidly based on the horizontal expansion of agriculture into virgin lands. The following decade showed a more intensive use of capital and labor per hectare, which became effective through the substitution of crops for previous extensive livestock production on native pastures. In this period of growth, technology was introduced into the agricultural sector through European immigrants, who had to adapt their technical know-how to the conditions of extensive agricultural production in the Pampean Region. At the same time, the government established the first experimental research stations and regional agricultural offices to try to endow the agricultural sector with a basic structure for the generation and diffusion of technology.[1]

As a result of the world-wide economic depression of the 1930s, production in the Pampean Region increased slowly until 1944. In this period, it was difficult to export agricultural products; internal prices dropped and the government intervened directly by creating the "Junta Nacional de Granos" (National Grain Board) and the "Junta Nacional de Carnes" (National Meat Board) in order to regulate prices and the marketing process. In this period, government did not focus attention on the process of technological innovation that had begun in Europe and the United States.

Following 1944, the level of agricultural production in the Pampean Region decreased until 1956. In this period livestock gradually displaced grain production. Simultaneously, national industry was being developed based on a process of substitution for imported industrial consumption goods. This process was protected by governmental policies transfering

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[1]The basic information for this overall diagnosis is taken from: Piñeiro, M. (Noviembre, 1975), pp. 7-16.

income from the agricultural sector to urban sectors. It appears that the mechanization of the agricultural sector was initiated as labor migrated to the industrial cities (mainly Buenos Aires) looking for a better salary level and a more comfortable environment. The substitution of capital for labor increased the productivity of labor but did not increase the aggregate level of agricultural output.

Meanwhile, other countries, especially the United States, were developing new technology which intensified land use through biological and chemical innovations. At the same time, the operative structure of research-extension institutions in these countries was strong.

Argentina remained isolated from this process of change until the end of the 1950s. The change in the economic-political structure in 1956 increased the recognition of the importance of agriculture within the national economy, particularly the necessity to increase agricultural exports. To attain this objective, the government focused attention on the creation of institutions such as the "Instituto Nacional de Tecnología Agropecuaria - INTA" (National Institute for Agricultural Technology), for the development and transfer of technology to the agricultural sector.[2] Such organizations were intended to open the country to the process of technological efficiency that was occurring in other countries, especially the United States. However, national economic policies did not provide guidelines for the generation of new technology according to the relative endowment of production factors of the Pampean Region.

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[2]INTA is the principal agency for agricultural research and extension in Argentina. INTA comprises approximately 40 experimental stations which are located in different regions of the country. These experimental stations will be named agricultural centers for research and development (AR and DCs).

At the same time, monetary and fiscal policies were not favorable for the adoption of innovations that increase land productivity.

At the beginning of the 1960s, the level of the agricultural output of the Pampean Region started to increase slowly through the incorporation of yield-increasing techniques. Corn and sorghum were the principal contributors to this increasing level of crop output. Corn yield increased from 1,770 kilograms per hectare in 1960/61 to 3,650 kilograms in 1977/78. Similar increases occurred in sorghum production, where yields went up from 1,270 kilograms per hectare in 1960/61 to 3,190 kilograms in 1977/78. This higher productivity in corn and sorghum was obtained basically by the use of hybrids and, to a much lesser degree, from chemicals and better agronomic practices. During the last ten years, the production of soybeans has expanded greatly, both in the area harvested and in the yield per hectare; in the latter case yields doubled from 1971/72 to 1977/78.

Consequently, due basically to the rapid increases of production of corn and sorghum, the accumulative annual rate of growth in crop production for the period 1970/77 was 2.2 percent.[3] However, the yields per hectare of other crops in the Pampean Region, such as wheat, oats, rye, barley, flax and sunflower seed have not shown any significant change since 1960.[4]

During the 1965/77 period, the stock of cattle increased from 46.7 to 61.0 million head[5] on approximately the same livestock area. There

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[3]The foregoing statistical information is taken from Ministerio de Economia - Instituto Nacional de Planificación Económica y Subsecretaría de Economía Agraria (1979), Appendix, p. 111.

[4]For analysis of wheat production in the period 1973/74 - 1977/78, see Regúnaga, M. and Martinez, J. (1978).

[5]Ministerio de Economía, op. cit., Appendix, p. 111.

was, however, a decrease in the stock of sheep and horses. While empirical information does not exist at the regional level, it may be assumed that this increase in cattle numbers was accompanied by the adoption of more efficient cattle management practices as well as the use of improved permanent pastures. However, the yield of meat per hectare has not changed substantially during the period 1968 to 1977 in the breeding-livestock producing region located in the southeastern part of the Province of Buenos Aires.[6]

In summary, after a period of stagnation during the 1940s and the 1950s, overall production in the Pampean Region has increased at a sluggish rate.[7] The total output levels remain at a lower average than the potential levels that could be obtained if innovations developed by INTA were incorporated. Thus, there exist gaps between the potential production levels generated by INTA and the state of the arts practiced by agricultural enterprises.[8]

Some innovations have been adopted in corn and sorghum production, and possibly in livestock. But, in general, these are situations that show the

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[6]See Chapter VII, pp. 174-176.

[7]During the period 1960 to 1978, the increase in agricultural output for the Argentine agriculture was comparable to the rate of growth in population, around 1.5 percent; see Banco Ganadero Argentino (Julio 1979), p. 9.

[8]For the specific technological situation of the southeastern part of the Pampean Region, see INTA-EERABalcarce (1978).

adoption of only a few practices, mainly hybrids, for specific products.[9] For that reason, the dynamics of this process of growth showed that higher levels of production would not be achieved unless land-saving/yield-increasing technological packages were injected into the overall range of activities that comprise the agricultural enterprise.

The main purpose of this study is to stress the role that INTA should perform to close technological gaps in the Argentine agricultural sector. Unfortunately, agricultural economists in Argentina have not delved deeply into the behavior and operation of research-extension institutions as a catalytic element for inducing technological change.

The stagnation of agricultural production in the period 1940 to 1960 brought about the development of different lines of thought in regards to the effects that governmental policies on relative input-output prices (monetarist school), farm size and land ownership patterns (structural school) and land rent (classical school) had in the allocation of resources in the Pampean Region.[10]

All three schools of thought noted the lack of technical progress. However, the discussion was centered on the role the government had in the agricultural stagnation of the Pampean Region. The monetarist called attention to the unfavorable effects of the economic policies of the Peronist Government upon the agricultural sector. The structuralists and classicists were aware of the economic power of land owners maintaining

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[9]For the technological diagnosis of corn and sorghum, see Piñeiro, M. (Junio, 1975).

[10]For general references see, for example, Monetarist thinkers: Reca, L. (1967); Fienup, D., et al. (1969); Ras, N. (1977). Structuralist thinkers: Giberti, H. (1964); CIDA (1965); Ferrer, A. (1973). Classical thinkers: Flichman, G. (1977), (1978); Braun, O. (1974).

a set of policies that did not penalize the extensive use of the land. Consequently, attention was paid to the behavior of producers in the use of available land and technology.

At the beginning of the 1970s, a new line of thought, which can be termed the technological approach, became concerned about the mechanism of the innovative process itself.[11,12] According to this way of thinking during the 1945 to 1960 period, there was no available technology that might have affected increases in production and reduced unit costs due to the transformation of production functions. Consequently, questions were raised in regard to the possibility of increasing yields per unit of land by the incorporation of land-saving technology. In order to analyze or focus on this problem, attention began to be paid to the process of generation and diffusion of agricultural innovations, as well as to the role the rural socio-economic context plays in the transfer of technology. The relationship between the utility function of producers and the generation and adoption of technology became the central focus for this point of view.[13]

The behavior of agricultural research-extension institutions was incorporated into this paradigm as an endogenous variable dependent upon the actual demand for technology by socially and politically dominant farm interests. These patterns of demand are not, overall, consistent with social goals which search for a significant increase in land productivity.

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[11]See, for example, Martinez, J. (1973); de Janvry, A. (1973); Hurtado, H. (1972); Obschatko, E. (1971); Piñeiro, M., et al. (1975).

[12]A deep discussion on the different lines of thought just mentioned can be found in Sábato, J. (1980), First Section, Chapters I, II and III.

[13]Sábato, J., op. cit., First Section, Chapter III, p. 30.

The mechanism that INTA has developed by itself in order to satisfy social needs in regards to agricultural innovations is not taken into account by the technological approach.[14] Consequently, the role INTA can play in discovering latent demands which are consistent with social objectives has not been recognized. Neither has the role of INTA in supplying to the government the basic information needed to formulate better economic policies to coordinate the supply and demand for technology been emphasized.

This strategic action of INTA in the process of technological change should be based on the identification of those groups of enterprises or systems of production that show a similar behavior in the incorporation of technology.

There exist few studies which explain the factors that limit or delay the incorporation of technology at the farm level in the Pampean Region.[15] Moreover, even today there exists a lack of a conceptual framework for characterizing the systems of production with the objective of analyzing the incorporation of technology at the farm level from a regional perspective. The points of view discussed above supply some guidelines for the thesis that the productive structure of farms, the characteristics of the producer and their interaction with the rural socio-economic context are the basic components for this analysis. Taking into account the price level defined in input and output markets, these components should be used to develop a micro-structural model for the assimilation of innovations in agricultural enterprises.

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[14]This reference is specifically valid for the studies of Martinez, J., op. cit., and de Janvry, A., op. cit., where a socio-economic model of induced innovations for Argentine agriculture is developed.

[15]See Obschatko, E., op. cit.; Tandeciarz, I. (1971); and Mulleady, J. (1973).

Before presenting additional considerations, the social demand for agricultural technology should be specified. This demand comprises those patterns of technology whose incorporation in the Pampean Region should help achieve a more efficient production level, in accordance with the development objectives of the Argentine society.

It is assumed that the Pampean Region should play an important role in the maintenance of the balance of payments; here the necessity arises to increase the exportable surplus of the country and consequently, the aggregate agricultural production of the Pampean Region. All the land suitable for agricultural production in this region is already in use. Any increase in output must come from increased productivity of the land itself. This can only be achieved through a more efficient use of available resources, as well as by a more intensive use of production factors maintaining the actual technological level, or by changing the state of the arts.

The first two alternatives have a physical limit imposed by the actual frontier of production at the farm level in the first case, and by the law of diminishing returns in the second case. In consequence, a substantial increase in the productivity of the land must be generated by technological change based on the incorporation of land-saving/yield-increasing technology, according to the relative endowment of production factors prevailing in the Pampean Region.[16]

In summary, the following can be asserted:

1) The Argentine agricultural sector, specifically the Pampean Region, has not experienced a consistent and continuing set of monetary, fiscal and technological policies that favored technological change based

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[16]For a deeper discussion on the optimum technological path for the Pampean Region, see Martinez, J., et al. (1976), pp. 139-153.

on the increase in land productivity. Consequently, there exist gaps between the available technological knowledge in INTA's experimental stations and the state of the arts at the farm level. To close such gaps would increase the land productivity as an overall social goal.

2) An explicit political decision about the conditions and degree of achievement of social goals is a "sine-qua-non" for improving the performance of research-extension institutions and agricultural enterprises in the technological process.

3) To close the technological gaps depends on the degree of coordination that can be established between the government, research-extension institutions and agricultural enterprises. INTA should behave as a catalytic element for this coordination. This catalytic action should be based upon a better understanding of the demand for technology and the behavior of agricultural producers in the incorporation of technology. This information should serve to detect unsatisfied demands for technology, as well as to induce the elaboration of supportive economic policies for technological change.

4) There is not enough research at the micro level to know which are the prevalent systems of production from a technological point of view, and the factors that limit or delay the adoption of agricultural innovations. The lack of this strategic information is one of the factors which prevents the government from taking appropriate political decisions about the technological path to be followed and, consequently, deprives INTA from knowing whether the existing gaps can be closed or, on the other hand, if other technological alternatives should be developed.

5) A conceptual framework and analytical procedure should be developed to assist INTA to identify, characterize and perform a technological diagnosis of agricultural production systems.

6) A study devoted to the application of the above mentioned framework to a cross-section of farms would serve as a pilot-experience on which to work out an overall regional approach for a systematic identification of the agricultural production systems. At the same time, this study should provide needed information for improving the technological process in a specific production area of the Pampean Region.

1.2 Objectives

This study directs attention towards the satisfaction of the needs outlined above. The general objectives are summarized as follows:

Theoretical Level:

1) To enhance the role of public research-extension institutions, specifically INTA, in the agricultural technological process.
2) To develop a conceptual framework and operative scheme to identify and characterize the behavior of actual agricultural production systems in regard to the incorporation of new technology.

Empirical Level:

To apply the conceptual framework to a cross-section of farms sampled from the breeding-livestock sector in the Ayacucho County in the Pampean Region.

This analysis has the following specific objectives:

a) To explore the relationships of interdependence among the basic components of the conceptual framework, i.e., the farm productive structure, the producer characteristics, technological package used, and the interaction of farmers with their rural socio-economic context.

b) To identify and characterize the dominant breeding-livestock production systems.

c) To make a diagnosis of the systems of production with respect to their behavior in the incorporation of technology.

d) To analyze the degree of efficiency in the allocation of resources within the production systems.

e) To make conclusions for improving the performance of the technological process in the cow-calf production, and to recommend areas for further research.

The analysis to be performed should serve to:

1) Assist in the elaboration of policies that induce technical progress compatible with social goals.

2) Improve the mechanism for programming and evaluating INTA's research and extension activities.

3) Define technological development alternatives at a regional level.

The cow-calf activity in the southeastern part of the Buenos Aires Province was chosen as the subject of research because this region remains stagnant without having shown any substantial increase in the output of meat per hectare. Ayacucho County was chosen for sampling because it represents the region, and there was ample economic information available as a result of different studies undertaken at the beginning of the 1970s.

1.3 Organization of the Dissertation

This study is divided into two parts. The first part deals with the development of the conceptual and methodological framework. This part includes Chapters II, III and IV. The analysis of the process of innovation involving research-extension institutions as a catalytic component is presented in Chapter II. Chapter III focuses on the development of the theoretical framework that supports the empirical analysis. Chapter IV presents the operative scheme and the econometric tools used in this study.

The second part of the dissertation is devoted to the study of the incorporation of technology in the breeding-livestock sector. Chapters V, VI, VII and VIII address this objective. A basic description of the cow-calf activity centering attention in the Ayacucho County is made in Chapter V. This chapter also includes a review of the conclusions reached in preceding studies that bear a direct relationship to the topic of this present research. Chapter VI explores the sample data, and identifies the actual systems of production in the study area. The diagnosis of the systems in regards to the incorporation of technology is performed in Chapter VII. Chapter VIII develops the analysis of efficiency in the allocation of resources for each system of production.

Finally, Chapter IX summarizes the main findings and reaches some general conclusions and recommendations useful for the technological development of the breeding-livestock region from an institutional perspective.

PART I

CONCEPTUAL AND METHODOLOGICAL ASPECTS

CHAPTER II

TECHNOLOGICAL CHANGE IN AGRICULTURE FROM AN INSTITUTIONAL PERSPECTIVE

2.1 General Outline

It has already been stated that the social demand for agricultural technology calls for a substantial increase of agricultural production through a more intensive land use. This implies changes from actual production systems to improved systems of production based on the incorporation of land-saving/yield-increasing technology. However, before this transformation of production can be achieved, better coordination is needed between the government, agricultural research and extension institutions and agricultural enterprises.[1] A graph of linkages for coordination between these three participants of the process of technical change is presented in Figure 2.1.[2]

In the diagram presented, government has the basic function of coordinating the supply and demand for agricultural technology.[3] This coordination will be realized through monetary, fiscal, and structural

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[1]This chapter draws heavily on Bocchetto, R. (1978).

[2]In this analysis attention is centered on the generation of agricultural technology by the public sector. This sector is the principal producer of land-saving technologies designed to improve the productive process of Argentine agriculture.

[3]For the purpose of this study, differentiation will not be made between the demand for technological information and the demand for technology (new inputs or innovations).

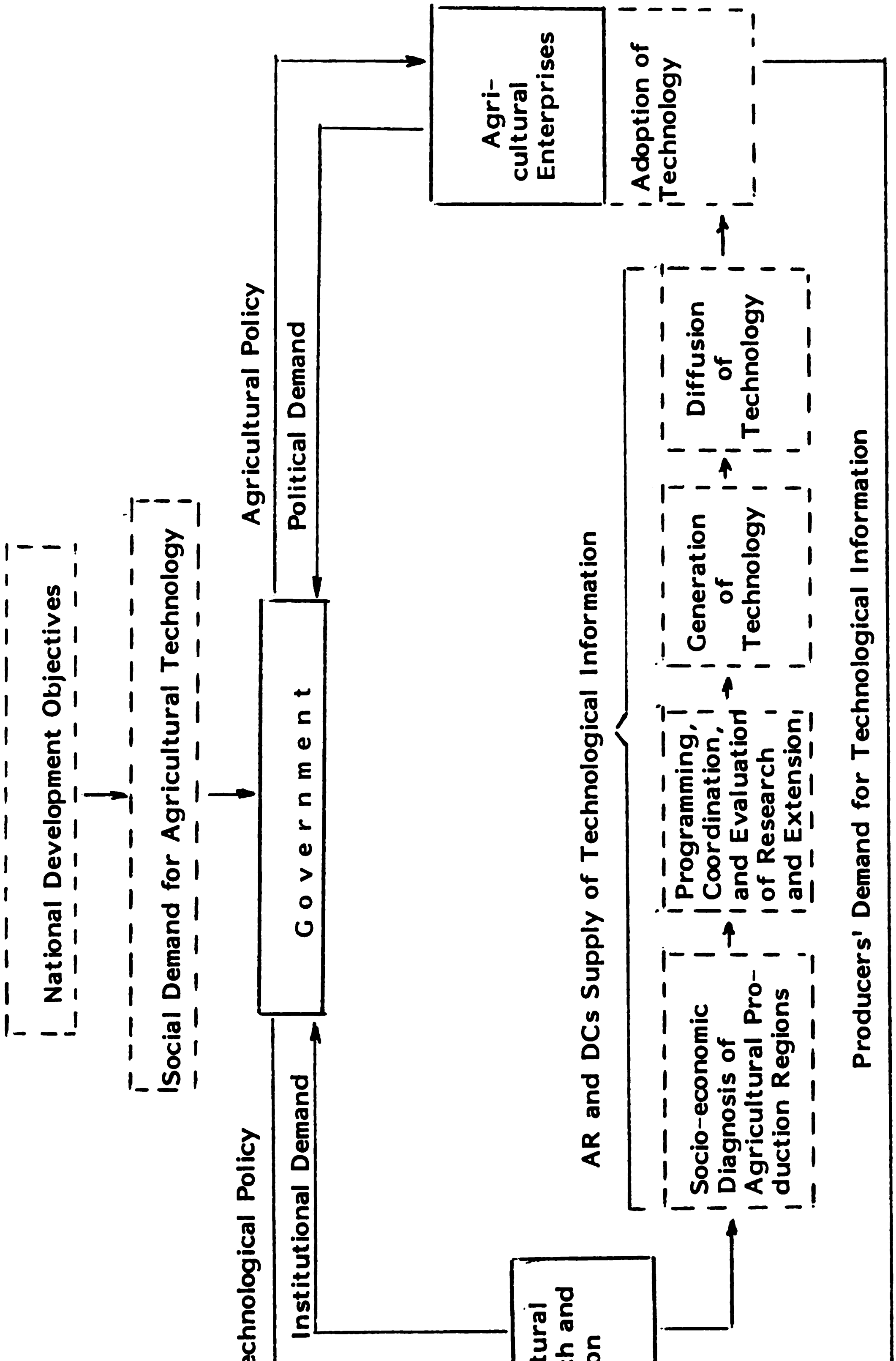

Figure 2.1 The Process of Technical Change

economic policies applied at the farm level, as well as by technological policies directed to agricultural research and extension activities. At the same time, a consistent response to these governmental actions should come from farmers' organizations and research-extension institutions. In the first case, the political demand of farmers should support the social demand for technology. Agricultural research and extension organizations should generate an institutional demand that would allow the government to be aware of technological needs at the micro level, in order to be able to elaborate specific and selective agricultural policies that would induce the desired technological progress.

However, lack of cohesion in this scheme generally appears which limits or delays the achievement of social goals. Within this breakdown of coordination, the supply and demand for technology are not necessarily compatible.

When the supply and demand for technological information meet, there is a contrast between the flows generated by the operative structure and decision making process of AR and DCs on the one hand, and by the farms' productive structure and the utility function of producers on the other.

This contrast takes place in the hypothetical market for technological information whose performance is measured by the degree of technical progress achieved, given the established framework of economic policies.[4] This paper will try to explain which are the socio-economic elements standing behind the producer demand for technology.

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[4]For a comprehensive analysis of the market for technical information, see Schultz, T. (1971), Chapter 12. Economic aspects of the supply of technical knowledge are discussed in Evenson, R. (1971), pp. 163-182.

The producer demand for technology depends upon the economic benefits obtainable through its adoption. The profitability of adoption is brought about by the farm productive structure, the utility function of the producer, and by the relative prices of inputs and outputs.[5]

The farm productive structure is characterized by the endowment and proportion of production factors used, as well as by the ownership patterns of the resources. The utility function, the entrepreneurial capacity, and the amount of time dedicated to farm activities are the principal attributes to characterize the producer. Dedication represents how much time the producer spends in the every-day direction of farm activities. Together, the farm productive structure and the producer characteristics define the structural component of the agricultural enterprise.

In addition to profitability there must be compatibility between the farm productive structure and dedication of the producer with the technological package to be adopted. This means that a degree of congruence must exist among the factor proportions that characterize the productive structure and the time devoted by the producer to his farm with the factor ratios and producer's dedication required by the technological package.

As a final result, for a given set of relative input-output prices and based upon congruence and profitability requisites the structural component indicates in the short run the patterns of needed technology. This demand derived from input-output market and structural conditions will be named in this study the structural demand for technological information. This demand will be an actual demand if it is met and

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[5]Profitability of adoption is defined as the rate of return per unit of capital due to the incorporation of the new technological package.

satisfied by the supply generated by AR and DCs. Otherwise, it will remain as a latent demand.

In this study the structural demand is defined for the prevailing set of input-output prices. However, other structural demand patterns for agricultural innovations could exist that will be brought to the market place if a new set of prices were available; for example, this can happen if the actual set of prices are not compatible with social goals, and monetary and fiscal policies are made to meet social objectives. Consequently, within this framework of analysis, any dissimilarity between the structural and the actual demand will be a result of unavailability of needed technology, or unfavorable interaction of farmers with their rural socio-economic context. This interaction is based upon instrumental conditions, such as the access to financial resources, factors of production and technical information, and the articulation of farmers with both the input and output markets.

If a new package of technological know-how shows congruence with the prevailing structural characteristics at the farm level, and marginal profitability is higher than for other technical arrangements, there may exist a latent need, an unmet demand, for such package of technology. Latent demand becomes actual demand provided articulation and conditions of adaptability are accomplished. The accomplishment of these conditions basically depends on the interaction of farmers with their socio-economic context.

Articulation implies the accessibility to technical information through the coordination between the supply and demand for technology. Adaptability includes the following necessary conditions for the adoption of technology:

a) transfer of the new information according to the "type" of production system which will incorporate it;

b) entrepreneurial capacity to incorporate the new technical information;

c) accessibility to financial resources.

A summary of the mechanism analyzed above in relation to the incorporation of technology in the agricultural enterprise is shown in Figure 2.2. Agricultural enterprises falling into groups or clusters in regards to the structural characteristics and the technology package used can be identified as belonging to a particular system of production, showing at the same time specific interaction with the rural socio-economic context. In this study, the analysis of production systems will indicate the different patterns of demand for technology coming from agricultural productive units, as well as the factors that limit or delay the incorporation of innovations.[6]

Lack of accomplishment of congruence, profitability, articulation and adaptability conditions between the supply and demand for technological information will limit or delay technical progress. Though the accomplishment of these conditions is resolved at the micro level, they depend on the institutional coordination between the government, the agricultural research and extension and the agricultural production sector. Breakdown of this coordination generally exists because the process of technological change generates conflicts among the social groups that want

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[6]This micro-structural approach as regards to the behavior of agricultural enterprises in the incorporation of technology will be developed further in the following chapter.

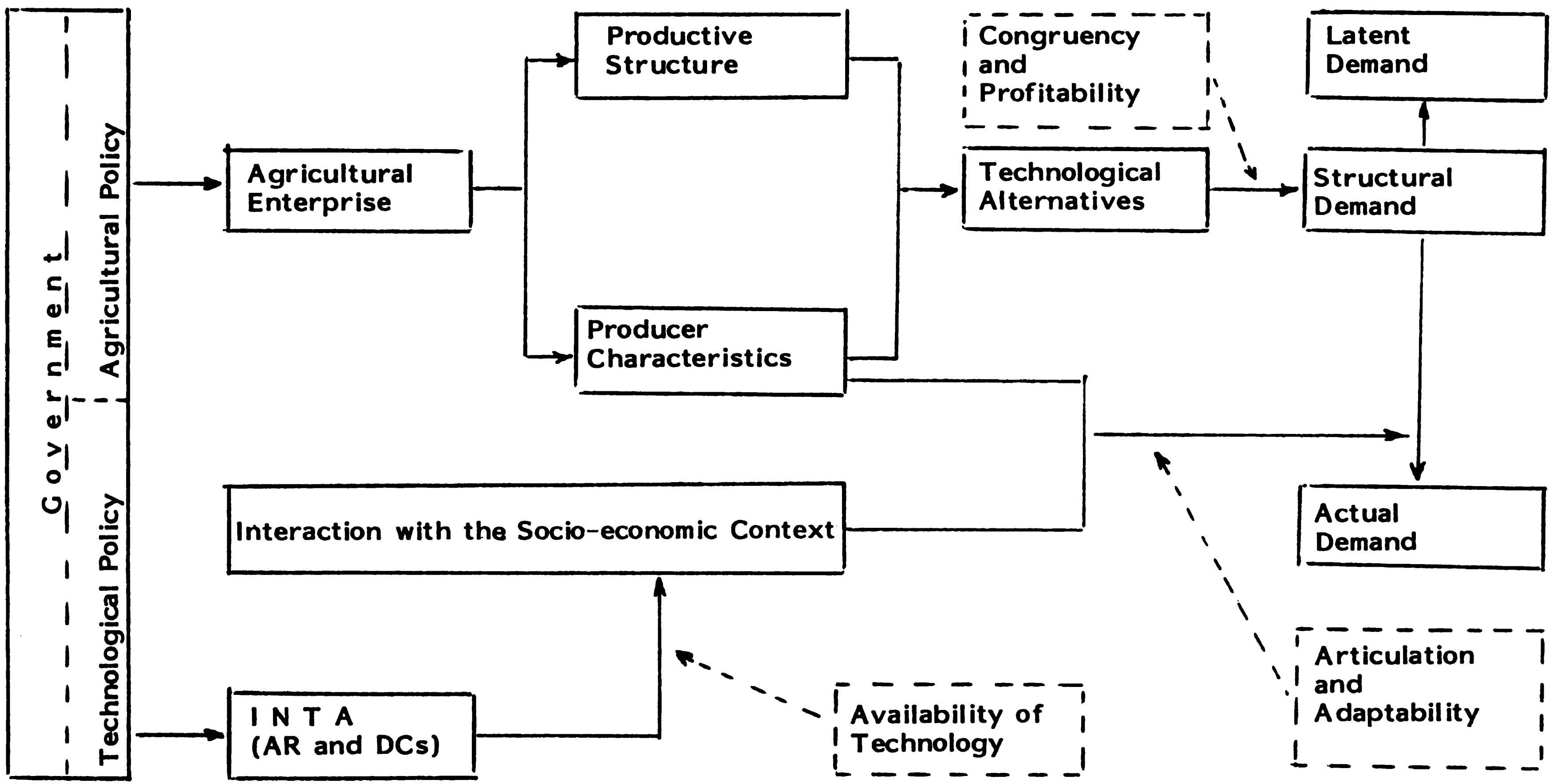

Figure 2.2 Incorporation of Innovations in the Agricultural Enterprise

a share of the economic surplus that this process generates. These conflicts show particular characteristics in the Argentine agricultural sector.[7]

Before proceeding to analyze the breakdown of institutional coordination in the process of technological change in Argentine agriculture, it is necessary to examine how technology has been generated.

2.2 Generation of Technology in the Argentine Agricultural Sector

The communication channel between the government and INTA has not been well defined. At the same time, the general research orientation from INTA's headquarters has been on specific crops and products. Problem definition for research was left largely in the hands of the researcher.

The academic background of the agricultural researcher was conducive for developing technological information during the 1960s with an experimental and disciplinarian approach. This approach took agricultural enterprises as being the aggregate of different product activities, such as wheat, corn, cattle, and so on. The main research objective was to increase physical yields per hectare by product.

However, the fact that the factors affecting production are interrelated require that they be studied within a biological system. The structure for research was only started in the early 1960s and the available stock of scientific knowledge was limited. So, much technical know-how was imported, especially in the case of livestock, from those countries where physical and biological patterns were similar to those of

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[7]An overall scheme of analysis applicable to different systems of generation and diffusion of technology in Latin America can be found in Piñeiro, M., et al. (1977).

Argentina. This imported knowledge was adapted to the Argentine agricultural environment by the use of experimental units that closely represented a real ecological situation. At that moment, it appeared logical to assume that Argentine producers would incorporate those types of technology, especially taking into account that they had already been adopted by farmers in the United States, New Zealand and Australia operating within a similar ecological environment. However, this method of generation of technology made strong assumptions about the structure of Argentine farms, behavior of producers and environmental socio-economic conditions in which producers operate.[8]

This method for generation of agricultural innovations brought about some degree of congruence between demand and supply. However, it did not necessarily assist in accomplishing conditions of adaptability, neither was it a guarantee of good interaction between the transfer system and agricultural producers.

The foregoing analysis is based upon research in livestock production. Similar conclusions can be extracted for agronomy production, although in this latter case experimentation commenced with a more apparent disciplinary approach, as well as a more narrow concept of the phenomena of production.

At the beginning of the 1970s, AR and DCs became aware of the existence of technological gaps. On the academic side, the answer to this problem was to search for the coordination between biologists and economists in order to deal with the agricultural enterprise as a biologic

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[8]This analysis demonstrates the personal viewpoint of the author, based upon technical reports from INTA's experimental stations, especially that located at Balcarce, Province of Buenos Aires.

and economic unit of production.[9] This was needed in order to affect an analysis that would be closer to actual production systems. This step brought into play more elements with which to detect the congruency and adaptability of technical information. The inclusion of risk aversion into the decision making process of agricultural producers followed the same objective.[10] Nevertheless, neoclassical static production economics was used extensively without adapting its assumptions to Argentine agriculture. Consequently, the different situations of production which determine technological heterogeneity at the farm level in Argentina were not explicitly identified or classified.

The involvement of agricultural economists in analysis of INTA research was not sufficient to change their product oriented disciplinary approach to research. Up to that time, AR and DCs had not used synthesis with an interdisciplinary approach to organize its research and extension activities.

The lack of coordination between demand and supply of technology caused INTA to begin raising questions about the difficulties in promoting technological change at the farm level. Questions were raised internally for a more critical analysis of its own behavior. The result of the analysis was the need to focus attention on managing technical information, both to satisfy internal needs and to respond to external demands, with the basic objective of resolving the incorporation of technology at the farm level.[11] It was recognized that even after new technology is developed,

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[9] See, for example, Bravo, B. and Piñeiro, M. (1971).

[10] See, for example, de Janvry, A. (1972).

[11] Oszlak, O., et al. (1971).

farms will not necessarily adopt it. Understanding the process of adoption should therefore be a major objective for AR and DCs. This process should be incorporated in the institutional model to define alternative solutions to the problem. At the same time, INTA should be aware of the need to strengthen the link with the government and rural clientele, thus inducing favorable conditions for the changes the institution is working towards.[12] This general awareness was partially incorporated by the institution within a short period of time. However, calling attention to the need was not sufficient to promote studies directed at understanding the limiting factors to technical progress as a part of the institution's research work.

In 1973, regional socio-economic diagnoses were started. This was an important step towards a better understanding of the rural environment, the general situation of the agricultural enterprise, and the productive activities developed in the region.[13] Though technical gaps were detected, it was evident that, at a micro regional level, there did not exist sufficient information to explain the problem. However, these diagnoses clarified the need for synthesis in order to identify particular agricultural problems, at least with respect to the regional agricultural system of production.

Next, the need arose to specify the existence of different types of agricultural enterprises trying to advance along the traditional approach

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[12]Oszlak, O., et al. (1973).

[13]See, for example, INTA-EERABalcarce (1973).

of farm management, based upon the cluster of farms by area.[14] This need was a starting point for studying systems of production more conceptually than as a mere disciplinarian approach.[15] Later on, it was argued that the increasing conceptualization of systems approach for analyzing agricultural production should be tied into the incorporation of technology. This association should assist AR and DCs to become the initiating force in the process of technological change.[16]

In 1976-77, through the initiative of the regional experimental stations, interdisciplinary research was begun with the objective of identifying and characterizing the dominant production systems.[17] In 1979 this new approach for effecting a diagnosis of the farming situation as well as for improving the productive process was supported at the national level by the principal authorities of INTA.[18] Recently AR and DCs

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[14] As an example of this new approach, see INTA-SIPNA (1975), pp. 1-11; and Bisio, R., et al. (1975), pp. 1-36; also the opportune commentary by Kaminsky, M. The objective of this theoretical scheme was to differentiate cost structures by products based upon a multivariate classification of the farms. Also see Bocchetto, R., et al. (1975); in this case farm classification was proposed in regard to their behavior in the incorporation of technology.

[15] See Cohan, H., editor (1975). These studies afford a general picture at that moment in the "Cono Sur" (Southern Cone) in regards to the level of analysis in the matter.

[16] This statement is related with the reference on footnote 1 of this chapter.

[17] As an example, mention can be made of the projects started at Anguil (Province of La Pampa) and Balcarce Experimental Stations.

[18] INTA-Direccion Nacional (1979).

have shown the need to enter the adoption problem by the elaboration at the regional level of the technological diagnosis of the principal production "activities."[19]

2.3 Disarticulation in the Process of Technological Change in Argentina: A Normative Solution

Technological progress through increased land productivity was a nationwide objective in Argentina, and it brought about the creation of INTA (the agricultural research-extension institution in Argentina). However, from the moment Argentina entered the technological stage at the end of the 1950s, the unstable political framework lacked a well defined economic and technological policy that would assure an adequate performance of the market for agricultural innovations from the standpoint of social objectives. It appears consistent to argue that the economic policy framework supported the existence of different patterns of technology at the farm level, which were not overall compatible with the social demand.

This situation called for a comprehensive knowledge from AR and DCs of the actual technological heterogeneity, especially if the prevailing economic policy was not going to be changed. However, INTA assumed that the government would create the necessary conditions for the incorporation of technology to achieve social objectives. Therefore, technology was generated for increasing land productivity[20] and, subsequently, social benefits.[21]

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[19] See, for example, INTA-EERABalcarce (1978).

[20] A global analysis for the Pampean Region with the technological information generated by INTA in the 1960s is presented in Piñeiro, M. (1968).

[21] For analysis of social profitability of technology generated by INTA for livestock production, see Hurtado, H. (1972).

It was shown above that the difficulties in promoting technological change induced INTA to search for a better understanding of actual production situations at the farm level. The process for arriving at the synthesis of information directed towards the generation of a more congruent and adaptable technological supply to actual production systems was conceptually arduous. This approach of course requires improvements in the operational scheme. Moreover, the need remains to incorporate a more definitive stage of analysis in order to understand the behavior of producers in the assimilation of technology, and to isolate the principal factors limiting the process of adoption in the systems of production.

Nevertheless, internal factors exist, based in part upon the need for the survival of the institution that forced INTA to become aware of the different patterns of technological demand and the bottlenecks restricting the incorporation of innovations in agricultural enterprises. It can be argued that INTA is the participant best suited within the technological process to act as a balancing force for resolving the breakdown of coordination between the government, the agricultural research and extension, and the agricultural production sector. Before arriving at further conclusions, it will be necessary to review some of the models for technological development in agriculture.

2.3.1 Induced Innovation Model

According to this model, demand conditions lead to the creation of the supply of technology. Producers respond to changes in relative prices by saving the increasingly scarce factors of production.

Consequently, agricultural producers demand from the public research institutions the type of technology which allows substitution for the scarcer production factors.[22]

The Induced Innovation Model (IIM) has been utilized to define a socio-economic model of induced innovation for the Argentine agricultural sector.[23] Within this particular application, the actual demand for technology responds to the utility function of large land owners. This demand is not compatible with the technologies that substantially increased land use intensity. Moreover, the actual demand guides the definition of research lines at AR and DCs because of the absence of technological policies based upon the patterns of the social demand.

However, there will exist a latent demand for yield increasing technologies based on fertilizers, agronomic practices and improved seeds, coming from small and medium sized farms in the traditional cereal and beef-breeding areas of Argentina. This demand has not been satisfied because of a relative lack of agronomic research, as well as a lack of technological information, particularly when innovations are combined in packages of techniques. If land-saving/yield-increasing technological packages were available, it would operate a land market-induced treadmill which would close the gap between the actual and latent demand. Such an adjustment would take place in the long run by means of a dynamic mechanism based upon the action of coercive elements all working together

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[22]See Hayami, Y. and Ruttan, V. (1971). Induced development hypotheses are outlined in pp. 53-63.

[23]de Janvry, A. and Martinez, J. (1972), pp. 192-210, and de Janvry, A. (1973).

towards the maximization of profits in the utility function of producers. The patterns of the actual demand would change towards land-saving innovations as a result of their availability and adoption as a first step by small and medium farmers providing the latent demand.

It remains unanswered what could trigger the technological treadmill, assuming that land-saving/yield-increasing technology should be available, and that its incorporation ought to be brought about. The application of the IIM to Argentina is based on assumptions that do not identify the starting force of the proposed treadmill mechanism. The generation of agricultural research responds to the actual demand which is not consistent with a more intensive land use. Also, existing economic policies support actual demand patterns. Consequently, the logic of this model results in a vicious circle for the achievement of technical progress.

It would appear that the assumptions of the IIM for Argentina, as to the size and allocation of public agricultural research funds to satisfy dominant farm interests, are overdrawn.

For example, it was argued that there is a lack of information for a technical package for corn that includes hybrids with high response to fertilizers, using herbicides and agronomic management practices.[24] This case could be illustrative to support the assumption of this model, in the sense that available technical information could be more compatible with dominant farm interests. However, it can be shown at the same time that a technological package for breeding-livestock production was generated that is congruent with a farm productive structure that uses

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[24]See Martinez, J., et al. (1976), pp. 94-120.

the land intensively.[25] This package of innovations does not appear to be compatible with production conditions on large farms. Moreover, there could exist latent demands coming from extensive patterns in the use of land that have not already been satisfied, e.g., improvement of natural pastures.

Consequently, going beyond particular examples, during its institutional development INTA generated research relevant to the achievement of social goals. This search for social relevance in the generation of agricultural technology by INTA is the basic argument for proposing a model of mutual causation to induce more intensive agricultural production in Argentina.

2.3.2 Institution Building Model

The Induced Innovation Model treats institutions as endogenous variables within the market process, which themselves can be transformed as a consequence of economic growth. However, supporters of this line of thought recognize that it is possible for the supply of services from an institution to be altered independently of economic growth considerations.[26] In this case, the Induced Innovation Model cannot explain such a change in the institution; it can be used, however, to determine the resulting effects of such change.

The Institution Building Model (IBM) offers a framework to analyze changes for which the Induced Innovation Model does not provide a satisfactory explanation. In order to meet this objective, the IBM treats

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[25]See INTA-EERABalcarce, op. cit.

[26]Schultz, T. (1968), pp. 1113-1122.

"institutions" as being those which are altered not so much as a consequence of economic growth, but rather to serve as a causal force generating the growth process itself.[27]

According to this model, the development process can be strengthened and accelerated by public organizations through which new values, functions and techniques are introduced into the environment in which they operate, as well as by those decision makers who must activate the process of change. In general, these organizations are needed when the behavior generated by the market mechanism does not coincide with the social demand.

The basic propositions of this model are:

1) technical, economic and social changes that generally go together with many innovations are not spontaneous, but are induced and guided;
2) innovations, in regard to their diffusion and adoption by any social group, are not a mere learning or communication activity, but a political process as well;
3) innovations are generally incorporated through an institutional process, sustained through adequate organization;
4) building up the organization and guiding its relationships with government, organizations that supply complementary services, institutions whose values and norms support technical and

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[27]The basic scheme of this approach is taken from Esman, M. and Blaise, H. (1966). A practical method of analysis is presented in Wood, G. (1972). For a comprehensive treatment of the role of institutions in agricultural development, see Blase, M. (1971).

social changes, and with public opinion within its own environment, is simultaneous, interrelated, and can be considered as a mutually supporting activity.[28]

The application of this model to the Argentine agricultural sector means that INTA, as the principal research-extension institution, could serve to promote socio-economic development in general, as well as generating technological changes, especially those compatible with social demand. In this sense, the main strategy is to identify the entire spectrum of the demand for technology, in particular those patterns compatible with social objectives, as well as to detect the limiting factors of technical progress. Simultaneously, action directed to government and the rural environment should induce the changes needed for arriving at an equilibrium between the supply and demand for technology that should be consistent with social goals.

With the creation of INTA some mechanisms of the IBM were introduced into the Argentine agricultural sector. However, testing this model against reality in Argentina shows that the propositions set forth above were only partially satisfied. At the micro level, the reasons that the IBM did not work well can be summarized as follows:

a) the lack of a comprehensive and selective knowledge of the agricultural situation by systems of production, defined with the objective to identify the structural demand for innovations, and the factors that limit the incorporation of technology; and

b) the programming of research by products instead of by systems of production.

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[28]Blase, M. (1972), p. 8.

At the institutional level, insufficient attention has been given to the coordination with government, and to the institutional diffusion towards the rural environment.[29]

2.3.3 Model of Mutual Causation for Inducing Technological Change in the Argentine Rural Sector

Where policies are directed towards farmers, to their socio-economic context, and to research-extension institutions that induce the increased production through more intensive land use, the supply and demand for innovations are compatible with the achievement of social goals. This situation that appears to be the basis in theory for a stable equilibrium in the technical process has not been achieved overall in the Argentine agricultural sector.[30]

It has been argued that Argentine agricultural policy has not provided inducement for technical change compatible with social demand. This could be for at least two reasons. First, the absence of some kind of policy is frequently a political decision supported, for example, by the political demand of some power group which does not necessarily represent society as a whole. Second, it may be that government does not have sufficient information to elaborate clear-cut policies, or possess a well conceived conceptual framework for generating them due to lack of experience about the problems at hand.

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[29] The Institution Building Model shares many analytical elements with the model used by Oszlak, O., et al. (1971), to analyze INTA's organization. Consequently, the present study shares some basic hypotheses with Oszlak's work, on the behavior of AR and DCs.

[30] See Forni, F. (1975), pp. 17-28.

Nevertheless, in order for there to be a compatible supply and demand for technology, policies directed to the farm sector should be compatible with those directed to the scientific sector. To handle this situation the government needs more precise information regarding the structural demand for agricultural innovations, as well as a knowledge of the behavior of producers in the technological process. This is needed to define selective policy measures to induce farmers to achieve a performance consistent with social demand.

This basic condition is not restrictive in postulating that it should be government which defines the rules for technical progress which is needed for a harmonious development of the agricultural sector. However, it would be better to count upon a catalytic component acting as the facilitator of the process. INTA has some comparative advantages over other divisions of government in being this catalytic agent in the rural environment, i.e., the degree of specialization of professional men, contact with agricultural producers, etc. This can definitely be accomplished if AR and DCs can develop a clearer concept of the technological change mechanism at the farm level, as well as strengthen the relationships with government, agricultural producers and their socio-economic environment.

Agricultural institutions are exposed to change due to economic growth, but they are also capable of serving as a causative force generating socio-economic development, and particularly to be an initiating force in the technological processes. Such objectives can be attained in the Argentine agricultural sector because in the specific case of INTA, this organization has become an established institution.[31]

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[31]For a test of institutionality, see Esman, M. and Blaise, M., op. cit., pp. 5-7.

The propositions of the Induced Innovation Model and the Institution Building Model cannot be proved to have an overall validity in the past in the agricultural sector of the Pampean Region. However, a Model of Causation can be proposed built upon the interaction of both models as a "normative" scheme for technological change.

The mechanism of the IIM takes care of the articulation between AR and DCs and the actual demand. The IBM guides AR and DCs in detecting and satisfying latent demand, especially those patterns congruent with the adoption of land-saving/yield-increasing technology.[32] This is a basic condition by which to put into movement the technological treadmill visualized by the IIM. At the same time, the IBM emphasizes the action of INTA towards government highlighting the needs for policies which facilitate the treadmill effect achieving technological progress. If this requisite is not satisfied, the structural demand at the farm level will show a higher degree of technological heterogeneity than under the situation where government establishes adequate economic policies from a social point of view. In this case, INTA will lose the possibility of inducing through government action coordination between the social demand for technology and the structural demand generated by agricultural enterprises.

The blocking of the institutional demand coming from INTA will curtail in the short run the practicability of achieving the potential level of output that could be reached if all patterns of demand for innovations were based homogenously on social goals. However, the identification

[32]Within the search for latent demand patterns it is open to AR and DCs the possibility of generating technological dominance. This is to say, the generation of techniques that could yield maximum profitability under different structural conditions and input-output price ratios.

of farm latent demands still remains as a specific function of AR and DCs. A higher socially efficient point could be reached in the long run if AR and DCs identify and satisfy latent demands for innovations.

Undoubtedly, this last alternative will have a high cost for society, which would have to use more time to allow the technological treadmill to function than under the situation where economic policy is the driving force. Meanwhile, AR and DCs will be on the way to search for technological alternatives that might be more efficient than the actual ones but not necessarily the most efficient in production from a social point of view. This is to say, AR and DCs will have to satisfy patterns of demand for technology that are not strictly compatible with social goals. However, a level of aggregate production can be achieved, that may not be the most efficient socially but will be more efficient than the existing situation.

It is not enough to emphasize that the government should make an explicit definition about the degree of achievement of social goals, as a "sine-qua-non" for improving the coordination of the supply and demand for technology. This definition should be brought about taking into account the technological diagnosis elaborated by INTA, and based upon the trade-off between the political demand and the established social objectives.

In summary, the Model of Mutual Causation for inducing technical progress in the Argentine agriculture assigns INTA the responsibility to identify the overall patterns of demand for innovations[33] and, consequently, the factors that limit or delay the incorporation of technology at the farm level. This "strategic" information is the starting point for

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[33]In relation with this proposition, see Arndt, T. and Ruttan, V. (1975), pp. 15-16.

inducing the government to make explicit the definition of economic policies at the farm level and technological policies directed to agricultural research and extension.

This technological diagnosis and the guidelines coming from the government should enable national decision levels of INTA to define programming patterns for research and extension based upon systems of production rather than by products. These systems represent those groups of enterprises that show homogeneous behavior in the incorporation of technology. This approach should be conducive for improving congruence, profitability, articulation and adaptability between the supply and demand for technology.

The institutional action towards the government and the search for the technological demand at the farm level should be complemented by improving the linkages of INTA with those organizations that, within the rural context, generate complementary services or support values and norms compatible with their institutional objectives.

The static technological diagnosis should be expanded with a dynamic approach. In this case, technological change should be quantified in the principal production regions searching for the transformation of production systems with the evolution of relative input-output prices and modifications in the package of economic policies. At the same time, study should be directed to the socio-economic effects of technological change on agricultural enterprises and the rural community. This dynamic information should be useful for analyzing the social and private costs and benefits of technical change, helping to guide the reformulation of economic and technological policies.

CHAPTER III

A CONCEPTUAL FRAMEWORK FOR THE ANALYSIS OF THE INCORPORATION OF TECHNOLOGY IN AGRICULTURAL ENTERPRISES

3.1 Scope and Objectives

The Model of Mutual Causation for inducing technological change in the Argentine agricultural sector is based essentially on the activities of the AR and DCs in discovering the structural demand for innovations (actual or latent patterns), and the factors limiting technical progress.[1]

It has been indicated previously that a conceptual framework is needed for the Argentine case to work on the assumptions of neoclassical firm theory with respect to the structural and behavioral patterns of agricultural enterprises in the incorporation of new technology. Consequently, it will be the objective of this chapter to develop a conceptual framework for grouping agricultural enterprises that have some degree of homogeneity in terms of those attributes that relate to the incorporation of new technology. These enterprises will be represented by a production system which show the type of factors that limit or delay the adoption of innovations. This model will help to define the operational framework of this study, as well as facilitate the choice of the most suitable statistical techniques for arriving at the conformation and validity of the systems. This last objective will be considered in the next chapter.

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[1]This chapter draws heavily on Bocchetto, R. (July 1979).

3.2 General Framework of Analysis: Hypothesis

The assumptions of neoclassical static economics[2] provide that the institutional setting (government and the socio-economic context) creates a neutral environment for the incorporation of new technology. Perfect mobility of resources and adjustment mechanisms to respond to market changes, plus the rationality, and equality of the utility function among producers constitutes a situation in which enterprises in a homogeneous ecological region use the same production functions, show the same demand for technology, and are able to satisfy these needs through the market for innovations. Such a process should not affect ownership patterns in regard to resources, and the distribution of income among social groups should stay the same.

The neoclassical model focuses attention on price determination which may be dependent upon different market structures. The theory of production is one stage in the analysis of markets. It is not the objective of this theory to try to understand the individual firm as such. Strong assumptions are made in accord with the type of economy under analysis, as to "who" produces, "what" types of production units are producing, and "where" production takes place. In other words, strong assumptions are made based upon the opportunity set where the producer makes his own decisions, as well as upon his individual economic conduct. Nevertheless, questions such as: what, how, and how much to produce under certain levels of equilibrium in both input and output markets, can be answered.

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[2]Basic reference: Johnson, G., Agricultural Economics course notes, Michigan State University, East Lansing, 1971.

Supposing the firm itself becomes the object of analysis, and there is a necessity for describing in what ways the firms incorporate technology? In such cases, the choice or selection of such firms should not be based on their level of resources used or output obtained, but should preferably be directed towards the different ways that things are decided and done;[3] that is, the existence of different systems of production.

Consequently, the conceptual framework of this research is based on the following hypotheses:

1) The elements comprising the productive structure and the characteristics of the producer, in conjunction with technological inputs bring about the existence of different systems of production.

2) Each production system is associated with a particular type of interaction of agricultural enterprises in the socio-economic context.

3) Each system of production shows a specific behavior in the incorporation of technology.

4) Each system of production, its instrumental component, and the supply of technology available, shape a technological configuration that identifies those factors which limit or delay the adoption process with respect to the prevailing set of economic policies.

Different agricultural productive systems result from dissimilarity in the distribution of opportunity sets among agricultural producers. The opportunity set is defined by alternative lines of action, or of

[3]The same type of comments are made by Dorfman, R., et al. (1969), pp. 141-143 in searching for a definition of the enterprise based on linear programming.

choices, open to the individual, each with a relative cost. Society, the groups of individuals, and their interrelationships, operate under conditions of scarcity; showing at the same time an interdependence in the distribution of opportunity sets which represent the allocation of scarcity. Generally, the distribution of opportunity sets is unequal, thus conducive to a structure of both advantage and disadvantage and, hence, to a structure of mutual coercion. Interaction between the power of individuals is the basis of the structure of mutual coercion which distributes opportunity sets.[4]

What factors determine the opportunity set of an individual? On the production side, the factors that shape the opportunity set of the agricultural producer are both the productive structure of the enterprise and his interaction with the socio-economic context. Within his particular opportunity set, the producer shows an economic conduct that guides his choices in production based upon his utility function. It is also the place where he exercises his entrepreneurial capacity and his dedication to the enterprise itself.

For a given set of relative input-output prices and available technological alternatives, the constraints of the opportunity set and the characteristics of the producer will define in the short run the package of technological inputs used by the agricultural enterprise, i.e., the actual demand. Therefore, the patterns of this demand are related to the conditions of congruence, profitability, articulation and adaptability, as well as to the availability of technology, as defined by the demand-supply

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[4]A general analysis of the economy as a system of mutual coercion is presented in Samuels, W. (1972), pp. 5-12.

scheme set forth in the previous chapter.[5] Unfavorable interaction with the rural socio-economic context, and the unavailability of needed technology can impede structural demand patterns. In this case, there would exist latent demands for innovations that show a higher degree of congruency and/or profitability in regards to the structural component of the agricultural enterprise than would be the case for actual demand patterns.

Distribution of income is a function of the structure of mutual coercion (the distribution of opportunity sets).[6] The same is true for the economic surplus generated by technological progress. Over and above the restriction imposed by the characteristics of demand for final products, from the supply side the appropriation of the economic surplus among social groups will be based upon the type of productive structure incorporating technology, and upon the structure of the different markets which characterize the relationship of farms with the socio-economic context. Nevertheless, since the basic organization of production factors is accomplished by the enterprise itself, different types of enterprises will induce not only different performances of the market for innovations from the point of view of production, but also a different distribution between land, labor and capital from the economic surplus generated by technical progress. This study will only focus attention on the production side. However, when the term enterprise is used it would mean a socio-economic unit of production and distribution.[7]

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[5]See Chapter II, pp. 16-19.

[6]Samuels, W., op. cit., p. 9.

[7]For an exhaustive analysis of the enterprise from the productive and distributive point of view, see Solbevilla, E. (1968).

Once the different modes of production have been analyzed in reference to the incorporation of technology, attention should be focused within each system upon differences in the level of efficiency with which the producer allocates his productive resources.

In the next section, the structural and instrumental components which characterize the opportunity set of the agricultural producer will be analyzed in regards to the adoption of technology. Afterwards, attention will focus upon efficiency in the rural enterprise.

3.3 Micro-Structural Approach to the Incorporation of Agricultural Technology

The behavior of the rural enterprise with respect to the incorporation of technology is a function of endogenous factors, and of those which define its interaction with the socio-economic context of the rural environment. The relationships shown by both internal and external factors are established as being the expression of economic policy that guides the development of the agricultural sector. The effect that exogenous factors have on the adoption of innovations by agricultural enterprises is shown simultaneously in a quantitative and qualitative sense on endogenous factors. Thus, variables utilized for characterizing internal factors serve by themselves to identify the firms' behavior in the adoption process. However, the conceptual scheme will be applied to external factors in order to explain these patterns of behavior.[8] Consequently, endogenous components of the agricultural enterprise will be looked at first; after which,the exogenous component will be analyzed.

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[8]A discussion on the use of internal and external attributes for agricultural typology is presented in Kostrowicki, J. (1977), p. 37.

3.3.1 Behavior of Agricultural Enterprises in the Incorporation of Innovations

The agricultural enterprise includes both the production unit and the producer. The production unit comprises the productive structure and the technological package. Output depends on both the services of production factors and inputs transformed by the actual productive process.[9] This situation is usually represented by a short run production function.[10]

When a production function is estimated at the farm level a "restrictive" production pattern is obtained with respect to all the possibilities open to the enterprise. It is an "ex-post" production function which does not include all possible designs.[11] Such a situation will force attention on the existence in a homogeneous ecologic area (definable as having the same production possibilities) of different production functions, i.e., technological heterogeneity.[12] This heterogeneity is based on differences among agricultural enterprises upon the requisites of congruence, profitability, articulation, and adaptability for the adoption

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[9] In this study distinction is made between factors of production, which are the permanent components that characterize the productive structure of farms, and technological inputs, which transform themselves in the process of production.

[10] For a general discussion on production laws from a technical and economic point of view, see Frisch, R. (1963), Chapter I. A theoretical and econometric scheme of production is presented in Kaminsky, M. (1971), Chapter IV.

[11] See Johansen, L. (1972), pp. 9-10.

[12] The recognition and analytic formulation of this situation within the neoclassical focus can be seen in Sturzenegger, A. (1975). Arguments from the classical point of view appear in Flichman, G. (1978).

of innovations and differences in the availability of needed technology, i.e., differences in structural and instrumental conditions in production, as well as in know-how available from AR and DCs.

To analyze the structural conditions it is assumed that farmers use the same technological information and have the same interaction with the rural context. In this case, for a given set of relative input-output prices, technological heterogeneity should respond to differences in the farms' productive structure or differences in the producer characteristics.

Assuming for the moment that the producer maximizes profits, the technological arrangement that corresponds to the optimal solution will depend, for a given set of relative input-output prices, on the endowment of production factors at the farm level. Thus, the available land, capital and labor determine the feasible production region which at the same time defines the optimal solution in the space of profit indifference curves.[13] It follows that the endowment of production factors and the input-output price ratios define the proportion of factors used, together with the technological package that shows factor ratios congruent with those prevailing in the productive structure. In this sense, the requisite of congruence says that the producer will tend to incorporate technologies that do not basically modify the actual productive structure,[14] or the dedication of the producer to the farm. Among those technological alternatives that show congruence with the structural component (proportion of production factors and dedication to the farm) the producer

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[13] See the approach of Baumol, W. (1972), Chapter 12, in regards to linear programming and the theory of production.

[14] See Martinez, J., et al. (1976), p. 70.

chooses the most profitable. Therefore, in accordance with the prevailing productive structure and input-output price ratios, profitability decides the incorporation of technology.

From the foregoing it can be argued that dissimilarities in structural conditions can explain the existence of technological heterogeneity for the prevailing price ratios. Different technological arrangements can have a similar level of private profitability when each one is associated with different productive structures. This is the case of technological heterogeneity without a dominant technique, showing no dominance in profitability for the existing input-output prices.[15] Under the assumption of homogeneity in instrumental conditions and producer characteristics, the absence of technological dominance at the farm level should also be valid for the supply of technology.[16]

Technological heterogeneity without dominance in profitability is shown in Figure 3.1, where UU', VV', and WW' are profit indifference curves, while P_1, P_2 and P_3 are three different production processes associated with three different endowments of production factors which define the feasible regions oaAb, ocBd, and oeCf. It can also be seen that I_1, I_2 and I_3 are the technological packages showing congruence and the highest profitability with the prevailing productive structures, in this case PS_1, PS_2 and PS_3.[17]

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[15] See Sturzenegger, A., op. cit., p. 5.

[16] For the definition of technological dominance, see Chapter II, footnote 32.

[17] This analytical framework follows Baumol, W., op. cit., pp. 295-310. Profit indifference curves show the same level of total profits. For simplification, it is assumed that points A, B and C in Figure 3.1 also define the same level of private profitability. To work with a two dimensional space a given combination of capital and labor is assumed in the horizontal axis of Figure 3.1.

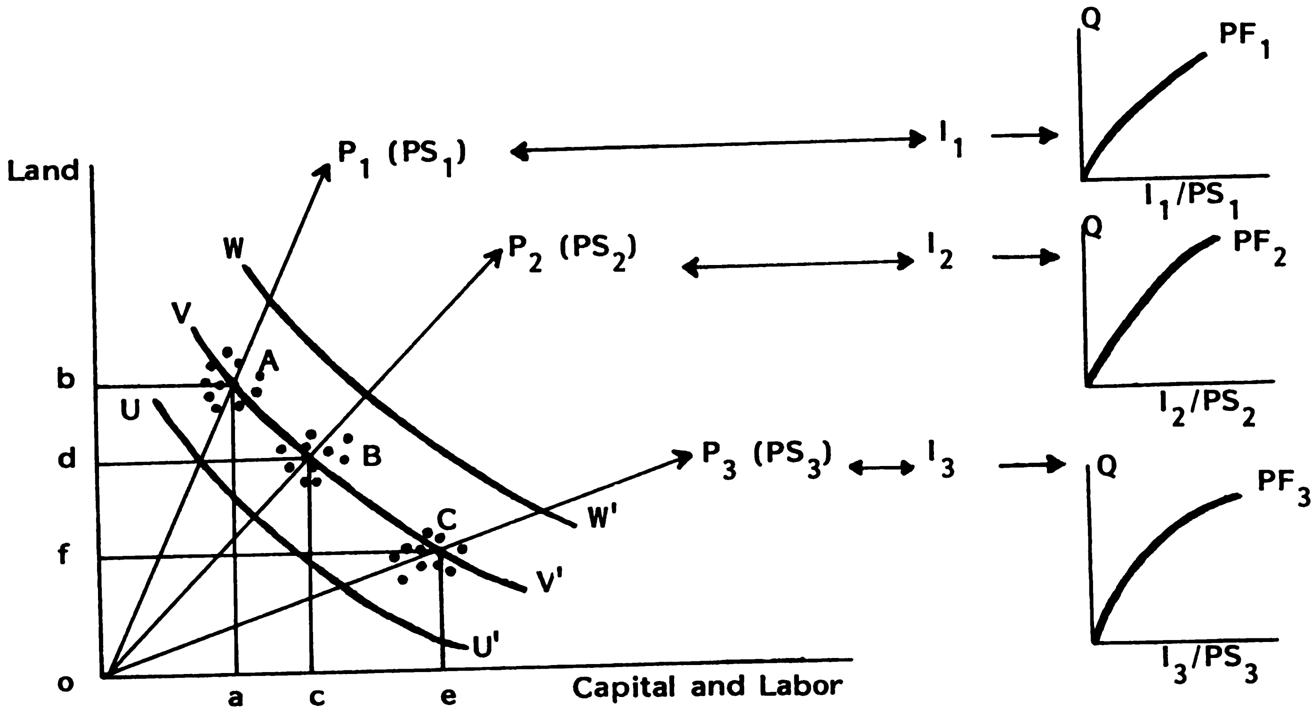

Figure 3.1 Technological Heterogeneity at the Farm Level

This situation leads to the existence of three different "ex-post" production functions, i.e., PF_1, PF_2 and PF_3.

These production functions characterize three different types of enterprises: in this example, those farms located at A, B and C in Figure 3.1. These types of enterprises will show a different behavior in the incorporation of technology based on technical relationships built into the farm productive structure. However, technical relationships operate together with those showing the ownership patterns of the resources. These social relationships resolve the "personal" distribution of income, particularly economic surpluses generated by technical progress.[18] In this sense, property rights affect the incorporation of technology.

Attention is now focused on the economic conduct of the agricultural producer. Differences in the utility function between farmers will generate different patterns of resource allocation and, consequently, economic decisions may be different for the same technological package.

Profit maximization is not necessarily the unique objective in the utility function. For example, risk aversion and expected profits can dominate profit maximization in the lexicographic utility function of the producer.[19] For a given set of relative input-output prices, dissimilar configurations of the utility function can locate two producers at two points of the same production function, which will each be economically efficient (efficiency being measured according with the structure of each

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[18]The "functional" distribution of the economic surplus generated by technological change will depend on: 1) the factors' proportions used by technology, and 2) the elasticity of the supply of production factors. See Piñeiro, et al. (1975), pp. 8-14.

[19]For an explicit definition of the utility function of the agricultural producer, see Martinez, J. (1973), pp. 37-47.

utility function). Consequently, failure to consider differences in the utility function between producers could lead to the error of explaining the different locations on the same production function as being due to economic inefficiency. At the same time, differences in the utility function may explain why two enterprises are on different ex-post production functions. For example, risk aversion could lead one producer to use fertilizers while another might decide to avoid fertilization. In the face of this situation any estimate of the production function at the farm level should separate those units with different utility functions. Consequently, if the utility function is not taken into account, one of the elements which could explain the existence of technological heterogeneity would be lost. In summary, for a given set of relative input-output prices, the type of farm productive structure and the utility function of the producer define the profitability of the inputs package, within technological arrangements open to the producer in accordance with congruence conditions.

Until now, availability of technological information which is profitable for the prevailing structural components at the farm level was assumed, together with favorable instrumental conditions in the rural environment. Under these assumptions, actual demands for innovations are the structural demands. Reasons for adoption or non-adoption should be analyzed looking at congruence and profitability requisites. In this case, technological heterogeneity should be based on differences in the structural component, as well as in the technological package. The structural component will appear as the principal factor shaping the overall technological configuration.

However, differences exist among farms with respect to the interaction with the rural environment, or in the availability of needed technology. Under this situation technological heterogeneity could be based on differences in the structural component, while the technological package would not show differences, i.e., farms would show equal actual demands for technical inputs.[20] In this case, structural demands and actual demands are no longer equal, and latent patterns of demand for technology should exist at the farm level.

Consequently, farms showing equal actual demand can have different behavior in the incorporation of technology. On the one hand, they can have different reasons for non-adoption of the actual supply of technology. On the other hand, needed technology for particular structural conditions might not be available. Reasons for non-adoption will depend on the interaction of farmers with their socio-economic context. This interaction accounts for the conditions of articulation between supply and demand for innovations, as well as for the adaptability of the available technical information to farm conditions. Under this situation the instrumental component will appear as a limiting factor of first order. Thus, it might be necessary to refer to external factors to explain homogeneity in technical inputs, when at the same time structural characteristics are heterogeneous. However, the heterogeneity in structural conditions identifies by itself the existence of different behaviors in the incorporation of technology.

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[20]This configuration of production is also possible with technological dominance. Consequently, this analysis is assuming that prevailing technical know-how in AR and DCs are not clearly conducive to achieve technological dominance at the farm level, particularly for breeding-livestock production.

Therefore, the preceding analysis shows that the behavior of agricultural enterprises in the incorporation of technology is based on the reasons of adoption and non-adoption of innovations making up the supply of technology available from AR and DCs, as well as on the unavailability of needed technology. In conclusion, whatever difference appears in any of the three basic endogenous components of the agricultural enterprise, it can be associated with different situations in the incorporation of technology. Each case can be represented by an agricultural production system that will comprise those farms that show a certain degree of homogeneity in the attributes that characterize the productive structure, the producer and the technological package in use.

From the foregoing, it will be gathered that the characteristics of the product, as an output variable, will not be used as a basic discriminative criteria. Production indexes and the corresponding economic results have been the elements utilized traditionally in farm management in Argentina, as attributes for classification. This led to a classification of such enterprises according to the type of isoquant that they occupy, and not to the type of process that they utilize to realize their production. In consequence, the present conceptual framework places emphasis upon the input variables by considering that their direct and interrelated effects permit an explanation of the different behaviors in the incorporation of technology.

The basic argument broached in this static and short run analysis points out the fact that the structural component of agricultural enterprises imposes conditions on the assimilation of innovations supplied from the AR and DCs taking into consideration the prevailing set of prices and the framework of economic policies established by the government.

3.3.2 Interaction of Farmers with Their Socio-Economic Context

It has been mentioned that an agricultural enterprise is a socio-economic unit of production and distribution. All the structural elements that comprise the social system are presented at the level of resolution of this economic unit. Although these elements can be taken into account in order to define the "agricultural enterprise," this latter maintains relations with its socio-economic context, within an institutional and political framework.[21]

In the previous section it has been argued that the internal factors of the farm can be utilized to describe different technological situations. Nevertheless, it has also been mentioned that to carry out a diagnosis of technological heterogeneity (without a dominant technique), external factors should be brought into the analysis. They can partially explain the differences that exist between actual and structural demands for agricultural innovations.

If attention is directed by the enterprise towards the technological process, the relations maintained by it with its socio-economic context will be effected through the following elements:

a) access to financial resources;

b) access to productive factors;

c) access to technical information; and

d) interaction with the input and product markets.

The type of productive structure and the economies of scale that it generates, as well as the efficiency with which the producer allocates

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[21]An analysis of the limits between the subsystems of society has been made by Parsons, T. and Smelser, N. (1969), pp. 51-70.

and manages his resources, are the determinative factors of the internal capacity of the enterprise to generate economic surpluses. The access to financial resources from outside, which are related to the characteristics of the productive unit and the producer, will determine the total capacity of the enterprise to renew its capital and to incorporate new technological packages. External financial resources may originate in credit or in a flow of capital entering from industry, commerce, professional practices, or even from the agricultural sector.

The access to production factors has a direct relation to the type of productive structure that the enterprise may develop, with a corresponding effect upon the congruency-profitability stemming from the incorporation of a package of innovations. The financial capacity of the enterprise to obtain capital and its entry into the respective markets, are the principal characteristics that define the access to production factors, which will define the range of alternative technologies from which the agricultural producer can choose.

Access to technological information is given by the degree of articulation that is achieved between the supply and demand for innovations. This defines the access to technical know-how, which can only become effective if, in addition, requisites of adaptability are fulfilled satisfactorily.

Interaction with the input and product markets is analyzed as an exogenous factor for the enterprise, on the basis of the dependence that this may have upon the structure of those markets. In this fashion, differentiation should be made between this situation and that which is built upon the personal capacity of the producer to relate himself with those markets. This personal characteristic is associated with his entrepreneurial capacity. However, interaction with input and output markets is defined basically by the capability of the producer to negotiate. This latter thereby determines the level of prices that he will pay, and has a corresponding effect upon the profitability of the technological package that he can incorporate.

A peculiarity of the Argentine agricultural sector is that the producer shows a competitive behavior going into the input and product markets. However, the concentration of property in land may allow him to generate economic power. This power has relevancy in the interaction between agricultural enterprises and the socio-economic context of the rural environment such as, the access to credit, and interaction with input and product markets.

3.4 Efficiency in the Use of Productive Resources

The differences in output shown by enterprises grouped together based on their similarity in the structural and technological component will be related to the efficiency with which the producer allocates and uses his productive resources.

In the economic literature it is usual to find a differentiation for the economic or overall efficiency, between technical efficiency and price efficiency.[22] The first measures the efficiency with which the producer obtains a maximum level of production from a given combination of resources. The second measures the efficiency with which the producer chooses an optimum combination of resources.

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[22] See Müller, J. (1974), pp. 730-731; Seitz, W. (1970), pp. 505-506, and Tandeciarz, I. (1971), pp. 9-15. The analytic framework which is used in these studies is based upon the proposition of Farrell, M. (1957), for the measurement of economic efficiency.

When a production function is estimated on the basis of observations of input-output relationships from a sampling of agricultural enterprises,[23] an average production function for the sample will be obtained, plus a number of observations around the same; some of the levels measured being on the frontier of production. Such a situation is envisaged in Figure 3.2, where along the horizontal axis will be found a measure of inputs and production factors, assuming a common denominator. In this case, the different levels of output corresponding to the firms at A and B, Q_0 and Q_1 respectively, which in turn share the same level of use of resources R_0, could correspond to differences in technical efficiency. However, these differences (measured as a "vertical hop" between the observations) could also arise as a consequence of specification errors, errors of measurement, or can be assigned to random errors.

It has been argued[24] that differences in the level of production between two enterprises sharing the same resource package will stem from an erroneous specification of the production function; preferably as regards technological changes, of an increase in the managerial capacity of the producer, or of improvements of the human element. There will always be some "new type" of input or a combination of traditional factors represented by one or more explanatory variables, that have remained in the residuals of the quantitative model. Faced with this situation, the definition of technical efficiency would be reduced to the correct choice of the production function; the location of the enterprise

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[23]Measurement of the economic efficiency in a sampling of agricultural enterprises is detailed in Bocchetto, R. (1970), Chapter IV; and Tandeciarz, I., op. cit., Chapter IV.

[24]See Johnson, G. (1968).

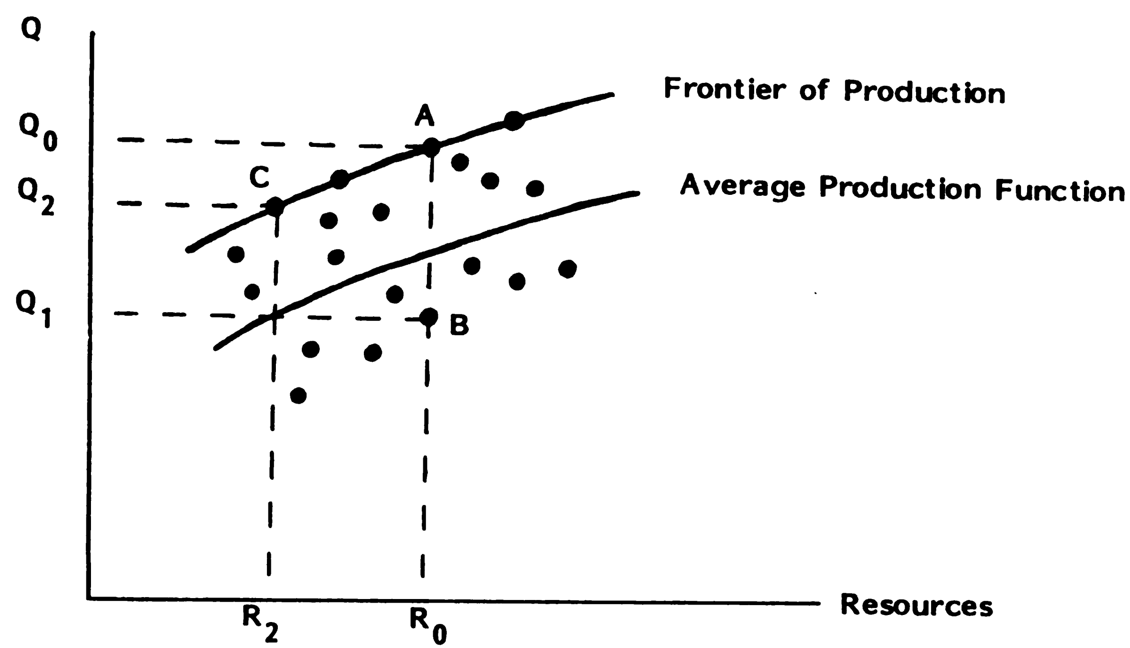

Figure 3.2 Localization of Technical and Price Inefficiency

on that function would be an economic problem that would be solved within the area of the utility function of the producer. Consequently, if technical changes are accounted for in the definition of the input variables of the production function, errors of specification will essentially be based on the difficulty of measuring the entrepreneurial factor.[25]

The enterprises located at A and B in Figure 3.2 by sharing a similar productive structure and inputs package, should not show any appreciable difference with respect to their interaction with the rural environment, i.e., they should belong to the same production system. In such a case, the entrepreneurial capacity of the producer is related to the technical management to explain differences in the levels of output between enterprises using the same set of resources, or what it was named, differences in technical efficiency. Nevertheless, it should be taken into account that these differences can also result from errors of measurement and/or can be random errors.

Given the utility function of the farmer and the price levels of inputs and products, there remains only one point within the production function that is an economic optimum. In Figure 3.2, it is assumed that the enterprise situated in A operates an efficient allocation of resources, and whereby Q_0 and R_0 are respectively the optimum levels of production and use of resources. This determines that the firm situated in C, and to which there corresponds a production level and use of resources Q_2 and R_2 respectively, shows price inefficiency. Nevertheless, since the enterprises differ in the use of resources, their different location on the production function can be affected by outside factors. Only in

[25]See Heady, E. and Dillon, J. (1969), p. 223.

the case where both enterprises belong to the same production system (same productive structure, same utility function of the producer and same interaction with the socio-economic context), could the inefficiency of the farm situated at C be attributed to a lower level of entrepreneurial capacity. This capacity being referred to the economic management of prices as such, or to the ability of the producer to identify himself with the input and product markets.[26]

3.5 Summary

Differences in the farm productive structure, producer characteristics, and technological inputs result in different agricultural production systems. Economic characteristics of the production factors, as well as attributes of the producer affect the condition of congruency between the structural component and the technological package. The structural component, which comprises the utility function of the producer, determines the profitability of innovations for the prevailing set of input-output prices.

Congruence and profitability are necessary but not sufficient conditions for technology adoption. An adequate articulation between the supply and demand for technology must be fulfilled, as well as the adaptability of technical information that is transferred to farms. These requirements are basically satisfied through the interaction of farmers with their socio-economic context, which is effected through the access to financial resources, production factors, technical information, and the interaction of producers with input and output markets.

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[26]See this chapter, p. 53, last paragraph.

However, the structural demand for technology will be entirely satisfied only when AR and DCs can supply to each system of production those innovations that are congruent and profitable in regard to the structural component and input-output price ratios. Consequently, unfavorable interaction with the rural context and/or unavailability of needed technology could generate latent demand patterns.

The degree of accomplishment of congruence, profitability, articulation and adaptability requisites upon the actual supply of innovations, and the availability of needed technology will explain the behavior of production systems in the adoption process. As a result, the systems of production, their interaction with the rural context, and the supply of technology available, shape a technological configuration that identifies the factors that limit or delay the incorporation of innovations under the prevailing economic policies.

Technological heterogeneity based on differences in the structural component and inputs package will indicate that structural characteristics could be the principal factor shaping the overall technological configuration. Homogeneity in technical inputs but dissimilarities in structural characteristics could be showing that instrumental conditions or unavailability of needed technology are limiting factors of first order.

Finally, differences in output among enterprises belonging to the same agricultural production system will depend on the efficiency with which the producer carries out the technical and economic management of the productive resources.

CHAPTER IV

ANALYTICAL PROCEDURE FOR STUDYING AGRICULTURAL PRODUCTION SYSTEMS RELATIVE TO THE INCORPORATION OF TECHNOLOGY

The objective of this chapter is to define an analytical procedure for the empirical analysis of actual production systems, based on the conceptual framework developed previously. This procedure will supply guidelines for exploring interdependence between conceptual components (structural, technological and instrumental components), and for the classification of agricultural enterprises, as well as for the characterization and technological diagnosis of actual production systems. Finally, the efficiency in the management of productive resources within each production system will be analyzed.

In what follows, each stage of this analytical procedure will be discussed. Particular attention will be given to the statistical methods used to achieve the objectives defined at the beginning of this study.

4.1 Exploration of the Sample Data

The farm productive structure, the producer characteristics, technological inputs in use and the interaction of farmers with their socio-economic context define for this study the domain of the production phenomena. This domain has a multidimensional structure. This structure is built on relationships of interdependence among the variables that characterize the four conceptual components used.

The objective of this exploratory stage is to search for an empirical identification of these relationships. The analysis will explore if the structure of the data comprises meaningful dimensions in regards to the conceptual framework developed in this study to explain the incorporation of technology at the farm level.

It will also be analyzed if there exists some underlying order, i.e., a gradient of dominance among the conceptual components for the explanation of the variance generated in the domain of the production phenomena.

Principal Component Analysis is a method for studying the structure of multivariate data sample.[1] This is a procedure developed by Hotelling (1933) to reduce a large set of correlated variables to a smaller number of uncorrelated hypothetical components.[2,3] These components are linear combinations of the original variables, explaining most of the variance generated by the original data set.

All the information needed for Principal Component Analysis is contained in the sample correlation matrix when standardized variables are used. The principal components turn out to be the characteristic vectors of this matrix (eigenvectors), and their variances the corresponding characteristic roots (eigenvalues).[4]

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[1]See Morrison, D. (1976), Chapter VIII; and Timm, N. (1975), Chapter VI.

[2]Timm, N., op. cit., p. 528.

[3]If the original variables were normally distributed, principal variates are not only uncorrelated but independent; see Kendall, M. (1975), p. 15.

[4]See Anderson, T. (1974), p. 272.

The first principal component is a linear combination with coefficients equal to the elements of the eigenvector associated with the greatest eigenvalue of the sample correlation matrix. This principal component explains the greatest proportion of the total variance.[5] The second principal component is orthogonal to the first, i.e., they are uncorrelated. The second component explains the greatest proportion of the "residual" variance. The remaining principal components have a similar explanation. The orthogonality guarantees that the variance of the successive components will sum up to the total variance. A few components explaining a high percentage of the total variance is desirable. In this case, these few components could replace the original variables in the analysis.

The statistical identification of a component does not necessarily mean that it can indubitably be associated with an aspect of the reality observed.[6] The utility of this method is based upon the possibility of succeeding in the identification of meaningful dimensions.

Each component presents a particular pattern of correlation with all variables entering the analysis. The correlation coefficient between the ith variable and the jth principal component is the product between the ith element of the jth characteristic vector and the square root of the jth characteristic root. The identification of the dimensions or aspects is realized for each principal component comparing the correlation coefficient corresponding to each original variable. Therefore, the algebraic symbol

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[5]Morrison, D., op. cit., p. 269.

[6]For the identification of dimensions in regards to farm analysis, see Cordonnier, P., et al. (1973), Chapter VI, Section II.

and the size of the elements of the respective characteristic vector will indicate the direction and significance of the contribution of the original variables in each component.

In the specific case of this study, the original variables are grouped in conceptual components.[7] Consequently, once the most important principal components are chosen, the percentage of explanation of the corresponding eigenvalue accounted for each conceptual component can be calculated. The ordering resulting from this analysis could be used for defining a gradient of dominance among the conceptual components for the explanation of the variance.

Since each principal component is a linear combination of the original variables, it is possible to determine the value taken by each component per observation, i.e., agricultural enterprise. Each characteristic vector has to be multiplied by the vector of responses corresponding to each observation. This data could be used for classifying observable units. In this sense, Principal Component Analysis is not generally used as an end in itself, but rather as a tool to identify meaningful patterns for a later analysis.[8]

In summary, Principal Component Analysis will be used to obtain some indication of how many dimensions underlying the original data are significant in regards to the conceptual framework of this study. Subsequently, these dimensions should help to rationalize the classification of agricultural enterprises.[9]

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[7]It should be clearly understood the difference between conceptual components and principal components. The former are the analytical categories brought forth by the conceptual framework of this study. The latter are the linear combinations founded by the application of Principal Component Analysis.

[8]Timm, N., op. cit., p. 536.

[9]See Ferreira, P. (1977), p. 84.

4.2 Classification of Agricultural Enterprises

The next question is whether agricultural productive units fall into groups or clusters, as against being more or less haphazardly scattered over the range of variation chosen for analysis.[10] The objective of this classification is to find meaningful groupings of enterprises in terms of the conceptual framework proposed for this study. In this sense, the domain chosen for analysis can represent the variance generated by the most important principal components detected in the exploratory stage.

Cluster Analysis offers a procedure to form groups of farms on the basis of their similarities in the variables used for classification.[11] Therefore, the units within groups should show less variation than across groups.[12]

Clustering techniques search for increasing the understanding and improving the organization of known facts permitting a more parsimonious description of the problem under study,[13] in the case of this study, the incorporation of agricultural technology. In this sense, the performance of clustering will be evaluated through the characterization and technological diagnosis of the actual production systems. At this stage validation of clustering results will be attempted.[14]

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[10]Kendall, M., op. cit., p. 1.

[11]See Gnanadesikan, R. (1977), Chapter IV.

[12]Gnanadesikan, R., op. cit., p. 103.

[13]Anderberg, M. (1973), p. 176.

[14]See Kaminsky, M. (1977), pp. 93-103.

Cluster Analysis can be based on hierarchical and nonhierarchical methods. In the hierarchical case, any group in a particular stage of clustering is a merger of clusters obtained before, i.e., the units that become grouped together do not cease to be part of that group until the end of the process of clustering. The hierarchical procedure will be used in this study. This is based essentially on heuristic techniques, i.e., there is nothing to show from the process, which or how many, are the groupings that will determine an optimum cluster.[15] It is left to the researcher to decide how many clusters will be used in the analysis.

In the hierarchical scheme,[16] N agricultural enterprises are grouped into clusters in a sequence of (N-1) interactions. Thus, a configuration of N clusterings is built, i.e., C_0, C_1, . . ., C_{N-1}, where C_0 is the polithetic clustering (the number of clusters is equal to the number of farms), C_{N-1} is the monothetic clustering (one cluster contains all the farms), and every cluster in C_i is the union or merger of two clusters in C_{i-1}, for i=1, . . ., (N-1).

Clusters are determined by the iterative seeking of neighborhoods that are defined in terms of some metric.[17] In this study the metric is based on Euclidean distance.[18] For this procedure a distance matrix is in order, where d represents the Euclidean distance between pairs of

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[15]See Alonso, A. (1977), pp. 52-53.

[16]The method for hierarchical clustering discussed in this section is developed further in Gnanadesikan, R., op. cit., pp. 105-116. This author follows Johnson, S. (1967), pp. 241-254. The computation program used in this study is based on the algorithm outlined by Johnson, S.; see Barr, A., et al. (1976), p. 72.

[17]Gnanadesikan, R., op. cit., p. 103.

[18]See Hartigan, I. (1975), p. 1.

enterprises. In general, the more complex algorithms of clustering utilize the square of the distance matrix.[19]

As one goes from the polithetic situation to the monothetic cluster, a monotonically increasing "strength" of clustering is produced. In C_1 those two enterprises that present the minimum distance will be grouped. Therefore, the strength of this clustering will be measured by that distance. Consecutively, the distance between any pair of units will be defined as the strength of the clustering at which the units first appear together in the same cluster. As a result, for each C_i there will be a corresponding strength α_i, where $\alpha_0 = 0$ and $\alpha_i < \alpha_{i+1}$, for i=0, 1, . . ., (N-1).

Once each interaction is performed, it is necessary to construct a new distance matrix; corresponding, for example, to clustering C_j. It is important to determine, therefore, if this matrix can be constructed in an unambiguous manner. This will happen if d, which defines the observed values in the interentity distance matrix corresponding to C_{j-1}, satisfies the ultrametric inequality.[20]

When the observed measures of distance between pairs of units are computed from data representing N observations in a k-dimensional space as in the case of this study, d may not necessarily satisfy this inequality. For resolving this problem either the minimum or the maximum method may be used.[21]

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[19]The reason for using the matrix of Euclidean distance to the square is that the more complex methods of clustering are based on the minimization of the variance within clusters (which implies the maximization of the intra-cluster variance); see Alonso, A., op. cit., pp. 57-58.

[20]See Gnanadesikan, R., op. cit., p. 109.

[21]Ibid., p. 109. Both methods could also be called "nearest neighbor" or "farthest neighbor" respectively; see Alonso, A., op. cit., pp. 60-62.

Using the maximum method the steps involved in the hierarchical clustering process can be summarized as follows:[22]

1) Form C_0, consisting of N clusters (polithetic clustering), with corresponding strength, $\alpha_0 = 0$;
2) Given C_j with associated dissimilarity matrix (where the observed values at stage C_{j-1}, may not satisfy the ultrametric inequality), merge those entities whose distance, α_{j+1} (>0) is smallest, to obtain C_{j+1} of strength α_{j+1};
3) Create a matrix of distances for C_{j+1} using the following rules: (a) if 1 and m are entities clustered in C_{j+1}, but not in C_j, i.e., $d(1,m) = \alpha_{j+1}$, defined $d([1,m], n) = \max. [d(1,n), d(m,n)]$; (b) if 1 and m are separate entities in C_j that remain unclustered in C_{j+1}, then do not change $d(1,m)$;
4) Repeat the process until the monothetic clustering is obtained.

It has been mentioned that the clustering procedure of the heuristic type offers no optimum solution. From a conceptual point of view, the comparative analysis of the different partitions formed, in regards to the theoretical layout proposed, should be conducive to a first approximation as to which partition represents a "good" clustering structure.

The clustering technique described above will produce a strong cluster, even though in the last stages very dissimilar entities may have to be grouped. The maximum distance within a cluster[23] will be measuring for each partition this dissimilarity. This measure will be quantifying

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[22]See Gnanadesikan, R., op. cit., pp. 109-110.

[23]When the ultrametric inequality is not satisfied, the strength of a clustering will be given by the maximum distance between any pair of units within the new cluster.

"how much it costs" the clustering process to form a new cluster. This will be yet another item by which to judge which is the most adequate number of clusters for the analysis.

It should also be taken into account that although the maximum method is chosen as a permanent rule for the construction of the different distance matrixes, it may be advisable to use other methods. Once the process has reached a certain level of interaction the minimum and average distance between the different clusters could be analyzed at the same time. This analysis can show with greater clarity the significance of the dissimilarities presented by the structure of a clustering.

Finally, the definition of which grouping is the most adequate can be clarified if the results of the clustering process are analyzed together with the information given by the arrangement of the enterprises in the "principal component space" obtained in the stage of data exploration.

The main objective of clustering in this study is to reveal the existence of different systems of production. However, this procedure also will be used for defining categories of analysis upon the conceptual components, e.g., when association between production systems and the interaction of farmers with the socio-economic context needs to be tested.

Up to this point, the two statistical techniques introduced, Principal Components and Clustering, both define an "a priori" stage of analysis where the object of research is agreed upon, i.e., the actual production systems.[24,25] First, the structure of the data is explored searching for

[24]Kaminsky, M. (1975), p. 2.

[25]As general reference for the analysis of Principal Components and Clustering, see Anderberg, M., op. cit., Chapters VIII-X; Gnanadesikan, R., et al. (1977); Kaminsky, M., op. cit.; and Cohan, H. (editor) (1975).

relationships between variables of the conceptual components that would appear meaningful for the proposed theoretic scheme. Second, a procedure is defined for grouping farms that are homogeneous in the aspects that seem revealing for the understanding of the incorporation of technology.

The analysis "a posteriori"[26] attempts to explore the set of hypotheses supporting the conceptual framework of this research. Simultaneously, evaluation and validation of the analysis "a priori" is accomplished. The main questions to be answered in this stage of analysis are related to the achievement of the objectives defined at the beginning of this study.[27] These questions are as follows:

a) Are the production systems different entities in regards to the conceptual components?

b) Do they behave differently in the incorporation of technology?

c) Which are the factors that limit or delay the adoption of agricultural innovations?

d) Do the production systems show differences in economic efficiency?

4.3 Characterization of Actual Production Systems

The objective of this stage of the analytical procedure is to describe the groups of enterprises or actual production systems. This stage searches for the recognition of "types" or "systems" that are not necessarily identical to any agricultural unit making up the group.

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[26]Kaminsky, M., op. cit., p. 2.

[27]See Chapter I, pp. 11-12.

The description of actual production systems should present a clear idea for the average of each farm group, how they are constituted in regards to their productive structure, producer characteristics, technological package used, and the interaction of farmers with the rural context.

At the same time, a comparative analysis between production systems upon the arithmetic means of the attributes that characterize the conceptual components will be developed. Means comparison should identify those attributes that bring about the most important dissimilarities among production systems.

4.4 Technological Diagnosis

This diagnosis will be based on a comparative analysis among actual production systems. This analysis will link the characterization of the production systems with "indicators" of their performance. In other words, the structural, instrumental and technological conditions of each production system will be related to physical and economic measurements. The association between the systems of production and performance measurements will also be tested.

This comparative analysis will facilitate understanding how the requirements of congruency, profitability, articulation and adaptability influence the adoption of technology. The structural demand for technology will be explored. This analysis will also establish if latent patterns exist in the technological demand. Up to this point, the factors that limit or delay the adoption of innovations should have been clarified by the diagnosis.

The implementation of the technological diagnosis requires the application of statistical analysis. The association between the actual production systems and different types of interaction with the rural socio-economic context will be evaluated by means of a r x c Contingency Table.[28] In this case, the application of the contigency table is based on a single random sample. Each observation in the sample is classified according to the two criteria already mentioned. One criterion shows r categories, and the other c categories. The test statistic (T) has an approximate chi-square distribution with (r-1) and (c-1) degrees of freedom. The hypothesis tested is one of independence between the two classification schemes.[29]

The test does not measure the degree of association between the criteria. A large T value does not necessarily imply a stronger association, but rather that it is possible to infer with greater confidence that there is some degree of dependence between the criteria. However, the results of the test do not permit an evaluation of the relationship of the dependence.[30]

The coefficients of Pearson and Cramer make it possible to measure the degree of association between the two criteria of classification.[31] These measures are based on the value of T corrected by the number of observations and/or the degrees of freedom.

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[28]For a general discussion on the use of contingency tables for the evaluation of clustering, see Ferreira, P., op. cit.; and Kaminsky, M. (1977).

[29]See Conover, W. (1971), pp. 154-158.

[30]See Kaminsky, M. (1975), p. 114.

[31]See Conover, W., op. cit., pp. 174-181. In the present study the Cramer's coefficient is used to be the square root of the coefficient as set out by Conover, W.; see Kaminsky, M., op. cit., p. 116.

The association between the actual production systems and the measures of physical and economic performance will be examined by means of the non-parametric test of Kruskal-Wallis.[32] On the one hand, there is available the categorization of the sample by systems of production, and, on the other hand, observations are arranged by increasing order in regards to a particular measure of performance. The Kruskal-Wallis test permits testing the hypothesis that there is no association between the fact that one observation (farm) can belong to a specific category (production system) as against the order given by the level of performance. The test statistic (K) has an approximate chi-square distribution with (k-1) degrees of freedom, where k is equal to the number of categories.[33]

4.5 Analysis of Efficiency in the Allocation of Resources

Once the actual systems of production have been studied in relation to the incorporation of new technology, attention will focus on analyzing the heterogeneity in efficiency among the enterprises belonging to each one. This micro-analysis[34] will cover the following general steps:

a) to estimate production functions;

b) to analyze economically the productivity levels of resources;

c) to analyze differences in efficiency among agricultural enterprises in the technical and economic management of resources.

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[32]For the application of this test as a part of "a posteriori" analysis to farm classification, see Alonso, A., op. cit., pp. 68-69; and Kaminsky, M., op. cit., p. 118.

[33]See Conover, W., op. cit., pp. 256-264.

[34]For differentiation of the micro-analytic approach from other approaches to production economics, see Kaminsky, M. (1971), pp. 146-147.

Production functions will be estimated by means of the Multiple Linear Regression Model[35] with a double logarithmic transformation, or Cobb-Douglas function.[36] The "power function" has been proved to be an appropriate theoretical form, as shown by the extensive use to which it has been put by agricultural economists.[37] The principal reasons for the use of the Cobb-Douglas function is the fact that provides an adequate fitting of the data, shows computational feasibility, and is a relatively efficient user of degrees of freedom.[38]

Regression coefficients of this model estimate the elasticity of production of each input. These elasticities are constant over the entire input-output curve. The sum of the regression coefficients estimates the nature of returns to scale. Direct estimates of marginal productivities are obtained by multiplying the average product of each input by the corresponding regression coefficient.[39]

Economic evaluation of the Cobb-Douglas production function will rest upon equi-marginal relationships, i.e., one compares the value of marginal productivity (VMP) of each input to its price (P_j), while the

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[35]See Kmenta, J. (1971), pp. 348-367.

[36]Ibid., p. 458.

[37]Several examples of the use of this function can be found throughout the works of Heady, E. and Dillon, J. (1969); and Heady, E., et al., editors (1956). Empirical applications within the Argentine agricultural sector were made by Nocetti, J. (1970), pp. 67-118 (Fattening - Livestock Region); and Bocchetto, R. (1970), pp. 37-53 (Breeding - Livestock Region).

[38]Heady, E. and Dillon, J., op. cit., p. 228.

[39]A general characterization of this model can be found in Kaminsky, M., op. cit., pp. 294-295.

level of the remaining resources is held constant. This analysis will indicate where producers are located in relation to an economic optimum, "if" they search for profit maximization under conditions of perfect competition.

The final objective of this study will be to separate levels of efficiency by system of production. The actual level of productivity of resources, as well as the differences in output and profitability corresponding to each efficiency level will be analyzed.

Differences in economic efficiency (technical and price efficiency) will be measured by the stochastic residual of the "ex-post" production function estimated for each production system.[40] The disadvantages of using this procedure[41] are attempted to be overcome in this study by performing the analysis of efficiency for those groups of farms that are more homogeneous in their structural, technological and instrumental components. Nevertheless, production function residuals can still be the result of measurement and specification errors, as well as to correspond to random errors. Consequently, the conclusions that can be reached in regards to differences in efficiency among agricultural enterprises are conditioned to the assumption that those errors are not significant for the present case of study.

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[40]See de Janvry, A. (1969), p. 4. This author associates the stochastic residuals to the technical management of the producer. Our approach is that for the "ex-post" production function these residuals are representing both the technical and economic management of the producer. Moreover, association can exist between technical and price efficiency. This possibility is also pointed out by Tandeciarz, I. (1971), p. 30.

[41]See Heady, E. and Dillon, J., op. cit., pp. 225-226.

The level of significance of differences in efficiency will be tested through a "dummy" variable which will take value of one for the efficients and zero for the inefficients.[42]

[42]For the treatment of "dummy" variables see Wonnacott, R. and Wonnacott, T., op. cit., pp. 68-77; and Kmenta, J., op. cit., pp. 409-430.

PART II

INCORPORATION OF TECHNOLOGY IN THE BREEDING - LIVESTOCK REGION

CHAPTER V

A DESCRIPTION OF BREEDING - LIVESTOCK PRODUCTION

The objectives of this chapter are:

a) To identify the most important breeding-livestock production region in the Argentine agricultural sector, called the "Pampa Deprimida Bonaerense," and within this to briefly describe the Basin of the Río Salado, which will receive preferential attention in the course of this study.

b) To describe the productive structure of the County of Ayacucho[1] in the Río Salado river basin, which is the study area of this research.

c) To review earlier studies written in reference to the state of technology in the agricultural sector of the "Pampa Deprimida Bonaerense."

d) To describe the sample of agrarian enterprises in the County of Ayacucho used in this research.

5.1 Description of the Breeding-Livestock Region

The Pampean Region represents 39 percent of the total area of Argentina, but produces 74.3 percent of the total value of agricultural

[1]The term "county" is used as the nearest applicable term for "Partido" which is the unit of political division of the Province of Buenos Aires.

production. It contributes 65.9 percent of the total value of all crops, and 85.4 percent of the value of livestock product. Likewise, 93.6 percent of the value of production of cereals and flax, 86.3 percent of beef production, and 53.5 percent of the wool comes from this area.[2]

Within the Pampean Region, the sub-region called "Pampa Deprimida Bonaerense" is the most important for breeding-livestock production. It covers approximately 7.7 million hectares, and is situated in the central-eastern part of the Province of Buenos Aires. In turn, this area includes two zones: the Basin of the Río Salado (5.6 million hectares), and the Laprida Depression (2.1 million hectares). Both zones have similar ecological characteristics, except that the latter does not have a sandstone layer near to the surface, and is less subject to flooding. Cow-calf operations are the basic activity in both zones. The Pampean Region also includes the fattening-livestock zone situated in the northwestern part of the Province of Buenos Aires and the northeastern part of the Province of La Pampa. In this zone, steers are fattened on improved pastures seeded with alfalfa. The breeding and fattening zones are the most important in regards to livestock production in the Pampean Region.

The Basin of the Río Salado is primarily an extended lowland, extremely flat, and covered by many waterways, ponds and marshes. Only those areas with rises or downs are suitable for crops. At surface level the soils are "solonetz solodizados" and "solod." They have a slight superficial acidity, or are neutral. The remainder of the valley topography is low-lying and more or less subject to flood. The majority of the soils are "solonetz," i.e., alcaline from the surface down, which

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[2]Information obtained from Banco Ganadero Argentino (Julio 1979), Statistical Section, pp. 48-52.

makes for a low permeability and poor structure. Vegetation is sparse and lacking in quality. The climate is variable, with winter and fall being very long and cold. The annual mean temperature is 14° to 16°C (58° to 62°F) with a maximum average of 23°C (74.5°F) and a minimum average of 8°C (47.5°F). The Basin of the Río Salado is located between the isobars of 700 to 900 millimeters of annual rainfall.[3]

The basin comprises the "partidos" (counties) of Saladillo, General Alvear, Tapalqué, Las Flores, Azul, General Belgrano, Rauch, Pila, Castelli, Tordillo, Dolores, General Guido, General Lavalle, Maipú, General Madariaga, Mar Chiquita and Ayacucho.[4] It is quite common also to differentiate in the Basin of the Río Salado, on the basis of certain soil characteristics, two different homogeneous ecologic zones that, nevertheless, do not differ noticeably in their production possibilities. This refers to the western zone which includes the first eight counties mentioned above, and the eastern zone which includes the remainder. The total area covered by the counties in the Basin of the Río Salado is shown in Figure 5.1. In this map the county of Ayacucho has been shaded, this being the area studied in this present research.

Focusing attention on the eastern zone of the basin, enterprises of more than 2,500 hectares cover 37 percent of the total area, but they constitute only four percent of the total farms. Enterprises in the 1,001 to 2,500 hectare bracket cover 25 percent of the area and represent eight percent of the total number of farms. Lastly, those enterprises between

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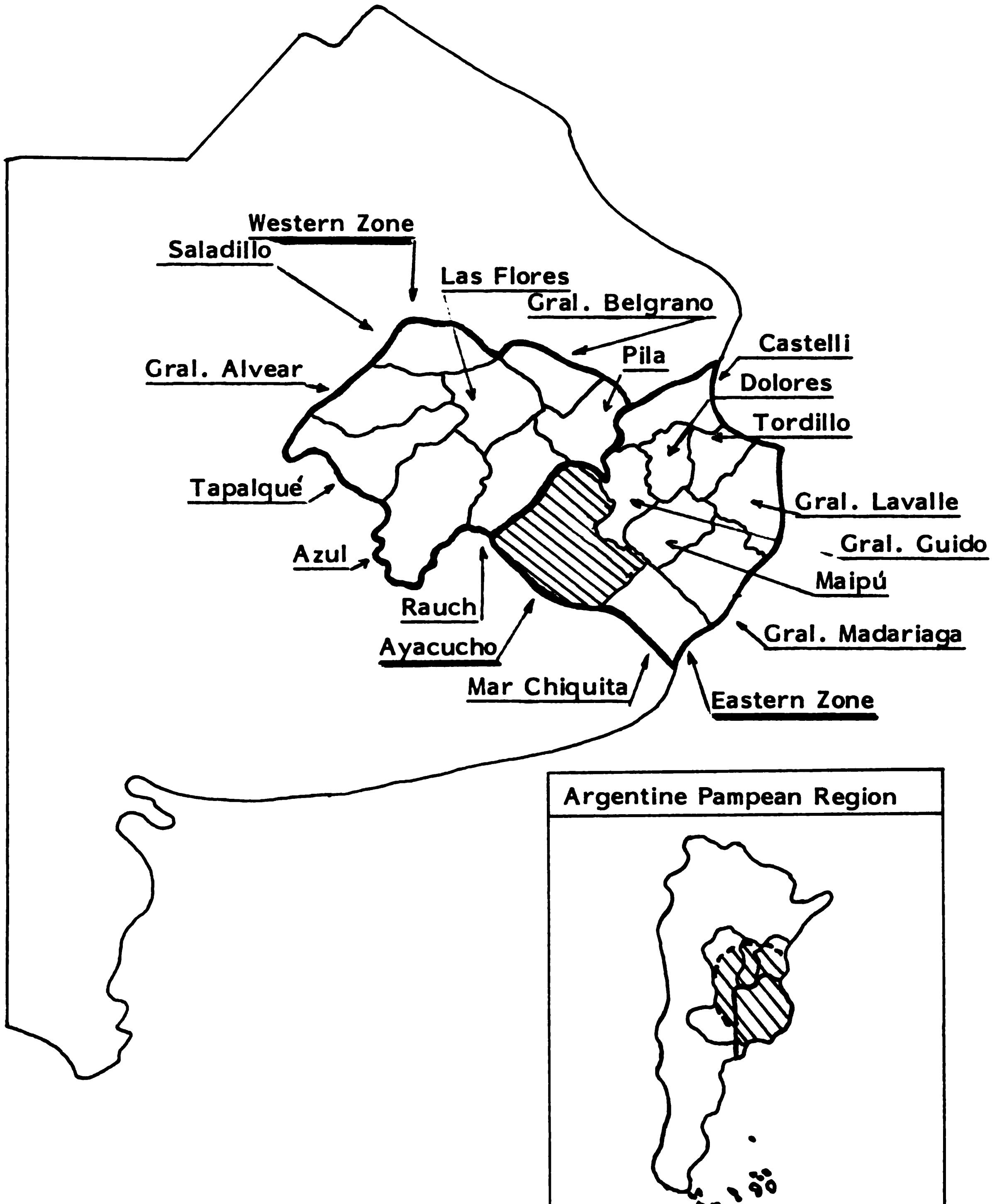
[3]The description of the soils and climate of the Basin of the Rio Salado is obtained from INTA-EERABalcarce (1973), pp. 16-19; and Santos, S. (1970), p. 12.

[4]INTA-EERABalcarce, op. cit., p. 6.



Source: Based on INTA-EERABalcarce (1973), p. 6.

Figure 5.1 Salado River Basin in the Province of Buenos Aires, Argentina

25 and 1,000 hectares cover 38 percent of the total area, but represent 80 percent of the total number of farms.[5]

In regard to land tenancy, 75 percent of the total area is owner-operated, 21 percent is leased, and four percent under other arrangements, in which the system of "co-partnership" is included. As regards the number of producers, nearly 90 percent are owner-operators.[6]

Fifty-three percent of workers are engaged in cattle breeding, and 37 percent in mixed activities (livestock and crops); only five percent are employed in crop production. The availability of salaried manpower and family labor varies in relation to the size of enterprise. Smaller establishments use a high proportion of family labor, whereas in farms over 1,000 hectares salaried workers can be as high as 95 percent of the total labor used.[7]

In the Rio Salado Basin 61 percent of the total area is devoted exclusively to cattle production, whereas 35 percent also includes crops, i.e., mixed agrarian operation. In the activities devoted to cattle, the most important are cow-calf operations on open pastures. Post-weaning production, together with fattening is practiced to a much lesser degree. These last two activities are generally a continuation of the establishment's own breeding program. The natural pastures are supplemented by annual and perennial seeded pastures, both on a relatively low scale. In livestock

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[5]Ibid., p. 78.

[6]Ibid., p. 94.

[7]Ibid., p. 101.

operations, mutton is produced together with beef in proportions that vary according to the areas.

The most common crops produced are: flax, corn, sunflower, sorghum, oats and wheat. The last two are harvested and also used for pasture.[8]

As regards marketing, the smaller farmers usually sell to cooperatives, whereas the larger enterprises deal directly with wholesale grain merchants. On the other hand, cattle are generally sold at local auctions. A smaller proportion finds their way to the Central Market of Liniers in Buenos Aires.[9] Producers in the fattening-livestock region buy most of the calves produced in the breeding zone.

5.2 Area of Study

Within the Río Salado Basin the county of Ayacucho was chosen as the study area because:

a) besides showing ecological characteristics similar to the other counties in the Basin, Ayacucho has a land use and production structure representative of the rest of the area;[10]

b) there is availability of complete information in different aspects of economic analysis; and

c) a sample survey of producers in the county of Ayacucho in the year 1968 provides a basis of comparison for the use of new technology.

The county of Ayacucho had 1,165 agricultural enterprises according to the agrarian census of 1969. The number of establishments and the

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[8] Ibid., pp. 85-92.

[9] Ibid., p. 106.

[10] See Santos, S., op. cit., p. 13; and Tandeciarz, I. (1971), p. 57.

area occupied are shown in Table 5.1. The basic difference shown by Ayacucho County compared with the overall total of the Basin is fewer farms with less than 100 hectares. For Ayacucho County, those farms located within the 101 and 1,000 hectare bracket include 59 percent of production units, but only 39 percent of the area; while the comparative figures for the Basin are 47 percent and 35 percent respectively. There is no noticeable difference when comparison is made in the largest size group.

The distribution of the land according to tenancy is shown below:[11]

Owner-operated	71.1%
Leased	23.9%
Co-partnership	3.4%
Other ways	1.6%

The above shows the predominance of owner-operators, although in the case of Ayacucho the proportions of enterprises leased and under co-partnership operation is higher than for the entire basin.

The soils in the county of Ayacucho are of the "solonetz solodizado" and "solod," while "alkalinic gleys" can be found in the flooded areas. In a small percentage of the area, soils can be found of the "brunizens" type, poorly drained. The distribution of these soils is not uniform, and each establishment will have these soils in different proportions. Figure 5.2 shows the three zones or association areas formed in accordance with the different distribution of the classes of soils. Zone I has the major productive capacity, and the Solonetz Solodized and Solod predominate. Zone II is relatively flat, and the proportions among the soils mentioned above, and the Solonetz type and the Alkalinic Gley are approximately the

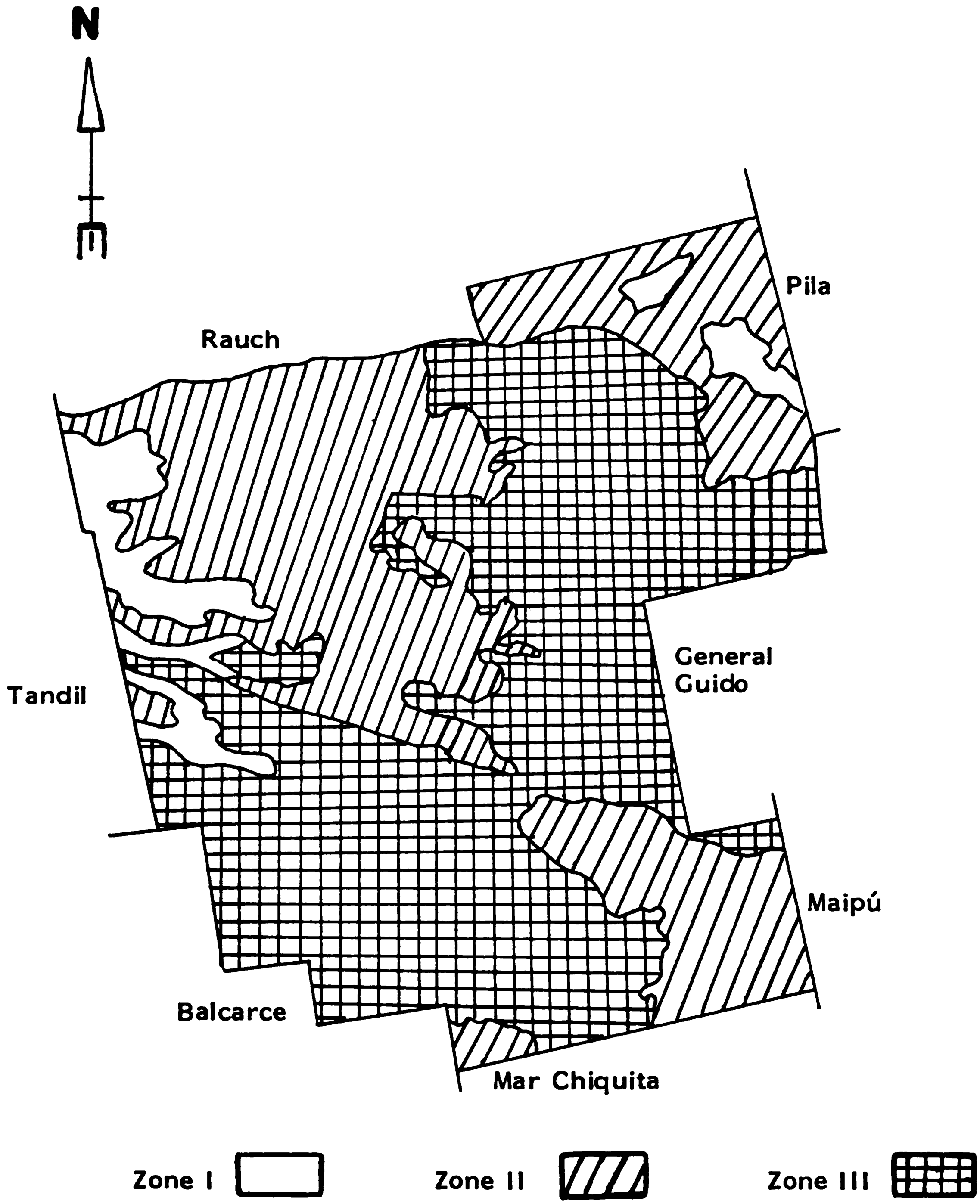
[11] Source: National Agrarian Census, 1969.

Table 5.1

Distribution of the Agrarian Establishments
in the County of Ayacucho, Argentina
According to Number and Area

Size (Hectares)	Establishments		Area	
	Number	%	Hectares	%
<100	318	27.30	14,624	2.25
101-400	434	37.25	102,251	15.55
401-1,000	249	21.37	155,290	23.85
1,001-2,500	119	10.22	180,290	27.69
>2,500	45	3.86	199,597	30.66
Total	1,165	100.00	651,052*	100.00

Source: National Agrarian Census, 1969.



Source: Soil Department, INTA-EERABalcarce, 1969.

Figure 5.2 Map of Association of Soils in Ayacucho County, Argentina same. In general, 30 percent of this zone is adequate for crops, although with certain risks, and the remainder is dedicated to cattle production on natural pastures or improved pastures. Zone III is almost entirely flat, and the soil is predominately Solonetz. There is, nevertheless, a relatively important proportion of Alkalinic Gley and Solonetz Solodized, and sporadically soil of the Solod type. Consequently, this zone, in almost its entirety, must be used for cattle breeding.[12]

Land use is shown in Table 5.2. These data confirm numerically the general characterization made earlier for the Río Salado Basin, i.e., there is a predominance of natural pastures, although it is important to point out the relatively high proportion of seeded permanent pastures. It can be seen also that 650,000 hectares are productive. Of this total area, approximately 13 percent was dedicated to crop production during the 1974 to 1978 period. Table 5.3 shows the distribution of the cropping area according to the type of cultivation, and according to the average values of the five-year period of 1974 to 1978.

Similarly to the Río Salado Basin, most activities in Ayacucho county are devoted to livestock, with emphasis on cattle breeding together with sheep farming.

Table 5.4 shows the number of head of livestock corresponding to the years 1974 and 1977 by types and categories of livestock. As regards cattle, the most outstanding feature is the percentage increase of steers, which indicates a tendency in the county to post-weaning production which has also been accompanied in recent years by a slight

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[12]The description of the soils of the county of Ayacucho are taken from Bocchetto, R. (1970), pp. 13-16, on the basis of information given out by the Soil Department of EERABalcarce - INTA.

Table 5.2

Land Use in Ayacucho County, Argentina

Use	Area (Hectares)	%
Annual Crops (harvested area)	37,800	5.63
Annual Winter Forage	7,500	1.12
Annual Summer Forage	2,600	0.39
Perennial Forage	50,000	7.45
Deferred Pasture Forage	10,700	1.59
Natural Pastures	540,200	80.52
Natural Forests and Woods	1,200	0.18
Area Not Used	20,900	3.18
Total	670,900	100.00

Source: Department of Rural Economy and Sociology of EERABalcarce-INTA. Information based on INTA - Rural Extension Cooperative Agency of Ayacucho (1977).

Table 5.3

Distribution of the Area with Crops
Ayacucho County, Argentina

Crops	Area Sown (Hectares)	%
Oats	22,400	26.96
Sunflower	21,600	25.99
Corn	16,200	19.50
Flax	11,700	14.08
Sorghum	7,540	9.07
Wheat	2,740	3.30
Barley	570	0.69
Rye	340	0.41
Total	83,090	100.00

Source: Department of Rural Economy and Sociology of EERABalcarce-INTA. Information based on the statistics of the Department of Agricultural Estimations, State Secretariat of Agriculture (1974/78).

Table 5.4

Cattle and Sheep Stocks, 1974 and 1977
Ayacucho County, Argentina

Cattle				Sheep			
	Number				Number		
Category	1974	1977	Change 74/77	Category	1974	1974	Change 74/77
Cows	269,275	296,482	+10.1	Ewes	304,962	270,332	-11.4
Heifers	105,335	89,224	-15.3	Lambs (female)	58,137	48,904	-15.9
Calves	111,001	139,662	+25.8	Lambs (male)	31,431	26,889	-14.5
Young Steers	32,358	35,511	+ 9.7	Lambs before Weaning	59,303	43,709	-26.3
Steers	5,220	7,536	+44.4	Castrated Lambs	14,579	15,462	+ 6.1
Bulls	18,194	18,746	+ 3.0	Rams	16,100	14,615	- 9.2
Total	541,383	587,161	+ 8.5	Total	484,512	419,911	-13.3

Source: Department of Rural Economy and Sociology of EERABalcarce-INTA. Information based on National Livestock Census and Agricultural Registration, 1974; and Livestock Census, 1977.

increase in the use of perennial pastures. In any event, the relationship between steers and young steers versus cows has hardly changed since the ratio of 0.14 in 1974 has only become 0.15 in 1977. This shows that in Ayacucho County cow-calf operation is the most common activity. Another fact brought out in Table 5.4 is the general decrease in sheep breeding in the period mentioned. Over the last decade, the percentage decline is around 40 percent. The lower profits in sheep have resulted in more cattle to replace them while crops have maintained their position in respect to land use. Sheep breeding has become a subsidiary activity with respect to cattle breeding. Further, sheep handling is largely neglected by most producers.[13]

Within the cattle breeding activity, 65 percent of the calves are sold at the time of weaning. The remainder are fattened after weaning on the farms where they are produced. The weight at weaning is approximately 160 kilograms (about 350 pounds), obtained at eight or more months. The post-weaning animals generally are marketed at weights between 230-260 kilograms (530 to 600 pounds) obtained at 18 to 20 months. Post-weaning production depends greatly upon the climatic conditions, since the producer mainly uses seeded pastures, and does not usually maintain other sources of forage (reserves, bales of hay, etc.). In any case, this decision is largely influenced by market prices and the financial resources of the producer.[14] When the weight of steers reaches 350 to 380 kilograms, it is referred to as a fattening activity.

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[13] See INTA - Rural Extension Cooperative Agency of Ayacucho (1977), p. 34.

[14] Ibid., p. 33.

5.3 The Allocation of Resources and Technological Change in the Animal Agriculture of the "Pampa Deprimida Bonaerense"

The objective of this section is to discuss the main issues raised in earlier investigations, generally based on 1968 data, with respect to the central theme of the present study.[15] The principal results can be summarized under the following aspects:

a) Cost Structure[16]

- From 65 to 70 percent of the total cost per unit of production corresponds to fixed costs. Within this percentage land and improvement costs form the major part. This is an indication of the relative rigidity of the productive structure in the livestock breeding enterprise.
- The relatively small incidence of variable costs, in particular those components which can be identified with land-saving innovations, points out the extensive nature of cattle production in the Pampa Deprimida Bonaerense.
- Economies of "size" are found in the medium sized establishments; total unit costs do not vary to any appreciable extent for the average of larger groups.
- Within each size group total unit costs vary considerably with respect to the average for the group. The lowest average cost can be found in each size strata in those establishments that have the highest beef production per hectare.

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[15] INTA and IICA are those institutions that have supported the main part of the investigations in the "Pampa Deprimida Bonaerense."

[16] See Santos, S., op. cit.

b) Profitability at the Farm Level[17]

- The profitability of breeding-livestock enterprises and the relationship between their income and certain components of the total cost show a high degree of sensitivity to the variations of price of the product and those elements that comprise the cost structure. This means that in cases of favorable input-product price relationships, the breeding establishment not only covers its total costs, but produces extraordinary profits. If input-product price relationships are unfavorable, the only possibility for the producer who wishes to maintain a specialization in breeding is to minimize his losses. In this case he can generate returns that only cover variable costs plus perhaps some part of the fixed costs, but excluding any payment to capital.

c) Efficiency in the Use of Productive Resources[18]

- The livestock breeding establishments utilize the land factor with a lower degree of intensity than would correspond to an economic optimum.
- There are significant differences in the levels of efficiency with which farms make use of their resources. Efficiency has a high positive association with the output of beef per hectare. The difference in the yield of meat per hectare for enterprises classified in two groups of efficiency is approximately 35 percent.

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[17]See Bocchetto, R., op. cit.; IICA (OEA)-INTA (1976); and INTA-IICA(OEA) (1979).

[18]See Bocchetto, R., op. cit.; and Tandeciarz, I., op. cit.

- Post-weaning operation and fattening appear to be the attributes that best explain the differences in efficiency levels. To a lesser degree, but also significant, there is an evident association between efficiency and the use of improved pastures and the time the owner devotes to his own establishment.
- There is no significant relationship between efficiency and the size of the enterprise as measured by its area.
- The size of the establishment does not appear to have an influence, at least to a recognizable degree, on the level of technical management. There are, however, marked differences in technical management among establishments of the same size group.
- Efficiency in the use of resources is not related to soil types. Differences in meat yields per hectare result from technical management of resources, and not in soil differences. Nevertheless, "within each efficiency group" the meat yields per hectare are greater for those enterprises located in soils of a lower quality. This would indicate that those producers possessing lower quality land are forced to a more efficient technical management of their resources. They reach a higher level of yields than those establishments that possess a better quality soil, but which in turn, are the least efficient members of their group.

d) Optimum Resource Allocation with the Actual Technological Level[19]

- The increase of production possible on breeding establishments using their resources at levels corresponding to an economic optimum is of the order of 30 to 40 percent.
- A more efficient allocation of resources would mean for the breeding establishment:
  * Increase the post-weaning activity and fattening of their own calves.
  * Increase the use of improved pastures and the number of head per area unit.
  * Better control of disease and animal health.
  * Improve the technical management of the enterprise.

e) Potential Performance with Available Technology[20]

- Technological packages including improved pastures and fertilization, an increase in the number of head per hectare, improved cattle handling practices together with a complete animal health program, will bring about an increase in the production of meat per hectare. With respect to the average results obtained in the zone, this means an 80 to 100 percent increase for breeding-livestock, and 140 to 150 percent for fattening operations. Obviously, the profitability of this technological package will depend upon the relationship between the value of beef produced and of the new inputs required.

[19]See Bocchetto, R., op. cit.; and Goldman, O. (1972).

[20]See Santos, S. and Cascardo, A. (1971); Delgado Castillo, E., et al. (1975); INTA-EERABalcarce (1965); and Vismara, C. (1978).

If this relationship is favorable, the cattle-breeding producer can increase the profitability of his enterprise in comparison to the average in the region. On the other hand, in those years when the price of beef is low resulting from the liquidation phase of the cattle cycle, investment in new technology can cause low or even negative profits. At this time the improved system is not able to compete with the more traditional production practices. The consequences can be aggravated if at the same time the price of inputs increases faster than normal. In such cases the new package of practices is profitable only if breeding is followed by fattening of the young stock.

f) Social Profitability of Available Technology[21]

- Under the assumption that all new technology produced in the period 1967 to 1972 was immediately adopted by producers, it would have been possible to achieve the following livestock production results within the breeding area:

  * An increase in the quantities traded in the cattle markets of the order of 13 percent, and a reduction in the prices of 20 percent.

  * An increase in the social benefit of 500 pesos for each peso invested in research and extension within the said productive zone.[22]

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[21]See Hurtado, H. (1972).

[22]Total revenue coming back to farmers would have decreased by ten percent.

g) Incorporation of the Available Technology[23]

- The degree of adoption of new technology by the breeding establishments is low. An overall adoption index with a range of variation between 0 and 11 showed an average for the establishments in Ayacucho County of 3.05.[24] This is to say that, of the eight practices which comprise the technological package on which this index was built, the enterprise adopts two or three depending upon the type of technology incorporated. Within the sample studied the index showed a value of only 2.04 for the establishments between 200 and 1,000 hectares, 4.74 for those in the 1,001 and 2,000 group, and 5.07 for those establishments with an area of over 2,000 hectares. It can be concluded that the index of adoption has a direct relationship to farm size.
- The fact that larger farms show higher rates of adoption can be related to their interaction within the rural environment. The type of producer that operates larger farms has a higher level of formal education, has more intensive contacts with sources of information and technical assistance, and a relatively more favorable financial position.
- Added to these positive characteristics of large producers is the negative one of low dedication to the enterprise as measured by the number of days that he is present on the farm.

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[23]See Obschatko, E. (1971); Obschatko, E. and de Janvry, A. (1971-1972); and Tandeciarz, I., op. cit.

[24]This index gives double points to those techniques that request capital investment: perennial pastures, fertilizers and forage reserves, and only single points to those techniques which are disincorporated; pregnancy testing, anticipated weaning, vaccination against Brucellosis, seasonal service and mineral supplementation.

- The number of days producers are present in their establishments is positively associated with the use of improved pastures and post-weaning production and fattening of their stock. These variables are closely related to efficiency.
- There is no association between the number of practices adopted and efficiency.
- It appears that larger producers who adopt more practices do not utilize that technology well, or that the practices cannot realize their full productive potential without a major replacement of natural grazing by cultivated pastures.
- Absenteeism of larger producers appears to be the principal cause of inadequate management of new technology, and/or is responsible for the poor adoption of improved pastures and cattle fattening.
- On the other hand, the small farmer adopts a smaller number of practices from the technological package. However, this type of enterprise devotes a larger percentage of their land area to improved pastures compared to other size groups, and also practices to a greater degree the post-weaning operation and fattening of its own stock. These attributes are significantly associated with the larger number of days spent by the producer on the farm.
- It can be concluded that major factors limiting efficiency and the adoption of technology in the breeding-livestock establishments of small producers are their low level of formal education, limited contact with sources of new information, and lack of access to credit. For larger producers, a major constraint is the small number of days they actually spend on the farm.

- The situation analyzed above is supported by economic rationale. The effect of new technology upon profitability begins to be evident for an adoption index equal to four and days of dedication on the part of the producer equal to 200 days. Small farms (average area 500 hectares) and medium-sized establishments (average area 1,500 hectares) showing actually 200 days of dedication have the incentive of higher profitability when new technology is incorporated. However, in the case of medium size farmers this incentive is slight and could simply disappear if risk aversion is taken into account. On the contrary, large farms (average area 3,600 hectares) with less than 200 days of dedication by the producer could achieve higher rates of profitability by adopting technology that would not substantially modify their productive structure and that might not require a greater attention of the producer to his farm. To sum up, the effects of new technology on the profitability of the agricultural enterprise will begin to act as a real incentive when there is a high level of adoption and of dedication by the producer. This reiterates the need of the incorporation of techniques and practices to be effected in a "package" of innovations, being accompanied also by a greater dedication and efficiency of management on the part of the farmer.

These results show the structural rigidity and the extensive nature of breeding-livestock production. The level of adoption of new technology is low. The package of innovations available could substantially increase social benefits.

Within this context of production, large sized farms show the highest adoption index, the lowest time devoted for the producer to farm activities, and a favorable interaction with the rural environment. In these farms the proportion of improved pastures is low, breeding being the principal cattle activity.

Small and medium sized farmers adopt less technology, though they use a greater proportion of improved pastures and devote themselves more to fattening operations than large producers. Smaller farmers have a high dedication to farm activities, but they show low interaction with the rural context.

Technological heterogeneity in breeding-livestock production appears to be based on profitability. However, conditions of congruence appear to be underlying the election of breeding or fattening activities. Important differences in efficiency are shown in each farm size.

These conclusions provide a basis for the general framework of analysis developed for the present study. This line of investigation tries to develop further the results of Obschatko, E. (1971), and Tandeciarz, I. (1971). This will be attempted by the identification of the prevailing production systems in the breeding-livestock region, looking at the structural and technological characteristics as a basis for classification.

5.4 Source and Nature of the Data

The present study was conducted to provide a framework of analysis to explain the incorporation of technology in different systems of livestock production. However, this research is part of a larger project that included a dynamic aspect, i.e., the transformation of livestock systems and the corresponding technical change. For this purpose, observations at two points in time of the same sample of producers was needed. In consequence, the sample included the same panel of producers interviewed in Ayacucho County in 1968.[25] The survey conducted in 1968 provided the data base for a series of economic studies examined in the previous section of this chapter.

It is necessary to return to the process of the sampling procedure of 1968. From the statistical point of view the term "population" was used to refer to all livestock enterprises in Ayacucho (the area under study) which contained more than 200 hectares. These livestock enterprises were divided into five groups, namely: 201-500; 501-1,000; 1,001 -1,500; 1,501-3,000 and more than 3,000 hectares. Subsequently, a random sample was taken being representative of each size group. In 1968 the sample contained 74 producers. Of this total, 63 cases were interviewed in 1977.[26] The remaining 11 were cancelled because of impossibilities of conducting the interview, e.g., they were out of business or refused to cooperate. These cases were evenly distributed over the size groups.

The survey of 63 producers was conducted in the period January to March, 1978 by university students[27] who were specially trained for that purpose, and supervised by senior technicians of the EERABalcarce-INTA. The author of this present work had overall responsibility for the survey. The financial period analyzed covered the calendar year of 1977.

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[25]The 1968 sample was originally obtained to fulfill the objectives of the study of Santos, S., op. cit.

[26]The representativeness of the sample according with the number of enterprises and the area covered by each group of the 1968 population is shown in Santos, S., op. cit., Table 2, page 16. The data could not be actualized to 1977 because of differences in area classification between 1960 and 1974 agrarian censuses.

[27]These were all fifth year students from the College of Agricultural Science of the National University of Mar del Plata.

The interview questionnaire was organized in two parts. The first part covered the following topics:[28]

a) productive structure of the breeding-livestock establishment;

b) technological package and technical management of inputs;

c) economic information;

* physical production and revenues

* production costs

d) technical management of cattle and sheep.

The second part of the questionnaire was designed to collect the following information:[29]

a) characteristics of the producer;

* economic conduct

* entrepreneurial capacity and dedication

b) economic management of the establishment;

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[28]The preparation of the first part of the questionnaire was based on the experiences accumulated by the Department of Economy and Rural Sociology of the EERABalcarce-INTA in the obtaining of this type of information. The only change was the restructuring required by the objectives of this investigation. Nevertheless, the questionnaire relating to the technical management of cattle, sheep, crops and pastures, were the object of discussions in the Department of Animal Production, Agronomy and Extension. The second part merited a more detailed treatment. A basic questionnaire was submitted for discussion by the technicians from the Department of Economy and from those departments previously mentioned of the EERABalcarce-INTA. Likewise, consultation was effected with technicians from the Experimental Stations at Pergamino, Marcos Juarez, Concepción del Uruguay, and the Agricultural Development Group of INTA. The basic questionnaire was tested in the study area, and the final questionnaire was then prepared.

[29]More specific details of the gathering of the information, and likewise the second part of the questionnaire are detailed in Bocchetto, R., et al. (June 1979).

c) interaction with the socio-economic context of the rural environment;

* access to financial resources
* access to production factors
* access to technological information
* interaction with the input and product markets.

The characterization of the sample through the principal variables of this study is given together with the description of the actual systems of production in Chapter VII.

CHAPTER VI

IDENTIFICATION OF ACTUAL PRODUCTION SYSTEMS IN THE BREEDING - LIVESTOCK REGION

The objective of this chapter is to identify the actual production systems of the breeding-livestock region in Ayacucho County, based on the sample discussed in Chapter V.

Identification of the production systems will be made in three steps: exploration of the data sample, classification of farms based on the results of the explorative stage, and characterization of the systems. The first two steps define what was termed "a priori" analysis. The last step initiates the "a posteriori" analysis. Chapter VII and VIII analyze the incorporation of technology and efficiency in resource allocation in the actual production systems.

6.1 Exploring the Domain of the Production Phenomena

The theoretical framework of this study examines production phenomena by means of the endogenous and exogenous components of the agricultural enterprise. The endogenous components, i.e., the productive structure of farms, the characteristics of the producer and the technological package in use, reflect the interrelationships that constitute different behavior in the incorporation of technology. However, the exogenous component, i.e., the interaction of farmers with their socio-economic environment, introduces explanatory elements to the technological behavior of farms. Consequently, this section of the study evolves in two steps. First, the structure of the multivariate data sample will be analyzed using the structural and technological components to determine if meaningful dimensions can be identified with respect to the conceptual framework outlined earlier. Second, the variables that represent the instrumental component will be added to the analysis to see how they affect the dimensions revealed by the first step.

This study will refer to livestock production. Moreover, it will be assumed that the technological level of livestock enterprises is basically shown by their beef production activities.[1]

6.1.1 Definition of the Variables

The objective of this section is to define the variables or attributes that correspond to the conceptual components.[2] For each component the basic variables are first defined; and, subsequently, the relationships used in the computations are presented for the cases to which they apply. Each variable is indicated by means of an abbreviation or code by which it will be identified during the remainder of this study.

Productive Structure

- Livestock area (LA): Covers the total number of hectares dedicated to natural, annual and perennial pastures. Fifty percent of the total area shared with grain crops during the calendar year, and 60 percent of the area planted to double purpose crops (livestock feeding and grain) are also included in the LA.

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[1] In the sample of the study, 94 percent of the total area utilized for agricultural production is devoted to livestock. At the same time, 83 percent of the animal units correspond to cattle.

[2] The traditional approach of Farm Management in Argentina classified agricultural enterprises according with their size. However, the studies of CIDA (1965), Flichman, G. (1974), and INTA-SIPNA (1975), developed the typing of farms based on a multivariate criterion. These studies were used as reference for the definition of variables in the present research.

- Total Labor (TL): Covers the total number of "family" and salaried work hours, whether permanent or temporary, including also those hours of contract work devoted to agriculture, and converted to man equivalents at the rate of 2,600 hours per year.
- Salaried Labor (TLs): Being that part of TL classified as "employed" and drawing a salary.
- Livestock Labor (LL): This figure is arrived at by subtracting from TL those work hours dedicated exclusively to crops. Labor dedicated to crops is expressed in relation to the area and to the time effectively dedicated to cultivation (only for grain or double purpose crops).
- Livestock (LS): Covers the productive animal stock, i.e., cattle and sheep. The totals for cows, bulls and served heifers, plus the replacement percentage corresponding to non-served heifers (not more than 25 percent of total cows) and female nursing calves (not more than 30 percent of the total cows) are included under the term of cattle. In regard to sheep, it covers the totals for ewes and rams, plus a percentage for replacement of female lambs (not more than 30 percent of total ewes). In all the cases, each category of animal is converted to equivalent animal units.[3]

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[3]The animal unit combines different categories of cattle into a common unit of measurement, in accordance with the consumption capacity and nutritional requirements of the animal. Conversions per head of cattle is as follows: breeding cows--1.0; bulls--1.3; heifers over 2 years old--0.8; heifers less than 2 years old--0.7; grown steers--0.8; half-grown steers--0.7; weaned calves--0.6; and nursing calves--0.25. For sheep, the conversions are the following: ewes, rams and mutton--0.2; lambs--0.07; and lambs before weaning--0.05.

- Improvements (ID): Expressed in values of depreciation;[4] covers those improvements used specifically in livestock breeding, plus a proportionate part of those used alternatively for crops and livestock activities. The corresponding percentage is determined as the proportion of LA over the total area devoted to agricultural production. Excluded from this value is the depreciation of perennial pastures, which is classified as a technological input.

Having defined the basic variables, the productive structure will be represented by the following variables or relationships:[5]

a) Farm size: LA;[6]

b) Proportion of factors: LS/LL,[7] LL/LA, LS/LA, ID/LS, ID/LL, ID/LA;

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[4]The value of depreciation is calculated by subtracting the residual value from the original capital value and then dividing the answer by the number of years of use. This last is taken from INTA-SIPNA (1979), pp. 14-20.

[5]Machinery is not taken into account for determining the factor proportions. In a first stage the basic factors to be taken into consideration are land, labor and capital. While it is true that the first two could be expressed directly, capital implicitly includes such important items as improvements, machinery and livestock. Nevertheless, the three items do not have, at the level of the livestock-breeding establishment, the same importance for the characterization of the production structure. While improvements and livestock represent 35 percent and 56 percent respectively of the capital invested (land is not included), machinery only represents a total of six percent.

[6]The farm size is defined by the endowment of production factors. The livestock area (LA) is chosen in this study to represent the farm size. There exists a high positive correlation between the livestock area and the endowment of labor and capital stock. The sample correlation coefficient between LA and LS is equal to 0.96, between LA and LL is 0.72, and between LA and ID is 0.84.

[7]For computation purposes, the value of LL is multiplied by 100.

c) Salaried relationship: TLs/TL.[8,9]

Characteristics of the Producer

a) Economic conduct (Objective): The utility function is defined by a "proxy" variable which implies that the objective which has priority for the producer is increased land productivity through the incorporation of new technology. The variable is given a value of 1 if the producer shows this objective has an overall priority, and a value of 0 for any of the following cases: if the producer is not interested in investing in technology; if his objective is merely investment in land, but due to lack of capital is forced to intensify; if he intensifies because he cannot find suitable land for purchase.[10]

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[8]While it is true that livestock labor could be separated thus obtaining the difference between the total hours and those incurred by crops, insufficient information was available to be able to determine, within the salaried group, temporary or permanent, the number of man hours dedicated exclusively to livestock. For this reason, the salaried relationship is calculated on the total agricultural labor force.

[9]The relation between owned area and the total area is not included. Approximately 70 percent of agricultural land in Ayacucho is operated by its owners. In the sample, 87 percent of the producers own all of the land they use. The relationship between owned and hired machinery is also not included.

[10]The construction of this variable is based on the questions presented in Bocchetto, R., et al. (1979), pp. 31-34.

b) Entrepreneurial Capacity:[11]

- Schooling received by the producer (Education): This item takes a value of 1 or 2 respectively, depending upon whether the producer failed to complete, or did in fact complete primary school; value 3 or 4 for similar situations for secondary school and, similarly, values 5 or 6 for university education.
- Age of the producer (Age): Expressed in years.
- Interest of the producer (Predisposition): Represented by an index with a theoretical range between 0 and 11. If the producer shows that he consistently tried to obtain the information detailed below, he is given the value shown:[12]

New methods of organization and handling of his enterprise:	2
New techniques and management practices:	2
New inputs and/or products:	2
Inputs and product prices:	1
Marketing conditions:	1
Credit:	1
Taxes:	1
Agricultural policies in general:	1

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[11]This variable comprises the educational level of the producer and his "intellectual" disposition towards technological changes. This variable does not intend to define the "managerial" capacity (from a technical and economic point of view) with which the producer allocates the productive resources. This aspect of the producer will be taken into account in the analysis of efficiency developed in Chapter VIII.

[12]See Bocchetto, R., et al., op. cit., pp. 52-54. The first three types of information receive double points because they are directly related with the incorporation of technology.

c) "Dedication" and source of decision making (Dedication):[13] Measured by means of an index with theoretical range between 0 and 20, and which is built up as specified in Table 6.1.[14]

Technological Package

Within this component five categories were analyzed, namely: type of activity, feeding, health, genetic improvements, and cattle management.

a) Type of activity (Activity): Classified by an index giving a value of 1 if the producer is dedicated to cattle breeding (pure breeding including short term post-weaning); a value of 2 if the producer practices post-weaning operation (this may be post-weaning over a long term, or a mixture of long and short term post-weaning); and a value of 3 if he undertakes fattening (breeding and fattening directly, or practices also long and short term post-weaning). In all cases the post-weaning or fattening activity is carried out following normal breeding and calving operations.

b) Animal nutrition (Feeding): Expressed by an index (FI) between 0 and 5; the producer receiving one point for each of the following practices:

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[13]Within the technical and economic management of the farm, it is necessary to separate those activities related to "programming," and those based upon "day-to-day" decisions. By programming, the producer looks at technical and economic plans for a complete productive period. "Day-to-day" management refers to short term decisions needed to run a farm on a daily basis. These activities require the continued presence of the farmer. To define this attribute it is necessary to consider the time devoted to the enterprise by the person who makes day-to-day decisions, as well as the degree of authority that he has, and the economic incentive associated with his function.

[14]See Bocchetto, R., et al., op. cit., pp. 61-62.

Table 6.1

Structure of the Index Measuring Dedication and Source of Decision Making in Day-to-Day Management

Source of Decision Making	Dedication to Farm	
	Full-Time	Part-Time
Producer	20	16
Producer and Relative, or Administrator	19	15
Producer and Supervisor, or Majordomo,** or Foreman	18	14
Producer and Day-laborer	17	13
Relative and Administrator/Profit Sharing	12	6
Relative and Administrator/Non-profit Sharing	11	5
Administrator and Majordomo/Profit Sharing	10	4
Administrator and Majordomo/Non-profit Sharing	9	3
Supervisor or Majordomo, or Foreman/Profit Sharing	8	2
Supervisor or Majordomo, or Foreman/Non-profit Sharing	7	1

*The producer, relative, administrator, supervisor, majordomo, foreman and day-laborer is the order of authority for decision making in the sample.

**Manager of day-laborers.

- Annual Pasture (AP)
- Perennial Pasture (PP)
- Fertilized Perennial Pasture (PP_f)
- Forage Reserves (FR)
- Mineral Supplements (MS)

c) Health of beef cattle (Health): Qualified by an index (HI) varying between 1 and 5, giving the producer one point for each one of the following health practices:

- Vaccination against Foot and Mouth (AV)
- Vaccination against Brucellosis (BV)
- Brucellosis Reactions (BR)
- Parasitosis Control (PC)
- Diagnosis of Venereal Diseases (VD)

d) Cattle breeding improvements (Genetics): An index is used (GG) which gives one point if the producer performs any selection practices (SE), and another point if improvements are effected by cross-breeding (CB); i.e., this scale will run from 0 to 2.

e) Cattle management: Defined through an index (MI) varying between 0 and 4; the producer receives one point for each of the following practices:

- Pregnancy Testing (for the total females sent to bull at 3 months) (PT)
- Seasonal Service of three months (SS)
- Anticipated Weaning at 6 to 7 months (AW)
- Artificial Insemination (AI)

Lastly, for representation of the total technological inputs that have been incorporated, an overall adoption index (GI) ranging from 0 to 16 has been constructed. It is the result of the sum of the four partial indexes (FI, HI, GG and MI) previously defined.

Interaction of the Enterprises with their Socio-Economic Context

a) Availability of technological information:

- Extent of technical information available (Information): This index has a theoretical scale between 0 and 18. For each technique or practice that the producer says is available, he is credited with one point if the source is mass information (radio, TV, etc.), and two points if the communication has been of a direct or personal nature.[15] The techniques and practices considered include: production and handling of pastures; supplementary feeding; health; selection and cross-breeding; artificial insemination; pregnancy diagnosis; seasonal service; premature weaning; post-weaning production and fattening.
- Availability of technical advice (Assessment): This is determined on the basis of whether the producer has, or had, availability of technical and economic advice, either totally or partially,[16] whether he looks up to some outstanding farmer, and whether he has contact with INTA, either through the extension agent, through visits to the extension agency, or by visits to the experimental station. The scale of values ranges from 0 to 9.[17] The producer receives points for each one of the alternatives mentioned as follows:

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[15]See Bocchetto, R., et al., op. cit., p. 55.

[16]Total "assessment" is defined as being that offered by an agricultural professional by means of the technical/economic programming, administration and supervision of the enterprise. Partial assessment is understood to cover only some of the mentioned advice activities.

[17]The maximum value is obtained when the producer has all advice available, looks up to outstanding farmer, and his contact with INTA is frequent.

Assessment:

Has total availability	6
Had total availability	4
Has partial availability	3
Had partial availability	2
Looks up to outstanding farmer	1
Degree of contact with INTA:	
- Frequent	2
- Sporadic	1
- Nil	0

b) Access to Capital:[18]

- Degree of access to credit (Access to Credit): An index is used with a value of 0 if the producer is not interested in obtaining financial credit; 1 if he needed it but did not obtain it; 2 if he obtained credit but did not use it; and 3 if he actually used credit.

- Intensity of the Use of Credit in each investment item (Credit Use): This index is built up considering six lines of investment which signify an intensification of production, namely: barns and outbuildings, wire fencing and drainage ditches, machinery, cattle/stock, pastures and fertilizers. The period 1968 to 1977 is analyzed, and the producer receives one point per year and per item.[19]

c) Access to production factors (Own Funds): Determined with respect to the same capital items taken into account for the use of credit (although to make it comparable with the index of credit pastures and fertilizers are also included). Similar to

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[18]Availability of external funds and outside investment were not analyzed because at a simple glance both attributes did not show significant differences between production systems.

[19]See Bocchetto, R., et al., op. cit., p. 32.

the previous index, the theoretical range runs from 0 to 60 allowing one point per item and per year in which the producer makes investments with his own resources.[20]

d) Interaction with the farm inputs and product markets: It was not possible to determine from the questions asked in the survey[21] if there was, in fact, any "bargaining strength" by some producers in their input and/or product markets, and whether any differences existed between producers.

6.1.2 Principal Component Analysis

Multivariate Analysis is used to identify the principal components in the data sample. At the same time, the data sample is organized upon the conceptual components of the theoretical framework. As a result, it is expected that each principal component will show a relationship among the variables that characterize the conceptual components. These relationships should describe relevant dimensions or aspects for understanding the incorporation of technology in the breeding-livestock enterprises. Afterwards, these aspects will be used to help identify the actual production systems in the study area. The analysis is begun by studying the endogenous components of the livestock enterprises.

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[20]This index can only be considered as a variable that trys to "approximate" access to productive factors and should be analyzed together with the credit use index. In reality, an overall index of investment should be built up which would be the sum of the two indexes mentioned. However, the credit effect would be confused with the use of resources of an internal nature, this being a facet of the investment process which also permits analysis of the availability of both indexes. In any event, what is obtained is the quantification of the number of times the producer "enters" into the capital market, which does not necessarily imply the measurement of the access to those markets.

[21]See Bocchetto, R., et al., op. cit., pp. 62-66.

6.1.2.1 Analysis of the Structural and Technological Components

Sixty-three observations were used to analyze the variables that represent (a) the farm productive structure: LA, TSs/TL, LS/LL, LL/LA, LS/LA, ID/LS, ID/LL and ID/LA; (b) the characteristics of the producer: objective, age, education, predisposition and dedication; and (c) the technological package used: activity, feeding, health, genetics and cattle management.

By using the sample correlation matrix for the variables mentioned above, the results of Principal Component Analysis are shown in Table 6.2.[22] This table shows the correlation coefficients between the four principal components and these variables.

The first principal component is bipolar.[23] In this component the farm size (TLs/TL and LS/LL are highly correlated with LA), the propensity to incorporate innovations (objective), the education of the producer and technological inputs in use (basically health and improved cattle management) are compared with the use of labor and investment in improvements per unit of land, and the dedication of the producer. The first principal component summarizes the size dimension.[24] This dimension appears correlated with the adoption of technological inputs, but not necessarily with cattle fattening.

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[22]The correlation coefficients between the variables representing the structural and technological components of breeding-livestock enterprises plus the variables that characterize their interaction with the socio-economic context are presented in Appendix A, Table A.1.

[23]There exist positive and negative signs for the coefficients that have higher values in the principal component.

[24]The dimension that corresponds to each principal component is defined based on the relationship of interdependence shown in Table 6.2 by the attributes with underlined coefficients.

Table 6.2

Principal Component Analysis with the Variables that Represent the Productive Structure, the Producer Characteristics and the Technological Package of Breeding-Livestock Enterprises Ayacucho County, Argentina, 1977

Conceptual Components	Variables	Correlation 1st Ppal. Component	2nd Ppal. Component	3rd Ppal. Component	4th Ppal. Component
	1. LA	-0.710	0.061	-0.283	-0.028
	2. TLs/TL	-0.738	-0.159	-0.041	0.127
Productive	3. LS/LL	-0.775	0.319	0.040	0.073
	4. LL/LA	0.626	-0.475	-0.045	-0.074
Structure	5. LS/LA	0.215	-0.526	-0.368	-0.315
	6. ID/LS	0.556	-0.335	0.642	0.236
	7. ID/LL	-0.390	0.061	0.668	0.317
	8. ID/LA	0.604	-0.577	0.465	0.058
	9. Objective	-0.482	-0.444	0.051	0.262
Producer	10. Age	0.195	0.274	-0.217	0.724
	11. Education	-0.670	-0.246	0.132	-0.340
Characteristics	12. Predisposition	-0.313	-0.534	0.072	-0.174
	13. Dedication	0.543	-0.273	-0.469	-0.042
	14. Activity	0.070	-0.457	-0.460	0.482
Technological	15. Feeding	-0.320	-0.472	-0.314	0.341
	16. Health	-0.477	-0.404	0.145	-0.100
Package	17. Genetics	-0.320	-0.246	-0.390	0.021
	18. Cattle Management	-0.576	-0.522	0.279	0.065
Eigenvalues		4.795	2.698	2.150	1.391
Percentage of Total Variance		26.64	14.99	11.94	7.73
Cumulative % of Total Variance		26.64	41.63	53.57	61.30

The most significant correlation coefficients between the second principal component and original variables are all of the same sign. This factor summarizes the dimension of the intensity in land use. This aspect is correlated with the objective and predisposition of the producer to incorporate new technology, as well as the use of the total package, i.e., incorporating fattening. Though the dedication of the producer does not show a significant correlation coefficient with the second principal component, this coefficient has the same sign as the coefficients used to define the intensity in land use dimension.

The third principal component is bipolar comparing the use of improvements per unit of labor and livestock with dedication and activity. The projection of particular observations on this component will rank higher those farms which have the highest proportion of improvements with respect to LL and LS, the lowest dedication of the producer, and which are involved in cow-calf operation. So, the investment in improvements, represented especially by ID/LL, appears to be a basic aspect of cattle breeding with low technology.

The fourth principal component defines a dimension based on the age of the producer. This dimension is positively correlated with the fattening operation activity. There is also some degree of bipolarity comparing age and fattening with the education of the producer. It appears that higher age and low education are relevant aspects when the producer is involved in fattening activities with low technology.

The first two principal components identify two basic lines of interdependence among the attributes that characterize the conceptual components. These lines of interdependence can be summarized as follows:

- Size; Objective; Education; Technical inputs (excluding activity).
- Intensity in land use; Predisposition; Dedication; Activity.

Both situations of interdependence among variables are clearly represented in Figure 6.1. This is a plot of the eigenvectors corresponding to the first two principal components of Table 6.2.

As a result, the component space[25] built upon these two components will develop an order-line going from large size-high technical level[26] to small size-low technical level in the first dimension, and from "intensive" proportion of factors-fattening operation to "extensive" proportion of factors-cow/calf operation in the second dimension.[27] Later, the values of the first two principal components for each enterprise will be represented in the component space. An attempt will be made in this space to identify the predominant actual production systems of the study area.

Before entering that stage, the technological component will be further analyzed. Afterwards, the attributes that characterize the interaction of farmers with their socio-economic context will be related to the production phenomena.

Homogeneity Among Farms for Technological Inputs

The different behavior shown by technical inputs (feeding, health, genetics, and cattle management) and "activity," within the size and intensity in land use dimensions, calls for a separate analysis of the technological component. This analysis reveals the homogeneity that different groups of farms show in their technical level.

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[25]This component space is the result of projecting each observation vector on the first and second principal component.

[26]The technical level is an expression that represents the amount of inputs incorporated without taking into account the activity variable.

[27]The intensive/extensive proportion of factors are those proportions showing an intensive/extensive use of land.

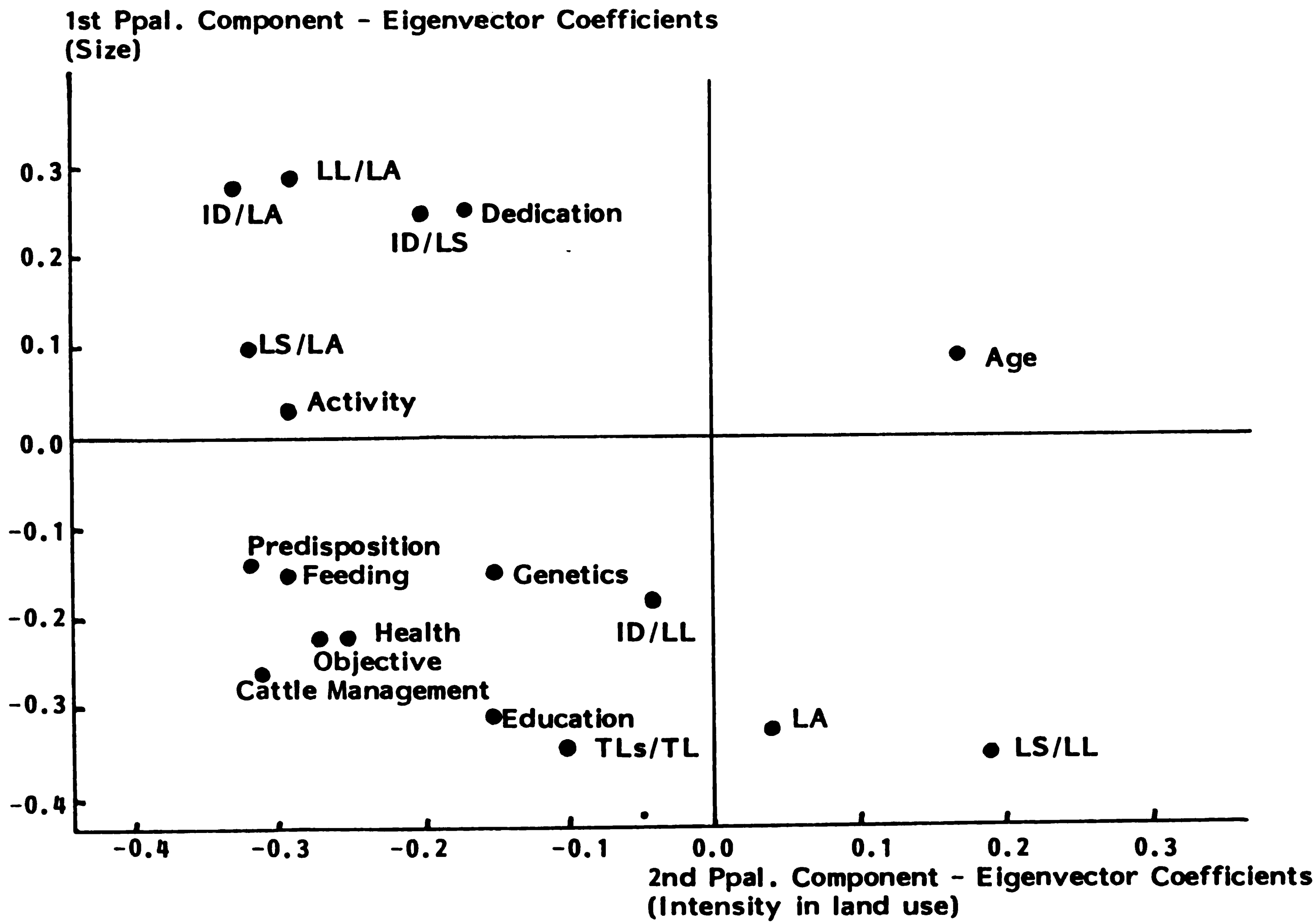

Figure 6.1 Plot of the First Two Principal Components Using the Structural Component and the Technological Package, Ayacucho County, Argentina, 1977

The first two principal components of the technological inputs explain respectively 47.7 percent and 24.1 percent of the corresponding eigenvalues.[28] The first principal component presents response of equal sign for each one of the technical inputs where feeding, health and cattle management are highly significant. The second component is essentially a genetic improvement dimension. The projection of each observation vector into both principal components define the component space shown in Figure 6.2. In this space each plot represents an enterprise which is enumerated according with the area variable from 1 (the smallest farm) to 63 (the largest one). The first factor makes an ordering of the enterprises from that with the lowest adoption index (observation No. 6) to the farm with the highest technical level (observation No. 50). The second factor separates from the main group those farms undertaking some type of genetic improvement.

It readily can be seen that the first two principal components form a clear set of clusters. This configuration of the component space is validated in Figure 6.2 through cluster analysis showing a partition of seven clusters.

However, when activity is added as a variable, inter-cluster variance substantially increases. This is shown in Figure 6.3. In this case, the observation vectors are projected into the first and second factors obtained by the application of principal component analysis to the variables: type of activity, feeding, health, genetics and cattle management.[29] The comparison of Figures 6.2 and 6.3 shows that type of activity and technical inputs accomplish different roles within the technological package.

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[28]Principal component analysis for technological inputs is presented in Appendix A, Table A.2.

[29]See Appendix A, Table A.3.

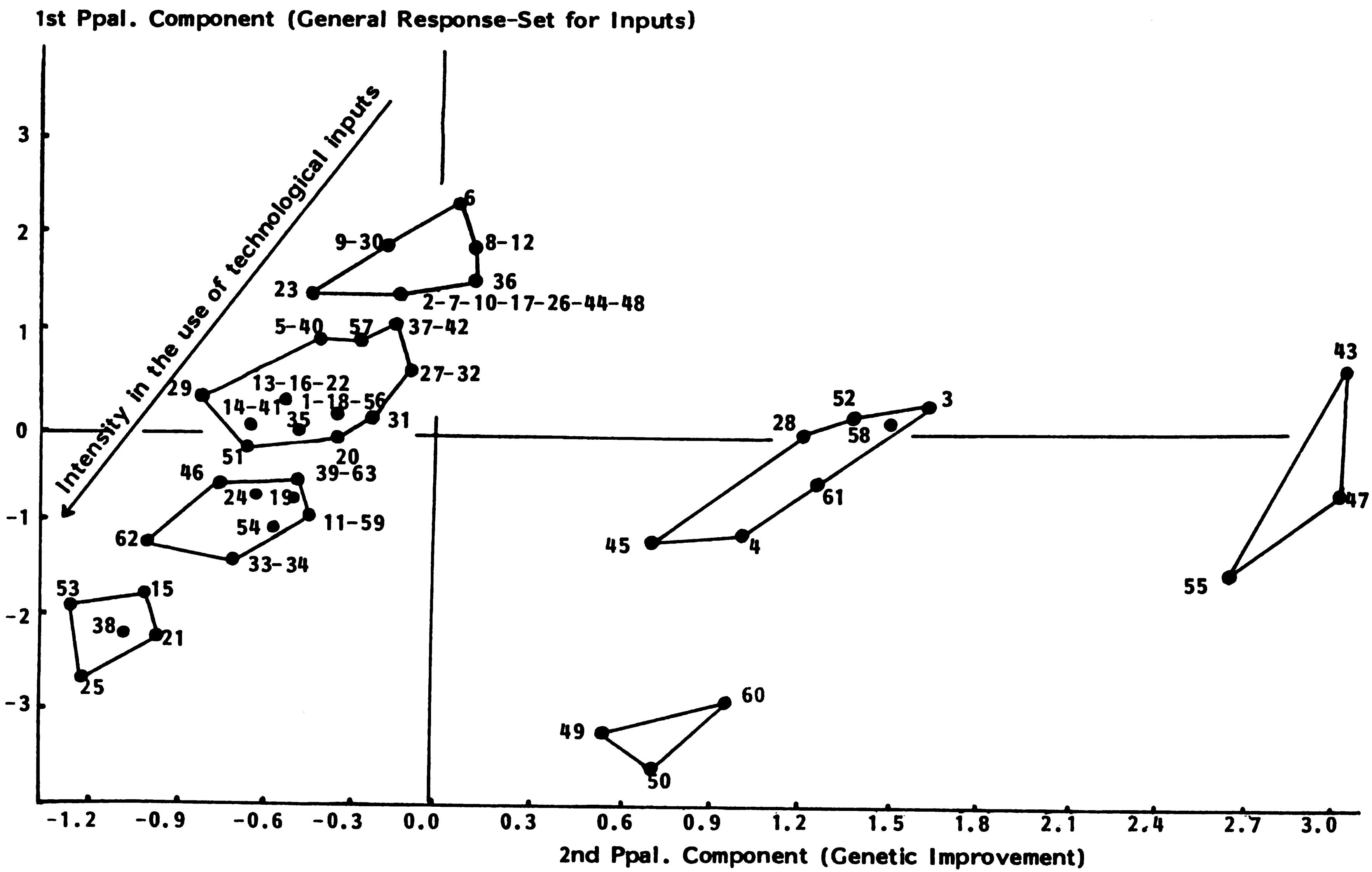

Figure 6.2 Projection of the Observations into the First Two Principal Components of the Technological Inputs, Ayacucho County, Argentina, 1977

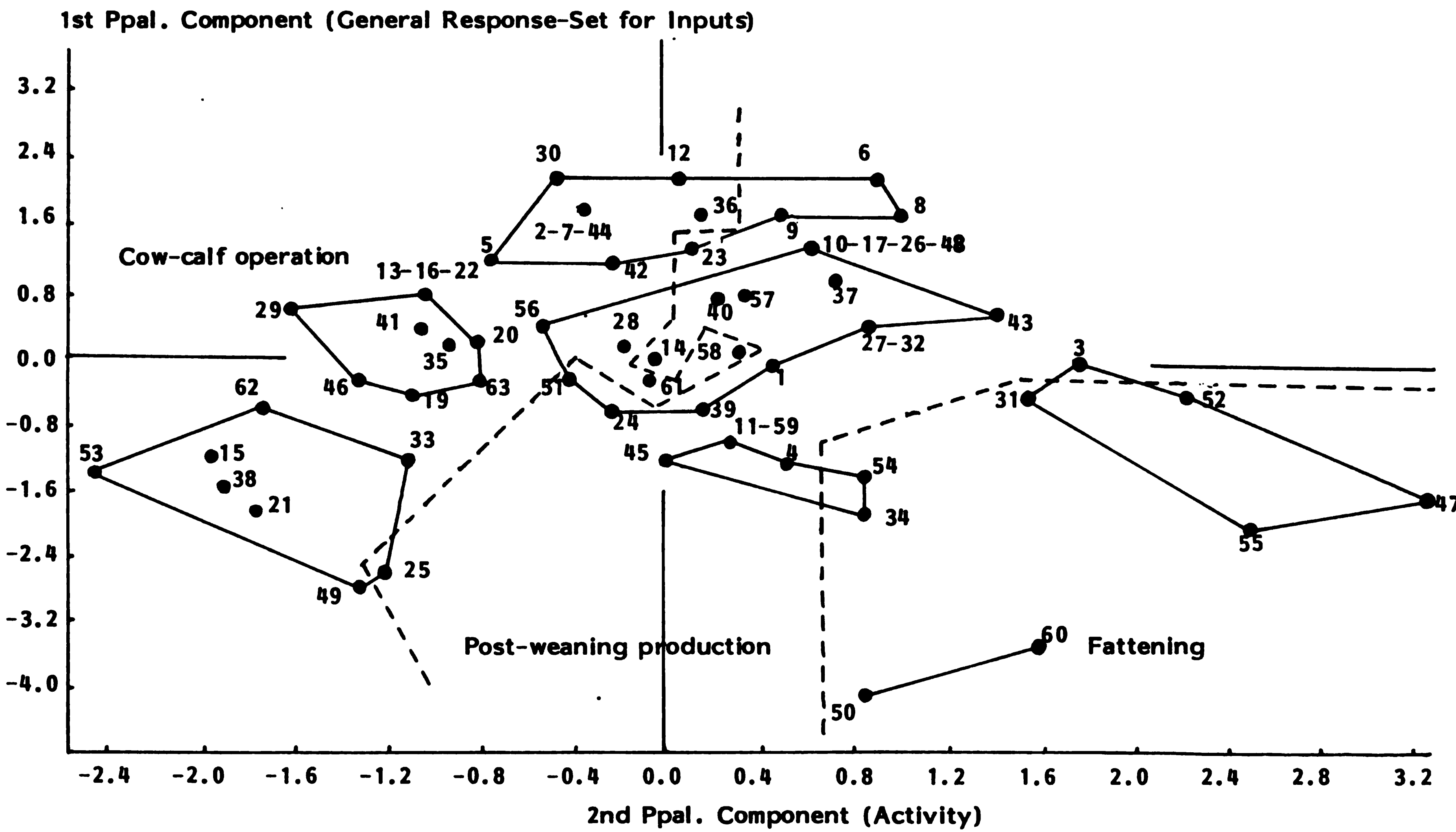

Figure 6.3 Projection of the Observations into the First Two Principal Components of the Technological Package, Ayacucho County, Argentina, 1977

6.1.2.2 Interaction of Farmers with Their Socio-Economic Context

The following variables-- information, assessment, own funds, credit access and credit use--are now added to the principal component analysis. Table 6.3 shows the correlation coefficients between the first five principal components and the variables that characterize the conceptual components of this study, including now the instrumental component.

This table shows that the first three principal components have not changed from the configuration presented in Table 6.2. The first principal component is a general response-set component of the instrumental variables. The size dimension is associated with a favorable interaction of farmers with their rural environment. This interaction is dominated by technical assessment.

The second principal component again shows a response of equal sign for each one of the instrumental variables. In this case, own funds dominates this set of variables, having the lowest participation, technical assessment and use of credit. Thus, the intensity of land use has a greater interdependence with the availability of funds for investment, which in the real situation of breeding-livestock production comes from farms themselves.

The incorporation of the instrumental variables has improved the interpretation of the first two principal components, especially at the level of the producer and the technological package. The first factor includes higher weights for objective, education and technical inputs than those shown by the corresponding correlation coefficients in Table 6.2. In the second factor "dedication" dominates the characteristics of the producer. At the same time, "activity" appears to be the most significant variable within the technological package.

Table 6.3

Incorporation of the Interaction of Farmers with Their Socio-Economic Context in the Analysis of Principal Components Ayacucho County, Argentina, 1977

Conceptual Components	Variables	Correlation 1st Ppal. Component	2nd Ppal. Component	3rd Ppal. Component	4th Ppal. Component	5th Ppal. Component
	1. LA	-0.681	-0.153	0.291	-0.086	0.086
	2. TLs/TL	-0.748	0.027	0.011	-0.061	0.245
Productive	3. LS/LL	-0.697	-0.456	-0.021	0.230	-0.082
	4. LL/LA	0.519	0.601	-0.033	-0.152	0.065
Structure	5. LS/LA	0.111	0.559	0.237	0.003	-0.481
	6. ID/LS	0.505	0.336	-0.678	0.003	0.216
	7. ID/LL	-0.340	-0.240	-0.670	0.263	0.081
	8. ID/LA	0.514	0.570	-0.566	-0.026	-0.021
	9. Objective	-0.565	0.380	-0.159	0.083	0.270
Producer	10. Age	0.204	-0.131	0.220	0.434	0.616
	11. Education	-0.676	0.045	-0.172	-0.276	-0.208
Characteristics	12. Predisposition	-0.403	0.405	-0.190	-0.079	-0.277
	13. Dedication	0.447	0.472	0.426	0.064	-0.136
	14. Activity	-0.023	0.532	0.337	0.359	0.218
Technological	15. Feeding	-0.396	0.441	0.211	0.056	0.325
	16. Health	-0.496	0.214	-0.146	-0.485	0.174
Package	17. Genetics	-0.396	0.234	0.282	0.198	-0.221
	18. Cattle Management	-0.658	0.325	-0.332	-0.161	0.060
	19. Information	-0.359	0.372	0.246	0.187	-0.066
Instrumental	20. Assessment	-0.623	0.122	0.011	0.004	-0.195
	21. Own Funds	-0.329	0.623	0.157	-0.222	0.284
Component	22. Credit Access	-0.095	0.305	-0.193	0.528	-0.126
	23. Credit Use	-0.394	0.151	-0.307	0.676	-0.218
Eigenvalues		5.364	3.297	2.279	1.691	1.378
Percentage of Total Variance		23.62	14.33	9.91	7.35	5.99
Cumulative % of Total Variance		23.62	37.65	47.56	54.91	60.90

The correlation coefficients among the instrumental variables and the third and fifth principal components are low. Both factors can be identified with the third and fourth principal components of Table 6.2.

The fourth principal component in Table 6.3 defines a financial source dimension related to the age of the producer. A "rationalization" of this interpretation would relate this component with the presence in the area of study of a livestock development project based on supervised credit. The objective of this research is to look at the incorporation of technology under "normal" conditions of the interaction of farmers, with their socio-economic context. Consequently, the fourth factor will not be incorporated when each component is analyzed.[30]

In Table 6.4 the conceptual components are ordered within each principal component detected in Table 6.3 according to the percentage explained of the corresponding eigenvalue. The top of Table 6.4 shows how much of the total variance explained by the first five factors isolated in Table 6.3 correspond to each conceptual component. In this case, the productive structure dominates over the other conceptual components to explain the variance of the system.

Within each principal component, the major explanation, except for the fifth factor, is given by the farm productive structure. In any case, the structural component is always dominant by means of the two elements that it comprises, the productive structure and the producer characteristics. It can be argued that the dominance of the productive structure is entirely logical because, while the other three conceptual components are represented by five variables each, the productive structure has eight variables.

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[30]The need for this "rationalization" shows that the actual results of Principal Component Analysis could be improved with further processing of the data.

Table 6.4

Dominance Among Conceptual Components for the Explanation of Eigenvalues Ayacucho County, Argentina, 1977

Principal Components	Ordering (Percentage of Eigenvalues)			
	1°	2°	3°	4°
First Five Components	Productive Structure (40.86)	Producer Characteristics (20.86)	Technological Package (19.36)	Interaction with The Social Context (18.93)
First	Productive Structure (45.25)	Producer Characteristics (21.97)	Technological Package (18.44)	Interaction with The Social Context (14.34)
Second	Productive Structure (42.55)	Technological Package (20.67)	Interaction with The Social Context (20.06)	Producer Characteristics (16.72)
Third	Productive Structure (60.09)	Technological Package (16.23)	Producer Characteristics (14.04)	Interaction with The Social Context (9.65)
Fifth	Producer Characteristics (42.75)	Productive Structure (26.09)	Technological Package (17.39)	Interaction with The Social Context (13.77)

Since the total number of variables is twenty-three, if all of them had the same weight in the explanation of each eigenvalue, it would be consistent to suppose that the productive structure would explain approximately 35 percent in each case. Nevertheless, Table 6.4 shows this percentage is always superceded in the first three factors. One could expect by similar reasoning that the productive structure and the producer characteristics would explain 57 percent of each characteristic root. The four factors considered (first, second, third, and fifth of Table 6.4) give an explanation at the level of the structural component of 67 percent, 59 percent, 74 percent and 69 percent respectively of each eigenvalue. These percentages are, in all the cases, superior to the values expected if the explanatory level of each variable is the same.

It can also be seen in Table 6.4 that the instrumental component explains the lowest proportion of each characteristic root, except for the second principal component. This is so even in the case when the instrumental component shows a favorable interaction of farmers with their socio-economic context, as exhibited in the first principal component.

6.2 Classification of Livestock Enterprises

The conceptual framework of this study points out that the productive structure, the producer characteristics and the technological package of breeding-livestock enterprises bring about the existence of different production systems. Each system has its own particular behavior in the incorporation of technology.

Principal component analysis has identified the size and intensity in land use dimensions. These dimensions are meaningful for understanding basic relationships of interdependence between the structural and technological criteria.

Four alternative situations are represented by the four quadrants of Figure 6.4. The values taken for each enterprise for the first and second principal components (Table 6.2) using the structural and technological criteria are plotted in the figure. The four quadrants can be characterized as follows:

- Large size; Extensive proportion of factors; High technical level; Breeding operation.
- Large size; Intensive proportion of factors; High technical level; Post-weaning and/or fattening operation.
- Small size; Extensive proportion of factors; Low technical level; Breeding operation.
- Small size; Intensive proportion of factors; Low technical level; Post-weaning and/or fattening operation.

Cluster Analysis was used to find homogeneous groups based on the component space already mentioned. Figure 6.4 shows the outcome of the clustering process. It is the result of taking that partition which in the cluster map generates seven clusterings. The corresponding distance matrix within and among clusters (maximum, average and minimum) is shown in Table 6.5.

Figure 6.4 shows the formation of five groups of enterprises which appear as the most relevant because of the number of observations contained. According with the cluster map, clusters 3 and 4 could be grouped together in a partition comparing six clusters. In a later interaction this new cluster must associate with the one resulting from unifying groups one and two. Following this algorithmic rule, observations 4 and 8

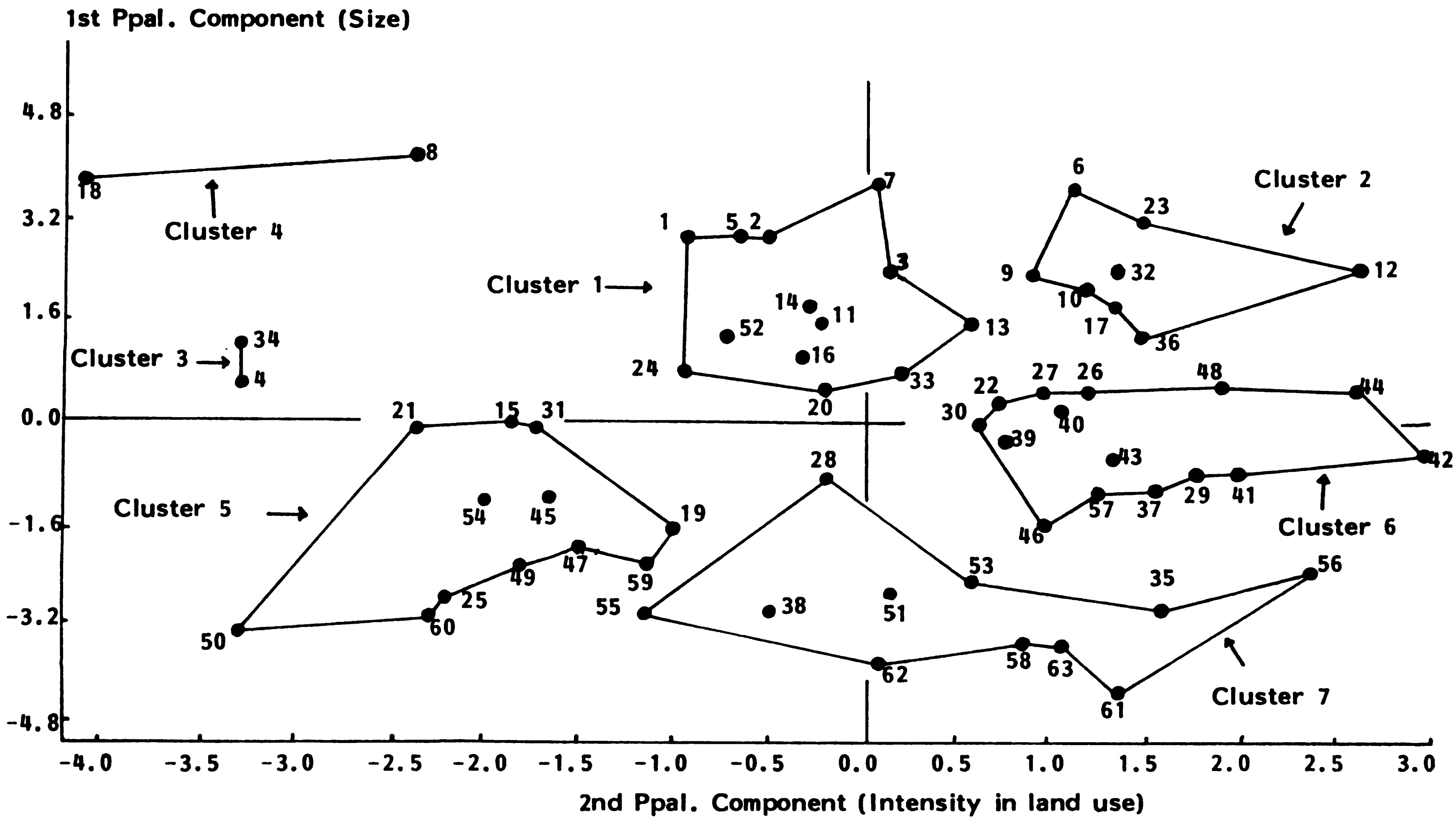

Figure 6.4 Classification of Livestock Enterprises Using Cluster Analysis Upon the Projection of the Observations into the First Two Principal Components of the Structural and Technological Criteria, Ayacucho County, Argentina, 1977

Table 6.5

Distances Within and Among Seven Clusters
Using the Structural and Technological Criteria
Ayacucho County, Argentina, 1977

Number of Observations	Cluster No.	1	2	3	4	5	6	7
13	1	1.316* 0.344 0.000						
8	2	2.109 0.707 0.082	0.673 0.209 0.000					
2	3	2.746 1.501 0.754	5.216 3.451 2.614	0.040 0.040 0.000				
2	4	3.882 2.124 0.548	6.442 3.583 1.779	1.935 1.449 1.004	0.430 0.430 0.000			
12	5	7.817 2.322 0.177	8.964 3.985 1.678	2.597 1.363 0.196	7.690 4.934 2.467	1.639 0.455 0.000		
15	6	3.973 1.322 0.073	3.743 1.191 0.114	5.766 3.424 2.156	9.367 5.840 3.646	6.604 2.098 0.564	0.981 0.258 0.000	
11	7	8.619 3.590 0.282	8.231 4.281 1.097	6.909 4.315 1.592	12.733 8.933 4.300	4.422 1.504 0.124	3.605 1.405 0.096	1.845 0.492 0.000

*Upper value: maximum distance; middle value: average distance; lower value: minimum distance.

are included in the first cluster.[31] Nevertheless, taking into consideration the structural feature and the type of activity, observation 34 is included in cluster 5. A similar analysis leads to the transference of observation 52 to cluster 5; the 28 to cluster 6, and Nos. 46 and 57 to cluster 7. This transference of observations (eight percent of the total enterprises) does not modify the characteristics of the clusters formed.

It will be important to analyze the possibilities of clustering among clusters 1, 2, 5, 6 and 7. In this case, the maximum, average and minimum distances among the groups will be studied based on the distance matrix reported in Table 6.5.

Cluster 1 shows the least maximum and average distance with cluster 2. Cluster 1 has the least minimum distance with cluster 6; however, the difference with respect to the minimum distance between clusters 1 and 2 is very small. When the distances are measured from cluster 2, the least maximum, average and minimum distance corresponds to cluster 1. Based upon these reasons of distance, clusters 1 and 2 are combined.

To continue the analysis, the distance matrix of Table 6.6 is used. In accordance with the former consideration, cluster (3-4) is not taken into account. Only the new layout of distances among the new cluster (1-2) and clusters 5, 6, and 7 are of interest. Cluster (1-2) has the least maximum, average and minimum distance with cluster 6; cluster 5 with cluster 7, and cluster 7 with cluster 6. Cluster 6 has the least maximum distance with cluster 7, while the least minimum and average distance is with cluster (1-2). Consequently, these clusters do not mutually attract each other.

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[31]Observation No. 18 is omitted from the analysis because it corresponds to an enterprise dedicated principally to dairy farming. In the following sections the analysis is based on 62 observations.

Table 6.6

Distances Within and Among Five Clusters
Using the Structural and Technological Criteria
Ayacucho County, Argentina, 1977

Number of Observations	Cluster No.	(1-2)	(3-4)	5	6	7
21	(1-2)	2.109* 0.506 0.000				
4	(3-4)	6.442 2.462 0.548	1.935 1.044 0.000			
12	5	8.964 2.956 0.177	7.690 3.148 0.196	1.639 0.455 0.000		
15	6	3.973 1.272 0.073	9.367 4.632 2.156	6.602 2.098 0.564	0.981 0.258 0.000	
11	7	8.619 3.853 0.282	12.733 6.654 1.592	4.422 1.504 0.124	3.605 1.405 0.096	1.845 0.492 0.000

*Upper value: maximum distance; middle value: average distance; lower value: minimum distance.

If attention is focused on the characteristics of the productive structure, the producer, and the technological package, it will be seen that the same lack of definition is introduced with respect to the degree of similarity among these clusters. For each one of the mentioned aspects each cluster shows greater similarity with different clusters and not exclusively with one alone.

It is proposed as a definitive clustering structure, the one which is built with groups (1-2), 5, 6, and 7, subject to the "transference" of those observations previously commented upon. As a result, these four clusters of enterprises represent, by reason of the euclidian distances, an equal number of actual production systems (APS). The structuring of these systems by enterprise number is shown in Figure 6.5.

The classification stage is finished by recovering in the first two principal components space of Figure 6.5 some structural and technological features of the farms making up each production system. Since the first principal component is identified with the size dimension, APS_1 comprises small farms and APS_4 the largest ones. The other two systems have an intermediate size, being APS_2 medium-small and APS_3 medium-large.

Figure 6.6 identifies the farms within each system of production with four different levels of the adoption index, with sample values 0 to 13. APS_2 appears to have the least advanced technology. This system is followed in increasing order of technology levels by APS_1 and APS_4. Lastly, APS_3 enjoys the highest level in adoption of technology.

Figure 6.7 shows clearly that APS_4 is essentially livestock breeding. APS_3 clusters most of the enterprises practicing fattening. The other two systems are dedicated simultaneously to breeding and post-weaning production. Nevertheless, in APS_1 this later activity takes dominance

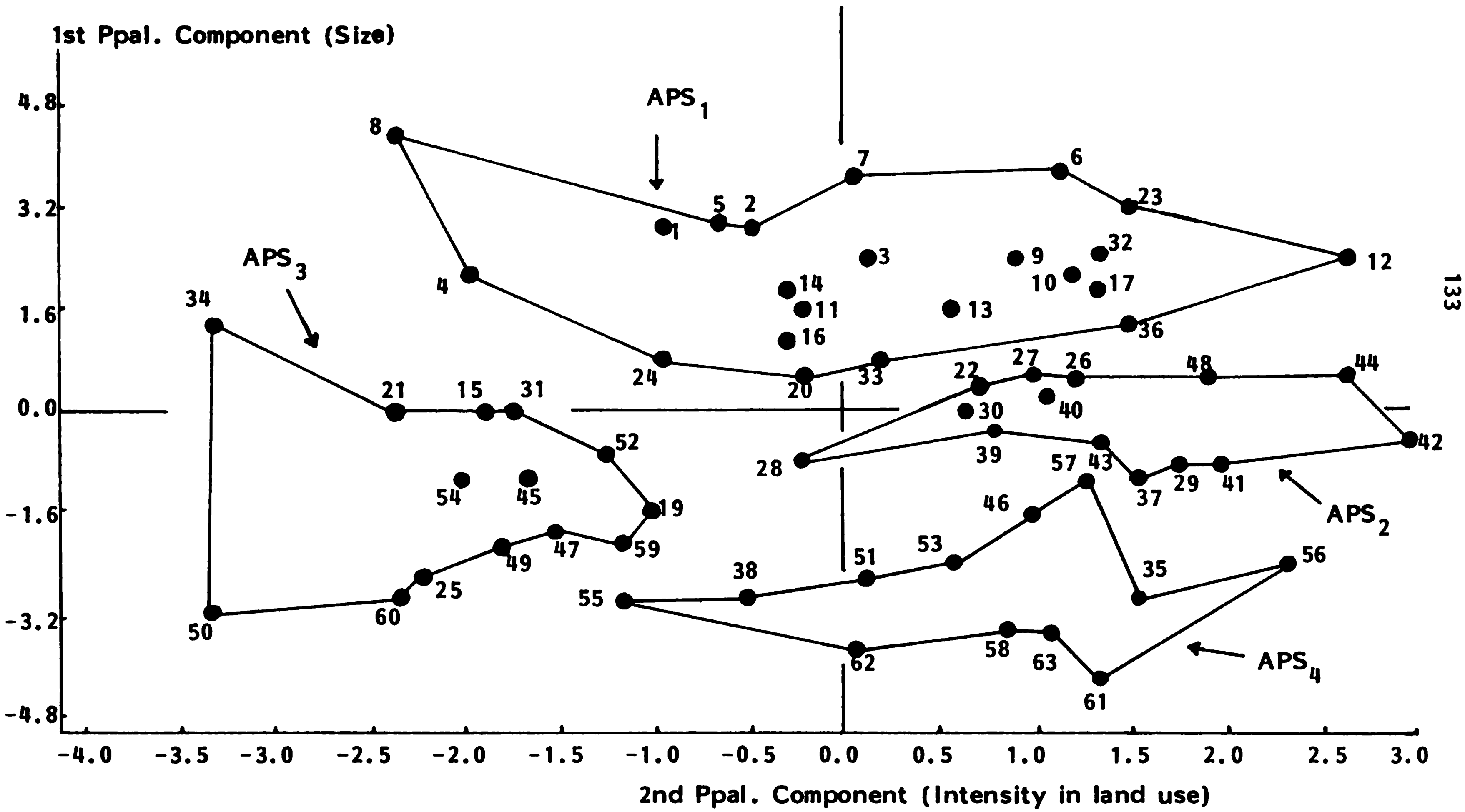


Figure 6.5 Identification of Actual Production Systems Using Cluster Analysis Upon the Projection of the Observations into the First Two Principal Components of the Structural and Technological Criteria, Ayacucho County, Argentina, 1977

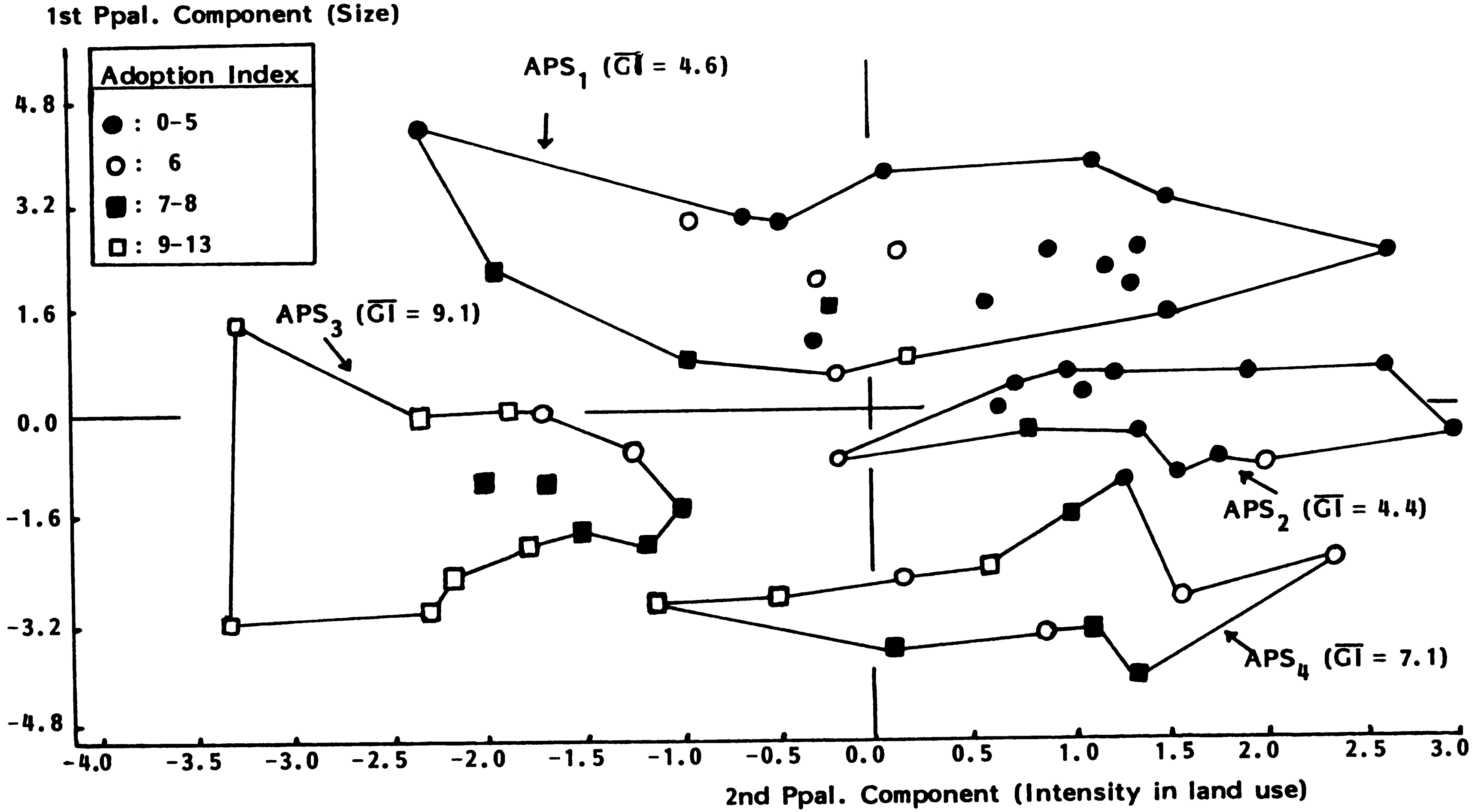
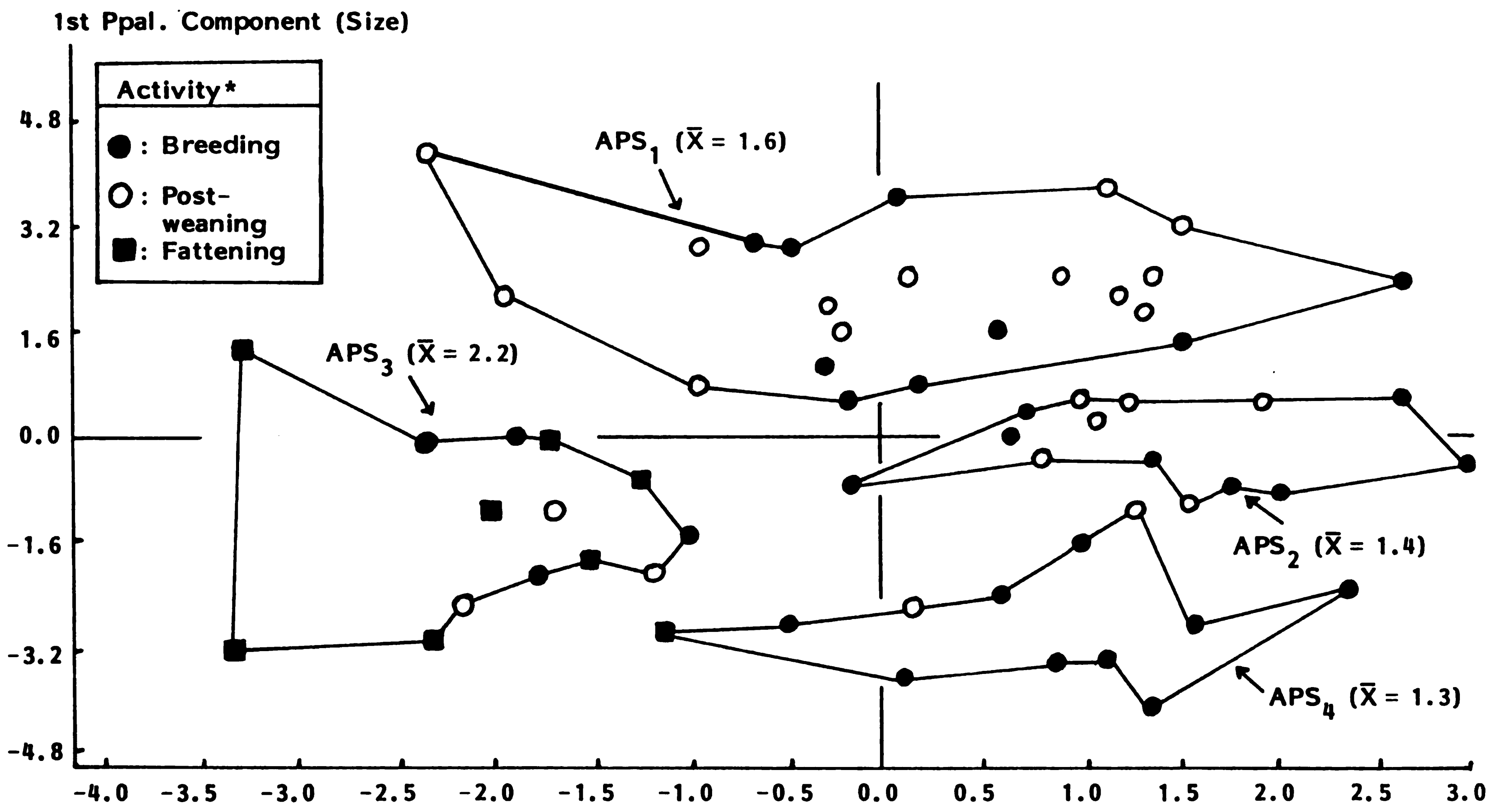


Figure 6.6 Relation Between Actual Production Systems and the Adoption Index Ayacucho County, Argentina, 1977 (Projection of the Observations into the First Two Principal Components of the Structural and Technological Criteria)



* The sample range of this variable is 1-3.

Figure 6.7 Relation Between Actual Production Systems and the Type of Activity Ayacucho County, Argentina, 1977 (Projection of the Observations into the First Two Principal Components of the Structural and Technological Criteria) over the former, while in APS_2, it is the reverse. These situations will be designated respectively as long post-weaning and short post-weaning production. All the foregoing is summarized in Table 6.7. These basic characteristics of the actual production systems will be analyzed further in the following section.

Table 6.7

Basic Identification of Actual Production Systems in the Breeding-Livestock Region Ayacucho County, Argentina--1977

APS	Farm Size	Activity	Technological Level
1	Small	Long post-weaning	Medium-low
2	Medium-small	Short post-weaning	Low
3	Medium-large	Fattening	High
4	Large	Breeding	Medium-high

6.3 Characterization of the Actual Production Systems

The objective of this section is to describe the actual production systems using the arithmetic means of the variables that represent the conceptual components of this study. Simultaneously, the important dissimilarities among the systems will be identified by statistical tests.

Table 6.8 shows for each production system the average of the variables that characterize the productive structure, the producer, the technological package in use and the instrumental component.[32] Comparison of the averages is based on the quotient between each pair of means

[32]The range and standard deviation for the variables used in this characterization are presented in Appendix B, Table B.1.

Table 6.8

Basic Comparison Between Actual Production Systems
Ayacucho County, Argentina, 1977

Conceptual Components	Variables	Arithmetic Mean of the Whole Sample	Arithmetic Mean				Ratios of Arithmetic Means					
			APS_1	APS_2	APS_3	APS_4	2/1	3/1	4/1	3/2	4/2	4/3
	1. LA	981.4	300.5	700.8	1,205.7	2,295.4	2.33*	4.01*	7.64*	1.72*	3.28*	1.90*
	2. TLs/TL	0.684	0.305	0.595	0.784	0.882	1.95*	2.57*	2.89*	1.32	1.48*	1.13
Productive	3. LS/LL	2.578	1.429	2.695	2.351	3.652	1.89*	1.65*	2.56*	0.87	1.36*	1.55*
	4. LL/LA	0.348	0.662	0.327	0.451	0.217	0.49*	0.68*	0.33*	1.38	0.66	0.48*
Structure	5. LS/LA	0.898	0.947	0.881	1.061	0.794	0.93	1.12	0.84*	1.20*	0.90	0.75*
	6. ID/LS	3.384	5.046	3.322	3.800	2.593	0.66*	0.75*	0.51*	1.14	0.78	0.68*
	7. ID/LL	8.725	7.213	8.954	8.932	9.468	1.24	1.24	1.31	0.99	1.06	1.06
	8. ID/LA	3.041	4.777	2.926	4.030	2.058	0.61*	0.84	0.43*	1.38*	0.70*	0.51*
Producer	9. Objective	0.371	0.091	0.143	0.786	0.667	1.57	8.64*	7.33*	5.50*	4.66*	0.85
	10. Age	49.95	52.50	52.43	46.36	46.58	0.99	0.88	0.89	0.89	0.89	1.00
Charac-	11. Education	3.40	2.18	3.64	4.21	4.42	1.67*	1.93*	2.03*	1.16	1.21	1.05
	12. Predisposition	6.29	5.18	5.29	7.93	7.58	1.02	1.53*	1.46*	1.50*	1.43	0.96
teristics	13. Dedication	14.65	17.68	13.43	15.64	9.33	0.76*	0.88	0.53*	1.16	0.69	0.60*
Tech-	14. Activity	1.52	1.59	1.43	2.21	1.33	0.90	1.40*	0.84	1.55*	0.93	0.60*
	15. Feeding	1.95	1.64	1.36	3.00	2.00	0.83	1.83*	1.22	2.21*	1.47	0.67*
nological	16. Health	2.90	2.41	2.57	3.57	3.42	1.07	1.48*	1.42*	1.39*	1.33*	0.96
	17. Genetic	0.26	0.09	0.21	0.50	0.33	2.33	5.56*	3.67	2.38	1.57	0.66
Package	18. Cattle Management	0.92	0.41	0.29	2.00	1.33	0.71	4.88*	3.24*	6.90*	4.59*	0.67
Instru-	19. Information	4.47	3.41	3.79	7.00	4.25	1.11	2.05*	1.25	1.85	1.12	0.61
	20. Assessment	2.53	1.68	1.36	3.07	4.83	0.81	1.83	2.88*	2.26*	3.55*	1.57
mental	21. Own Funds	4.87	3.00	3.21	10.36	3.83	1.07	3.45*	1.28	3.23*	1.19	0.37*
	22. Credit Access	2.15	2.14	2.00	2.29	2.17	0.93	1.07	1.01	1.15	1.09	0.95
Component	23. Credit Use	2.21	1.82	1.14	2.86	3.42	0.63	1.57	1.88	2.51	3.00	1.20

*Null hypothesis for the difference between means rejected at .05 significant level.

as shown in the right hand side of this table. An asterisk indicates that the difference between two particular means has a level of significance equal to five percent, when the two-tail "t" test is used.[33] The left hand and right hand of Table 6.8 will be analyzed simultaneously, i.e., the description of the systems and the differences between average levels.

The average area shows those sizes previously detected, i.e., small (300 hectares), medium-small (700 hectares), medium-large (1,200 hectares) and large (2,300 hectares). The salaried relationship (TLs/TL) indicates that the smaller establishments are basically family farms with only 30 percent hired labor. The larger farms hire an average of 88 percent of their labor.

Variables 3 to 8 represent the proportions of factors. Proportions LS/LL and ID/LL bear a direct relationship with size. The remainder of the proportions are in inverse relationship with size. However, APS_3 does not follow this rule. This system shows the largest absolute values in manpower and improvements and a relatively high absolute value in cattle stock.[34] Taking into account that LL/LA, LS/LA and ID/LA show negative coefficients of correlation with LA , APS_3 has relatively high intensity of land use. APS_4 shows the highest indexes of TLs/TL, LS/LL and ID/LL, and the lowest values of LL/LA, ID/LA, LS/LA and ID/LS. It is the type of farm that has the highest investment per labor unit and the smallest one per area unit. APS_1 has the smallest value of ID/LL and LS/LL, i.e., the lowest proportion of investment per man-equivalent. At the same time, APS_1 has the highest level of LL/LA, ID/LS and ID/LA. In the case of

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[33]See Appendix B, Table B.2.

[34]See Appendix B, Table B.3.

APS_2 the most evident characteristic is the high absolute value of man-equivalents,[35] which in turn defines high levels of ID/LL and low levels of LL/LA.

The means comparison shows that LA (farm size), TLs/TL (salaried relationship), and LS/LL, LL/LA, ID/LS and ID/LA (proportion of factors) set up important differences among the systems.

Looking at LL/LA and ID/LA the strongest dissimilarities correspond to APS_4/APS_1, APS_4/APS_3 and APS_2/APS_1. It appears that APS_3 and APS_1 are more intensive in the use of land than APS_4 and APS_2. This situation is further clarified in Table 6.9. Attention should be focused on the proportion of land and improvements over total capital.

Looking at the characteristics of the producer, the objective to incorporate technology, the level of education and the predisposition to get information all show the highest values in large farms. The age of the producer is lowest for APS_4 and APS_3. The relationship between size and the attitude of the producer to technical changes does not have an equivalent response in high dedication to the farm. It appears that dedication follows the same patterns of similarity among the systems of production as those shown by LL/LA, LS/LA and ID/LA.

"Objective" is the attribute that generates more significant dissimilarities among the systems for the producer characteristics. However, these differences are not significant when APS_2/APS_1 and APS_4/APS_3 are compared. Education shows the highest differences when APS_1 appears as the base of comparison. The interest of the producer to obtain technical information (predisposition) has a dissimilarity pattern close to the objective

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[35]See Appendix B, Table B.3.

Table 6.9

Structure of Total Capital by Actual Production System
Ayacucho County, Argentina, 1977

APS	Land		Improvements		Machinery		Livestock		Operating capital		Total	
	10,000 pesos	%	10,000 pesos	%	10,000 pesos	%	10,000 pesos	%	10,000 pesos	%	10,000 pesos	%
1	12,020.5	64.1	3,123.1	16.6	515.3	2.7	2,889.4	15.4	215.9	1.2	18,764.2	100
2	28,031.4	72.2	3,074.1	7.9	1,035.7	2.7	6,361.6	16.4	311.3	0.8	38,814.1	100
3	48,228.3	64.8	10,730.6	14.4	1,561.5	2.1	13,253.7	17.8	692.5	0.9	74,466.6	100
4	91,814.4	73.1	9,655.1	7.7	1,360.6	1.1	21,763.1	17.3	964.1	0.8	125,557.3	100
Whole Sample	39,255.8	69.4	6,094.1	10.8	1,032.7	1.8	9,666.7	17.1	489.9	0.9	56,539.2	100

Definition of the Variables:

Land: Livestock land value was estimated at 400,000 pesos per hectare.

Improvements: The present value of each item was calculated based on replacement value and age of the improvement. The structure of the variable is equal to the depreciation value (ID), including the total value of perennial pastures.

Machinery: The present value was calculated the same as for improvements; covers that machinery used exclusively for cattle production, plus that proportion corresponding to the simultaneous use for crops.

Livestock: The structure of this variable is equal to that defined in animal units (LS). Each livestock category was valued with an average price for 1977.

Operating Capital: Calculated as 25 percent of operating costs.

variable. Dedication shows significant differences when APS_2/APS_1, APS_4/APS_1, and APS_4/APS_3 are compared.

From the foregoing the following situations of production can be listed, using for the moment the characteristics of the productive structure and the producer:

- Large size; extensive proportion of factors; high predisposition to technical changes; low dedication: APS_4.
- Medium-large size; intensive proportion of factors; high predisposition to technical changes; high dedication: APS_3.
- Medium-small size; extensive proportion of factors; low predisposition to technical changes; low dedication: APS_2.
- Small size; intensive proportion of factors; low predisposition to technical changes; high dedication: APS_1.

The arithmetic means in Table 6.8 show that APS_3 and APS_4 are those systems in which more technical inputs are incorporated. At the same time, APS_3 has the highest level of fattening, while APS_4 practices basically breeding.

The dissimilarities between the systems appear under different configurations when the activity variable or technical inputs are used as a base of comparison. Activity and feeding show the strongest differences when APS_3 is the base. Health and cattle management indicate that dissimilarities are significant when the larger and smaller systems are compared.

It is interesting to observe the distribution of types of pastures utilized. It can be seen in Table 6.10 that APS_4 and APS_3 have approximately 72 percent natural pastures in their livestock area, APS_1 utilizes 81 percent, and APS_2 89 percent. In the rest of the land area devoted to

Table 6.10

Utilization of the Livestock Area with Pastures
by System of Production
Ayacucho County, Argentina, 1977 (Averages)

APS	Livestock Area		Natural Pasture		Annual Pasture		Perennial Pasture				Wooded Area	
							w/o Fertilizer		with Fertilizer			
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	300.5	100	243.59	81.06	25.43	8.46	22.63	7.53	6.50	2.16	2.36	0.79
2	700.8	100	621.59	88.70	52.25	7.46	14.93	2.13	9.07	1.29	2.94	0.42
3	1,205.7	100	866.11	71.83	130.89	10.86	61.64	5.11	128.21	10.03	18.86	1.56
4	2,295.4	100	1,672.87	72.88	163.52	7.12	268.17	11.68	176.75	7.70	14.05	0.61
Whole Sample	981.4	100	746.15	76.03	82.02	8.36	77.23	7.87	67.52	6.88	8.47	0.86

livestock the most important differences are found in the use of perennial pastures. APS_2 has only three percent of this type of pasture, APS_1, ten percent; APS_3, 15 percent; and APS_4, 19 percent. The last two systems fertilize respectively 68 percent and 40 percent of their perennial pastures.

The average values of the global index of technology adoption are as follows: APS_1, 4.6; APS_2, 4.4; APS_3, 9.1; and APS_4, 7.1 (see Figure 6.6); the average for the whole sample equals 6.0. The distribution of the farmers according to the type of activity used is presented in Table 6.11 (also see Figure 6.7). The rates of adoption to feeding, health, genetics and cattle management, for each technique and by system of production is shown in Appendix B, Tables B.4, B.5 and B.6.

Above results show that farms in the APS_3 category use the highest level of technology. This group includes 88 percent of the enterprises practicing fattening. APS_4 has an adoption index that is 44 percent of the potential level. In this system, 75 percent of the farms are dedicated to cattle breeding. The other two systems have a relative low index of adoption. However, as Table 6.10 shows, APS_1 and APS_2 differ in the percentage of perennial pastures used (situation that is not taken into account by the adoption index). At the same time, 60 percent of the farms in APS_1 practice post-weaning operations, while this percentage is close to 43 percent in APS_2.

Coming back to Table 6.8, the interaction of farms with their socio-economic context can be analyzed. The arithmetic means show that larger farms enjoy a more favorable interaction than smaller enterprises. This general picture also shows that only in the case of "assessment" is the actual level of the variable 50 percent of the potential level. In the

Table 6.11

Distribution of the Number of Producers
by Type of Activity Within Each System of Production
Ayacucho County, Argentina, 1977

APS	Producers		Breeding		Post-weaning		Fattening	
	N°	%	N°	%	N°	%	N°	%
1	22	100	9	40.91	13	59.09	0	0.00
2	14	100	8	57.14	6	42.86	0	0.00
3	14	100	4	28.57	3	21.43	7	50.00
4	12	100	9	75.00	2	16.67	1	8.33
Whole Sample	62	100	30	48.39	24	38.71	8	12.90

other cases, the levels are lower than this latter value. It reveals that the interaction of farms with the rural environment is generally poor.

The comparison between means shows that "assessment" is the attribute that makes clear the differences between large and small farms. The "own funds" variable only establishes significant comparisons for APS_3. The access to and the use of credit do not show significant differences among the systems. The entry of farmers in the factor markets have basically depended on the use of their own financial resources.[36]

Table 6.8 could be analyzed in a vertical direction looking at each one of the six comparisons between production systems for the 23 variables listed. At least 60 percent of the comparisons between APS_3/APS_1 and APS_4/APS_1 exceed the five percent significance level. At least 40 percent of the comparisons between APS_3/APS_2 and APS_4/APS_3 appear to be significant. The lowest percentage of significant comparisons between means (around 35 percent) correspond to APS_2/APS_1 and APS_4/APS_2. In the comparison between APS_2/APS_1 no significant level is obtained for the technological package. However, it was indicated that differences exist in the use of pastures. The test for the difference between the means of total perennial pastures $[(PP + PP_f)/LA]$ for APS_1 and APS_2 determines a value of "t" equal to 2.30. This value is significant at the five percent level.[37]

In summary, the size of farm and intensity in land use define two meaningful dimensions to understand the incorporation of technology in

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[36]It is the outcome of the "indexation" of the credit system since 1975. This mechanism of automatic adjustment of the capital originally loaned was established in Argentina to compensate the annual inflation rate of anything between 100 to 200 percent.

[37]The corresponding means and standard deviations are respectively: APS_1, 0.105, 0.122; APS_2, 0.036, 0.055.

the breeding-livestock enterprises. These dimensions show relationships of interdependence among the attributes that characterize the conceptual components (the farm productive structure, the producer characteristics, the technological package and the instrumental component).

The size dimension relates to the incorporation of technical inputs (excluding fattening operations). The propensity to incorporate technology and the level of education of the producer are correlated with this dimension. It is also related to a favorable interaction of farmers with their socio-economic context, based essentially on technical assistance.

The intensity in land use dimension is associated with the practice of post-weaning production and fattening. The predisposition to obtain technical information and the time devoted to the farm are correlated with this dimension. It also is shown to be associated with the availability of "own funds" for capital investment and incorporation of improved pastures.

Both dimensions helped to cluster the breeding-livestock enterprises in four actual production systems. The global characterization of these systems based on the conceptual components is presented in Table 6.12.

In the next chapter, the technological diagnosis of the actual production systems will be elaborated. Chapter VIII analyzes the efficiency of resource allocation for each system of production.

Table 6.12

Global Characterization of Actual Production Systems
Ayacucho County, Argentina, 1977

APS	Structural Component												Instrumental Component		Technological Package														
	Productive Structure								Producer Characteristics				Interaction with the Rural Environment		Inputs												Activity		
	Size			Salaried Relationship			Proportion of Factors		Predisposition to changes		Dedication				Feeding			Health			Genetics			Cattle Management					
	S	M	L	H	M	L	Int.	Ext.	H	L	H	L	+	-	H	M	L	H	M	L	H	M	L	H	M	L	B	PW	F
1	x					x	x			x	x			x		x			x				x			x		x	
2		x			x			x		x		x		x			x		x				x			x		x	
3		x		x			x		x		x		x		x			x				x			x				x
4			x	x				x	x			x	x		x			x					x		x		x		

Key: S = small; M = medium; L= low; Int. = intensive; Ext.= extensive, H= high; B= breeding; PW= post-weaning; F = fattening.

APS_1	Small	Family farm	Intensive	Low Predisposition	High Dedication	Unfavorable Interaction	Medium-low Technical Level	Post-Weaning -long-
APS_2	Medium-small	Hired Workers 60%	Extensive	Low Predisposition	Low Dedication	Unfavorable Interaction	Low Technical Level	Post-weaning -short-
APS_3	Medium-large	Hired Workers 78%	Intensive	High predisposition	High Dedication	Favorable Interaction	High Technical Level	Fattening
APS_4	Large	Hired Workers 88%	Extensive	High predisposition	Low Dedication	Favorable Interaction	Medium-high Technical Level	Breeding

CHAPTER VII

TECHNOLOGICAL DIAGNOSIS OF THE BREEDING - LIVESTOCK PRODUCTION SYSTEMS

In the last chapter the principal relationships of interdependence among the conceptual components were established. These dimensions were used to identify several cow-calf production systems. Later, the most significant differences among the production systems were tested in relation to the conceptual components outlined previously.

The objective of this chapter is to develop a technological diagnosis of the actual production systems. This diagnosis will seek to associate the aspects that make a difference among the production systems with "indicators" of their performance. In other words, the structural, technological and instrumental characteristics of the systems will be related to physical and economic measures of performance. This will facilitate understanding how the requisites of congruence, profitability, articulation and adaptability influence the behavior of the livestock enterprises in the incorporation of technology.

Before the technological diagnosis is developed, the indicators of farm performance must be defined.

7.1 Definition of Measures of Performance

Physical and economic indicators will be utilized to measure the performance of livestock enterprises. These measures of performance will be estimated using the data sample discussed in Chapter V for the calendar year of 1977. The production of beef, mutton and wool per hectare of livestock area will indicate the physical performance. The economic indicators used are grouped into three categories:

a) average cost per unit of total revenue;

b) net revenue per unit of invested and total capital;

c) return and investment per area unit.

The basic variables used to build the performance indicators are defined below.

Physical Variables

- Beef Production: The greater part of the cattle produced in Ayacucho County is sold in open auctions. The sale weights of cows, heifers, steers, young steers and calves are based on the personal estimate of the producer. The kilograms sold and consumed are added, the kilograms bought are subtracted, and inventory differences are computed, thus obtaining the weight of the meat produced. The weight and stock of bulls is considered constant.
- Wool Production: The kilograms of fleece and belly wool are determined for each producer on the basis of the yields and number of head fleeced in each category.
- Mutton Production: A method similar to that used to estimate beef production is applied to mutton.

Economic Variables[1]

- Total Revenue (TR): This is obtained by valuing the total kilograms of beef, mutton and wool produced by each establishment. For the first two items, only one price is used to value each kilogram of meat.

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[1]The average values of the variables utilized in the elaboration of the economic indicators are shown for each system of production in Appendix C, Table C.2.

Income from other sources are added if there is any generated. The prices mentioned correspond to an average of the prices prevalent during 1969 to 1978, adjusted by the consumer price index (Base=1978).[2]

- Operating Costs (OC): Comprises expenditures in wages and salaries, annual pastures, supplementary feeding, health, plus other expenses, which include received and paid rents, fuel and lubricants, repair and maintenance of improvements, taxes, freight, and buying and selling expenditures.[3]
- Depreciation (DE): Comprises depreciation of improvements (ID) and machinery,[4] plus the annual depreciation of perennial pastures at the rate of 20 percent of their total cost of establishment.
- Production Costs (QC):[5] Equal to the sum of OC and DE.
- Net Revenue (NR): Equal to the difference between TR and QC.

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[2]The acquisitive value of the price of beef in terms of input prices remained approximately at the same level comparing the average of acquisitive values for 1977 to 1979 with the corresponding average for 1965 to 1969. However, the acquisitive value of beef price for 1978 was lower than the average values used for comparison. See Banco Ganadero Argentino (Noviembre, 1979), p. 27. Therefore, an average of the prices prevailing during 1969 to 1978 is used to value meat production. The prices used to value the physical production, and the method of calculation thereof, are shown in Appendix C, Table C.1.

[3]Repair and maintenance costs on machinery are included in the expenses of the annual pastures and depreciation of perennial pastures.

[4]The machinery depreciation comprises an estimated value of depreciation for the machinery hired in.

[5]The inputs and production factors are valued at current prices of August 1978. Source: data bank of the Department of Rural Economy and Sociology of EERABalcarce-INTA.

- Fixed Capital (FK): Comprises the value of capital in improvements, machinery and livestock.[6]
- Operating Capital (OK): Calculated as being 25 percent of OC.[7]
- Invested Capital (IK): Sum of FK and OK.
- Total Capital (TK): Sum of IK and land capital.[8]
- Interest on IK, [I (IK)]: Calculated at six percent on improvements, eight percent on machinery and cattle, and 12 percent on operating capital.[9]
- Interest on TK, [I (TK)]: Sum of I (IK) and five percent on land capital.
- Land Rent (RE): This is the difference between NR and I (IK).
- Total Cost I (TC_I): Being the sum of QC and I (IK).
- Total Cost II (TC_{II}): Being the sum of QC and I (TK).

In accordance with the three categories mentioned at the beginning of this section, the following economic indicators are thus defined:

a) OC/TR, QC/TR, TC_I/TR, TC_{II}/TR;

b) NR/IK · 100, NR/TK · 100;

c) TR/ha, NR/ha, RE/ha, FK/ha, OK/ha, IK/ha.

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[6]See the definition of each capital item in Table 6.9.

[7]It is assumed that livestock producers need to have available on an annual basis operating capital equal to 25 percent of total expenditures.

[8]For the definition of land capital see Table 6.9.

[9]Differences in interest rates correspond to the different risks attached to each capital item. The rates are those commonly applied in Farm Management analysis in Argentina. They are "real" interest rates, based on the assumption that the rate of inflation does not show differences for input and output prices.

7.2 Comparative Analysis Between the Actual Production Systems

The technological diagnosis will be developed based on a comparative study among the livestock systems. The objective of this section is to analyze the levels of land productivity, and the conditions of congruency, profitability and those which relate farmers with their socio-economic context. Finally, conclusions about the technological process in the cow-calf production should be attained.

7.2.1 Land Productivity

The basic characteristics presented in the last chapter for each production system can now be associated with the results in meat output per hectare shown in Table 7.1. Farms using APS_3 with an adoption index double that of APS_1, and with a fattening level that is higher, obtain 30 percent more meat output per hectare than the smallest farms. A similar difference in output appears between APS_3 and APS_4. Both systems have a similar technical level, however, there is a substantial difference in the type of activity and in the proportion of production factors used. Comparing APS_1 and APS_4, it is seen that the last system has a higher adoption index in the order of 1.5 to 1. Nevertheless, meat output is similar. APS_4 has a technical level higher by 61 percent with respect to APS_2; notwithstanding, APS_4 only has meat output nine percent higher than APS_2. APS_1 practices long post-weaning activity with an intensive proportion of factors, and has a higher technical level than APS_2. Farms using APS_1 generate ten percent higher meat output per hectare than APS_2, and more than duplicate the production of wool per hectare.

Table 7.1

Production by Actual Production System
Weighted Averages
Ayacucho County, Argentina, 1977

APS	Kilos of Meat per Hectare of Livestock Area			Kilos of Wool per Hectare of Livestock Area
	Cattle	Sheep	Total	
1	75.11	10.86	85.97	5.58
2	69.98	8.34	78.32	3.41
3	97.11	13.28	110.39	4.95
4	79.61	5.60	85.21	2.01
Whole Sample	82.42	8.74	91.16	3.44

The situations analyzed above suggest that fattening operations increase the output of meat per hectare. However, meat output achieved is lower than experimental levels. It could be explained seeing that the highest degree of fattening in the sample correspond to an adoption index 60 percent of the theoretical maximum level. These results also show that the package of new technology (basically health and management practices together with improved pastures) does not increase farm production significantly unless it is associated with an intensive proportion of factors and the practice of cattle fattening. In a similar manner, long post-weaning production does not generate an appreciable increase in production unless new technological inputs are incorporated.

7.2.2 Congruence Requisites

It is shown in Table 7.2 that the proportion of factors, and the dedication of the producer, appear to establish a condition of congruence for the type of activity.[10] The intensive factors proportion/high producer dedication, and the extensive factors proportion/low producer dedication are associated respectively with fattening (APS_3 and APS_1) and breeding activities (APS_4 and APS_2).

Farms belonging to APS_3 and APS_1 (intensive productive process) have an average output per hectare 22.5 percent higher than those farms making up APS_4 and APS_2 (extensive productive process); the average meat output for both groups is 103.5 kilograms per hectare and 84.5 kilograms per hectare respectively. It will be seen in the next section that these differences in land productivity do not necessarily generate differences

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[10]See Chapter III, p. 45.

Table 7.2

Congruence Condition Between the Structural Component and the Technological Package in Breeding-Livestock Enterprises Ayacucho County, Argentina, 1977

APS	Size	Proportion of Factors	Dedication of the Producer	Global Adoption Index	Activity	Meat Output (Kilos/ha)
3	Medium-large	Intensive	High	9.1	Fattening	110.4
1	Small	Intensive	High	4.6	Long post-weaning	86.0
4	Large	Extensive	Low	7.1	Breeding	85.2
2	Medium-small	Extensive	Low	4.4	Short post-weaning	78.3

in profitability. Consequently, congruence and profitability conditions could explain the technological heterogeneity associated with the simultaneous practice of fattening and breeding cattle in the study area.

However, different technical levels exist within the two productive processes. These technical levels are associated with the following paired situations and production levels:

- Large farm size; good predisposition to technical change; favorable interaction with the rural context; high technical level (APS_3 and APS_4): average meat output equal to 94.8 kilograms per hectare.
- Small farm size; low predisposition to technical change; unfavorable interaction with the rural context; low technical level (APS_1 and APS_2): average meat output equal to 81.4 kilograms per hectare.

The average for the high technical level shows 16.5 percent higher output per hectare with respect to the low level. Consequently, technological heterogeneity based on differences in technical inputs generates less impact on meat production per hectare than does classifying farms by the type of activity.

The paired situations analyzed above show that differences in technical level between production systems showing the same productive process could be based on the farm size itself (endowment of production factors), the objective of the producer, or instrumental conditions. Profitability analysis should make clear to which level the producer characteristics or instrumental conditions could explain the heterogeneity of techniques or if the productive structure is the main factor that affects the incorporation of technology for the prevailing set of input-output prices.

7.2.3 Profitability Conditions

As both breeding and fattening activities exist in the study area, it is not expected that one is clearly more profitable than the other. In other words, there is not technological dominance in the study area. Moreover, technological heterogeneity between both productive processes is expected without dominance in private profitability for the prevailing input-output price ratios.[11]

However, within each productive process the use of different technical levels can respond to structural or instrumental conditions. Small farms often cannot incorporate new technology due to lack of economic capacity to generate investment funds internally, or to obtain outside credit. Within a particular productive process, economies of size can also differ for different production systems generating similar profitability for alternative packages of technology. In both cases, the farm production structure would appear to have the greatest effect on the technology actually used given the set of input-output prices. However, different technical levels can show significant differences in profitability. In this case, the factors that shape technological heterogeneity should be found in the producer characteristics (basically the presence of utility criteria other than profit maximization) or in the elements that define his interaction with the socio-economic environment.

In what follows, the economic performance of the actual production systems will be analyzed. A comparative analysis will be developed to see if the heterogeneity of techniques is based on economic rationality. It will be tested statistically if this heterogeneity appears to show itself without

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[11]See Chapter III, pp. 46-48, for the economic rationality of the heterogeneity of techniques.

dominance with respect to private profitability. Producer characteristics will also be taken into account. The next section will be devoted to the interaction of farmers with their socio-economic context.

The indicators of economic performance of the breeding-livestock production systems are shown in Table 7.3. In section a) of this table it can be seen that economies of size become effective when passing from APS_1 to APS_2. Beyond the average level of 700 hectares, reduction in costs per income unit is relatively low.[12,13] Comparing indicators OC/TR and QC/TR, it can be argued that economies of size are basically in the operating costs. Fixed costs corresponding to permanent labor (mainly family dependents) are an important proportion of the operating costs. To a small extent the values of depreciation per unit of income also has a bearing;[14] the corresponding values from the smallest system to the largest being 0.155, 0.119, 0.122, 0.093 (values taken from Appendix C, Table C.2). Therefore, the indivisibilities that are presented in certain items of the fixed capital and fixed operating costs generate economies of size that brings about an evident difference in the average costs between APS_1 and the rest of the producing systems. As a consequence of this, all the systems except APS_1 are able to cover their overall costs, with the exception of land value returns (TC_I/TR). When the interest paid to this factor is considered, no systems generate an income level sufficient to meet the total costs of production (TC_{II}/TR).

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[12]This agrees with the information documented by Santos, S. (1970), p. 83.

[13]The costs per unit of total revenue are equivalent to the relationship costs/unit of physical production (Q), since the TR comes about from valuing Q at only one price for each cattle item.

[14]The same comment can be found in INTA-IICA (OEA) (1979), p. 77.

Table 7.3

Indicators of Economic Performance of the Breeding-Livestock Production Systems
Weighted Averages
Ayacucho County, Argentina, 1977

	a) Average Costs per Unit of Total Revenue				b) Return per Capital Unit	
APS	OC/TR	QC/TR	TC_I/TR	TC_{II}/TR	NR/IK .100	NR/TK .100
1	0.645	0.800	1.163	1.611	3.97	1.43
2	0.467	0.586	0.891	1.417	10.24	2.84
3	0.427	0.548	0.843	1.106	11.18	3.94
4	0.425	0.518	0.799	1.305	12.94	3.48
Whole Sample	0.456	0.569	0.867	1.307	10.71	3.28

	c) Return and Investment per Land Unit (1,000 pesos/ha)					
APS	TR/ha	NR/ha	RE/ha	FK/ha	OK/ha	IK/ha
1	44.6	8.9	-7.2	217.2	7.2	224.4
2	38.1	15.8	4.1	149.4	4.4	153.8
3	53.9	24.3	8.5	211.9	5.7	217.6
4	39.5	19.0	7.9	142.8	4.2	147.0
Whole Sample	43.8	18.9	5.8	171.1	5.0	176.1

Foreign exchange rate equal to 802,00 pesos per dollar (August, 1978).

The returns per invested or total capital unit shown in sector b) of Table 7.3 offer the same picture as the foregoing. On the average, APS_2, APS_3 and APS_4 have a higher invested capital return than APS_1 in a proportion of 3 to 1. It can be assumed that in the financial market, farmers using the three systems mentioned first are able to make investments that assure a real return of between six and eight percent. In this manner, the returns shown by these systems appear as a "normal" profit, even taking into account the additional expected return for the risks attached to agrarian investments. This means, likewise, that APS_1 is, economically speaking, unprofitable.

The reasons already mentioned make it logical to analyze APS_1 separately. This production system has an average area of 300 hectares. It shows an intensive use of factors; its investment per hectare is higher, for instance, than that shown by APS_3. At the same time, APS_1 has the higher average cost, the lower return on capital and a negative rent per hectare.

The net return available for the APS_1 producer to cover improvements in the living conditions of the family and investments for the enterprise is substantially low.[15] It is evident that this type of establishment cannot support the incorporation of new technology following the productive process corresponding to fattening operations (APS_3). It is significant to observe that in the study sample the smallest establishment that fattens cattle has 557 hectares of livestock area. This would indicate that in APS_1 the practice of post-weaning with a low index of adoption of innovations might be an equilibrium conditioned by economies of size associated with a "subsistence" income.

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[15]From Appendix C, Table C.2, it is calculated that for the period studied APS_1 generated a net return per month equal to 223,000 pesos.

This study analyzes only the cattle activity. APS_1 also dedicates 12 percent of their total productive land area to crops, which is the highest proportion of all the systems studied. It has been shown that in the breeding region, as the crop area increases, so does the total gross margin of the enterprise.[16] This is a means by which the small producer can protect himself from the low profitability derived from cattle.

Closer attention will now be focused to the economic performance of APS_2, APS_3 and APS_4. At first glance, the net return per invested capital unit (Table 7.3, section b)), does not show an appreciable difference in profitability among these systems. The absence of dominance in profitability will support the economic rationalism of the heterogeneity of techniques. The rest of this section will be devoted to an analysis of this situation. In spite of congruence conditions it will be analyzed whether or not it is profitable for APS_4 and APS_2 to undertake additional investment for using APS_3 technological arrangement. Second, it will be discussed if it is profitable for APS_2 to undertake APS_4, as both systems use the same productive process. Third, the production situation of APS_3 will be examined.

The profitability of the investment to be made in APS_2 and APS_4 if they use the technological alternative developed by APS_3 is presented as follows:

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[16] Gardella, E., et al. (1979), demonstrate this utilizing the same sampling of producers as this present study. The total gross margin is the difference between the total agricultural revenue and the corresponding variable costs.

APS	IK/ha	NR/ha	Δ(IK/ha)	Δ(NR/ha)	$\frac{\Delta NR}{\Delta IK} \cdot 100$
3	217.6	24.3	----	----	----
2	153.8	15.8	63.8	8.5	13.32
4	147.0	19.0	70.6	5.3	7.51

The principal indicators for the seven enterprises that, within APS_3, exclusively practice fattening, are as follows:

LA (hectare):	1,509
QC/TR:	0.544
NR/IK · 100:	11.84
NR/ha (1,000 pesos/ha):	24.9
IK/ha (1,000 pesos/ha):	209.9
Global adoption index:	8.86
Meat output/ha:	113.72

The additional profitability of the investment that APS_2 and APS_4 should make if they wish to develop the fattening alternative is indicated below:

APS	IK/ha	NR/ha	Δ(IK/ha)	Δ(NR/ha)	$\frac{\Delta NR}{\Delta IK} \cdot 100$
Fattening	209.9	24.9	----	----	----
2	153.8	15.8	56.1	9.1	16.22
4	147.0	19.0	62.9	5.9	9.38

These figures show that the APS_3 alternative and that of fattening specified afterwards are not profitable technological arrangements for APS_4. The alternative of a lower technical level for APS_4 can be analyzed using APS_2 as a point of reference. With respect to APS_2, which has an adoption index of 4.4, the large farm produces approximately seven kilograms more of meat per hectare (due principally to the use of perennial pastures). If the value of this difference in meat per hectare is subtracted from the TR of APS_4 (the OC are not changed), and the value of perennial pastures are deducted from capital and depreciation, the following results are obtained:

QC/TR:	0.530
NR/IK · 100:	12.12
NR/ha (1,000 pesos/ha):	17.11
IK/ha (1,000 pesos/ha):	141.2
Meat output/ha:	78.21

This situation of lower intensity in the use of techniques as compared to APS_4, has in turn a slightly smaller return on capital invested.

It might be argued, however, that improved alternatives do exist related to different degrees of fattening(improved alternatives with respect to APS_3), with a greater use of pastures, that might lead APS_4 to double meat output.[17] Simple calculations on these alternatives indicate that the necessary increase of capital does not generate economic results substantially better with respect to the extensive production, except for the alternative based on 70 percent of fertilized perennial pastures and 20 percent of annual pastures.

It is evident that the extensive mode of production, with the size of APS_4, together with a relative high use of technological inputs and the practice of breeding is economically rational given the market conditions prevailing in the period analyzed. This mode of production is

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[17] See Alais, A., et al. (1978), summary chart of five technological alternatives, using prices of July 1978.

seen to be congruent with a producer predisposed to technical changes but little accustomed to dedicate himself to his farm.[18]

The technological arrangement of APS_3 is more profitable than APS_2. A profitability of 13.3 percent and 16.2 percent is indicated respectively for the additional investment from APS_2 to APS_3 and for the alternative of "fattening" (pages 161 and 162 of this chapter). However, farmers using APS_2 have the highest age level and do not show predisposition towards technical changes. Not having to face the economic pressure that economies of size bring to bear on the smaller farm, the producer of APS_2 by only undertaking a short post-weaning activity reaches an absolute profitability level close to that of APS_3.

The APS_2 producer may be the one who resists the risk of incorporating an innovation. In the case of APS_1, the lack of producer predisposition to technical changes could be associated with the size restriction. Thus, he may need to take some risks in order to overpass the subsistence income level. But, for the APS_2 producer, the lack of predisposition appears to be related more to his "conservatism," thus implying in turn an aversion to the risk of innovation. These results show that for APS_2 the "type" of producer could be a limiting factor for livestock development.

Within the firms emphasizing the breeding activity, APS_2 shows a lower technical level than APS_4. It can be seen in Table 7.3 that both systems have a similar IK/ha and TR/ha. However, differences exist

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[18]This argument is consistent with the results of the studies brought about at the beginning of the 1970s in the breeding zone. See Chapter V, pp. 95-97.

in economies of size between them. The higher level of output obtained by APS_4 cannot compensate the higher costs generated by size economies in APS_2. Thus, profitability could be the basic reason for the difference in technical level between both systems. However, it is possible that the APS_2 producer characteristics used to explain the choice of different productive process with respect to APS_3 also influence the choice of technical level for APS_2 within the breeding process.

The remaining question is whether APS_3 constitutes a situation of equilibrium according to profitability criteria. The technological arrangement of APS_4 shows a slightly larger return on capital invested than APS_3. But would extensive production on the basis of breeding, as shown by APS_4, be profitable in an establishment of 1,200 hectares? Table 7.3 indicates that there exist economies of size going from APS_3 to APS_4, although these are of a lesser intensity than those shown at smaller size levels. It could indicate that an extensive mode of production would not permit a profitability level for the medium - large establishment as shown by APS_4. Consequently, given the structure of APS_3, which is intensive in the use of factors, with a producer predisposed to technical changes and with a full dedication to the farm, fattening appears as the most congruent and profitable alternative.

It can be seen in Table 7.3, section c), that APS_3 and APS_4 produce the highest rent on land per area unit. These are very similar values that justify from this point of view the co-existence of both an extensive and intensive mode of production. The corresponding value of APS_2 shows that an average of 700 hectares, with extensive production, is sufficient to obtain a surplus rent value. The negative rent value of APS_1 simply confirms its lack of economic capacity to undertake investments in land.

Profitability conditions have been analyzed up to now without a statistical test. Table 7.4 presents the results of the Kruskal-Wallis test for the association among the livestock production systems and the ordering of economic performance measures, i.e., return to invested capital (NR/IK) and economic surplus per hectare (NR/ha). The null hypothesis is rejected at the .05 significance level, which means that at least one of the four production systems differs from the rest as regards economic performance. Applying the same test to APS_2, APS_3 and APS_4, for the same measures of performance the null hypothesis is not rejected.[19]

Table 7.4

Association Among Production Systems and Indicators of Economic Performance Ayacucho County, Argentina, 1977

APS	Kruskal-Wallis Test Values (K)	
	NR/IK	NR/ha
1-2-3-4	12.50*	10.36*
2-3-4	1.60	1.63

*Null hypothesis rejected at .05 significance level.

These results show that in the first test the differences in NR/IK and NR/ha among systems are based on APS_1 observations. Thus, the difference in economic capacity for investing in technology among APS_1 and the other systems is statistically significant. Moreover, the second test shows statistically that significant differences do not exist among

[19]In this case the test is developed ordering once again the observations within the reduced sample make up by APS_2, APS_3 and APS_4. See Conover, W. (1971), p. 259.

APS_2, APS_3 and APS_4 in the return to invested capital and in the economic surplus per hectare. Consequently, different technological arrangements in the breeding-livestock production are not associated from a statistical point of view with significant differences in profitability, i.e., technological heterogeneity appears without dominance in profitability.

In summary, a critical farm size must be reached before farmers are able to generate their own financial capacity. Farms using APS_1 are below the critical level. Consequently, this structural restriction limits the incorporation of technological arrangements that APS_1 must have to obtain higher profitability.

The co-existence of both an intensive (APS_3) and extensive (APS_4) mode of production is based on economic rationality. Taking into account the respective productive structures and the prevailing input-output prices both systems are in equilibrium according to profitability requisites.

Economic analysis upon APS_2 shows that congruence conditions and producer characteristics may restrict the search for fattening activities that are more profitable than its actual technological arrangement. Profitability is the factor that induces APS_2 to operate cattle-breeding with a low technical level.

The statistical analysis shows that differences in profitability among APS_2, APS_3 and APS_4 are not significant. Thus, from a statistical point of view the basic reason that explains technological heterogeneity among these production systems is the absence of dominance in profitability.

Heterogeneity of techniques is a sufficient condition to postulate that each system of production has a specific behavior in the incorporation of technology. Moreover, the absence of dominance in profitability among their technological arrangements shows, for the prevailing market conditions, that the productive structure is the basic factor affecting such behavior.

7.2.4 Interaction with the Socio-Economic Context

The purpose of this section is to test statistically if the systems of production show specific ways of interaction with the rural context. This interaction relates to the conditions of articulation and adaptability for the incorporation of technology.

Table 7.5 summarizes four situations of association between production systems and different types of interaction with the rural environment. The categories that represent the different interactions are generated by clustering upon the first two principal components of the instrumental criteria[20] and, alternatively, by grouping the observations according with the quadrants of the first two principal components space.[21]

The analysis is developed using (4x4) and (2x2) contingency tables. In the latter case, APS_1 is grouped with APS_2, and APS_3 with APS_4. The categories of interaction with the rural context are obtained following the clustering process on one hand, and grouping quadrants (+-), (++) and (--), (-+) in the other.

Table 7.5 shows in all the cases that the null hypothesis of independence is rejected. Consequently, each production system appears to be associated with a particular type of interaction with the rural context.[22] The measures of dependence are higher when the categories of interaction are characterized with the quadrants of the principal component space. The

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[20]The analysis of principal components is presented in Appendix A, Table A.4. The clustering output is shown in Appendix D, Table D.4. Also see in the Appendix, Figure D.1.

[21]See Appendix D, Figure D.1.

[22]The contingency tables analyzed do not meet usual assumptions for chi-square test.

Table 7.5

Association Among Actual Production Systems and the Interaction with the Rural Context Ayacucho County, Argentina, 1977

Clustering Unit for the Instrumental Criteria	Situation of Association No.*	Number of Categories	T	C "Pearson"	V "Cramer"
First and Second Principal Components	I	4x4	23.08**	0.52	0.35
	II	2x2	10.90**	0.39	0.42
Quadrants of the Component Space	III	4x4	30.39**	0.57	0.40
	IV	2x2	13.71**	0.43	0.47

*The situations of association No. I, II and IV are presented in Appendix D, Tables D.1, D.2 and D.3 Situation No. III is exhibited in Table 7.6 of this chapter.

**Null hypothesis rejected at .05 significant level.

Cramer coefficient shows that the dependence is higher when farms are clustered in small and large groups, and the interaction with the context is described with two categories, i.e., unfavorable and favorable.[23]

In Table 7.6 the four categories of interaction with the rural context that represents each quadrant of the component space are ordered from the least to the most favorable as follows: (+-), (++), (--) and (-+). To decide this order it is assumed that the use of own funds (representing the interaction with the factors market), and the availability of information and assessment define a better interaction with the rural context than the availability of credit.[24] Consequently, the ordering of the systems of production from a more favorable interaction with the rural environment to a less favorable one appears as follows: APS_3, APS_4, APS_2 and APS_1.

According with these results, farmers using APS_3 and APS_4 (the larger sized systems) have a greater possibility for articulation with the technological supply, as well as for getting information adapted to their production schemes. This situation is associated in turn with a more intensive entry of larger farmers in the factors market.

The lesser degree of interaction with the rural context may make APS_2 and APS_1 (the smaller sized systems) "delay" the incorporation of technology. APS_1 has the most unfavorable interaction with the rural context but has a higher degree of incorporation of technology than APS_2. It may say that the unfavorable interaction shown by smaller producers with their rural environment may be originating at the farm level itself. That is, the low economic capacity of APS_1 and the "conservatism" of the

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[23]See Appendix D, Tables D.1, D.2 and D.3.

[24]See Appendix D, Figure D.1.

Table 7.6

Production Systems and the Instrumental Criteria:
Third Situation of Association of Table 7.4
Ayacucho County, Argentina, 1977

Interaction with the Rural Environment	Observed (O) and Expected (E) Values	APS				Total
		1	2	3	4	
Unfavorable -Lowest-	O	11	6	1	1	19
	E	6.74	4.29	4.29	3.68	
Unfavorable -Medium Low-	O	6	5	4	2	17
	E	6.03	3.84	3.84	3.29	
Favorable -Medium High-	O	3	2	1	7	13
	E	4.61	2.94	2.94	2.52	
Favorable -Highest-	O	2	1	8	2	13
	E	4.61	2.94	2.94	2.52	
Total		22	14	14	12	62

APS_2 producer (together with the absence of economic pressure) could generate a lack of "incentive" to interact with the rural socio-economic context.

7.3 Perspectives on Technical Change

A final synthesis of the actual technological situations encountered in the breeding-livestock region is presented in Table 7.7. This matrix shows, based on the foregoing analysis, that the structural component is the principal factor shaping the overall technological configuration in the breeding-livestock production, according with the prevailing economic policies. The interaction of farmers with their socio-economic context can delay the incorporation of new techniques, but does not appear as a basic limiting factor. In line with this argument, there is no evidence of a latent demand for the "actual" patterns of the technological supply. Each system of production appears to have specific reasons of non-adoption of available technology based on congruence and profitability conditions.[25] This would indicate in turn that the actual supply of technology does not comprise a dominant technique from a technical point of view.

The stability shown by structural conditions of the breeding-livestock region in the last ten years reinforces this technological configuration. The structural conditions outlined in the studies undertaken in the 1970s in the breeding-livestock region are similar to those already analyzed. It could also be seen in Table 7.8 that the yield of meat per hectare has not changed dramatically in the period 1968 to 1977. Neither has there been much change in the area devoted to natural pasture. Table 7.9 shows

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[25]See Chapter III, p. 49. Congruence refers to the compatibility between the farm structural component and new technology.

Table 7.7

Matrix of Actual Technological Situations
Ayacucho County, Argentina, 1977

Structural Component	Technological Level				Interaction with the Rural Context
	Medium-Low	Low	High	Medium-High	
	Long Post-Weaning	Short Post-Weaning	Fattening	Breeding	
Small Size Intensive Structure Low Predisposition High Dedication	APS_1 86.0 kg/ha NR/IK: 3.97 NR/ha: 8.9	Critical level of economic capacity			Unfavorable -Lowest-
Medium-Small Size Extensive Structure Low Predisposition Low Dedication	Technological heterogeneity without dominance in profitability	APS_2 78.3 kg/ha NR/IK: 10.24 NR/ha: 15.8	----	----	Unfavorable -Medium Low-
Medium-Large Size Intensive Structure Good Predisposition High Dedication		----	APS_3 110.4 kg/ha NR/IK: 11.18 NR/ha: 24.3	----	Favorable -Highest-
Large Size Extensive Structure Good Predisposition Low Dedication		----	----	APS_4 85.2 kg/ha NR/IK: 12.94 NR/ha: 19.0	Favorable -Medium High-

Table 7.8

Use of the Livestock Area and Yield of Meat per Hectare
in 1968 and 1977 for the Same Sample of Producers
Ayacucho County, Argentina

Year	Natural Pastures (NP/LA).100	Annual Pastures (AP/LA).100	Perennial Pastures (PP/LA).100	Meat/hectare (Beef and sheep in kilos)
1968	74.90	14.02	11.08	80.1
1977	76.69	8.43	14.88	91.2

Sources: 1968 data taken from Bocchetto, R. (1970).
1977 data based on information gathered for this research.

the rate of adoption for the principal techniques that comprise the supply of technology, as well as the average adoption index which has increased from 3.05 to 3.68 for a theoretical maximum of 11.0.[26]

Comparing the information available from the studies in the 1970s and the results of the present research, the small and medium-small farms have not substantially modified their methods of production. The larger enterprises have incorporated perennial pastures to some degree but continued to concentrate on the breeding activity. Medium-large farms increased the use of perennial pastures and the fattening of their own production.

Perspectives on technical changes for the breeding-livestock production can now be elaborated. APS_1 does not have economic capacity to operate the fattening activity. At the same time, it does not appear to be profitable for this system to evolve in breeding activities at a highly technical level. The minimization of losses would lead APS_1 to maintain the actual technological level, increasing post-weaning production so far as forage resources and financial possibilities permit. However, only quantitative changes in the actual production function can be expected for APS_1.

Farms using APS_2 and APS_4 differ both in size and technological level, but are similar in other structural features. For APS_2 high adoption of innovations in breeding do not appear to be profitable. The extensive proportion of factors used, and the lack of dedication by the producer indicate that fattening would not be adopted. At the same time, the lack

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[26]In order to arrive at a comparison, this adoption index corresponds to that used and elaborated by Obschatko, E. (1971), p. 47.

Table 7.9

Rate of Adoption of Techniques and Adoption Index Measured in 1968 and 1977 for the Same Sample of Producers Ayacucho County, Argentina

	Percentage of Producers that Use the Techniques	
Techniques	1968	1977
Perennial Pastures	50	63
Fertilizer	23	31
Forage Reserves	18	24
Mineral Salts	39	15
Brucellosis Vaccines	45	53
Pregnancy Testing	31	48
Service of Three Months	18	18
Anticipated Weaning	7	19
Average Adoption Index	3.05	3.68

Sources: 1968 data taken from Obschatko, E. (1971), Table 24.
1977 data taken from information gathered for this research.

of predisposition towards technical changes further implies that this producer would not establish sufficient pastures needed for this activity. The high average age of the producer and the absence of economic pressure are both factors that contribute to few quantitative and qualitative changes of any importance in APS_2. In turn, APS_4 is the most profitable system, using a relatively high technical level and practicing breeding. The disposition of the producer towards changes indicates that this technical level can be maintained or even improved. However, the high opportunity cost of giving more time to the farm does not favor adoption of fattening with the actual profitability level shown by this activity. This is the only alternative which would shift the production function of APS_4.

The overall outstanding characteristics of APS_3 for the incorporation of technology implies that with the aid of more favorable price relationships, this system should be able to increase the use of technological inputs and thereby the level of output of meat per hectare. There is available for this system a potential production level close to 170 kilograms of meat per hectare which is not the maximum of its production function. Data obtained from the Balcarce Livestock Development Project indicate the existence of farms in the "Pampa Deprimida Bonaerense" with an average size of 1,000 hectares, that dedicate 40 to 50 percent of the useable area to cultivated cattle pastures, with a stocking rate approximating 0.90 to 1.10 animal units per hectare, and outputs of 140 to 160 kilograms of beef.[27] Actual cases corresponding to the CREA groups[28] indicate

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[27]Preliminary results supplied by Rodolfo Gaioli, technician from the Department of Agricultural Economics of EERABalcarce-INTA; April 1980.

[28]CREA: "Consorcio Regional de Experimentacion Agricola," "Regional Consortium of Agricultural Experimentation."

outputs of 135 to 165 kilograms per hectare, with 50 percent of improved pastures and the fattening of its own production.[29] These are, however, levels reached by establishments with availability of technical information and assessment higher than the average for the region. The Balcarce Project is reinforced by a program of supervised credit. As a result, the question remains whether under "normal" conditions, those farms which comprise APS_3 could, in fact, reach the levels indicated.

Different studies indicate the possibility of increasing land productivity in the breeding-livestock region. The majority of these studies make reference to a "better allocation" of available resources, but do not precisely analyze improved alternatives for each predominant system. In other words, the conclusions are based upon the possibility of increasing "efficiency" of farms with their existing technological level.[30] Chapter VIII will show differences in efficiency within each productive system. The solution as regards inefficiencies at the level of the sample has its limit at 140 kilograms of meat per hectare (see maximum output in Table B.2, Appendix B). Thus, to be able to reach higher results, it is necessary to extend the present "frontier of production" of each productive system, which could mean direct modification of existing production functions. Taking into account this need, the present supply of innovations does not seem to make readily available "for each type of enterprise," production alternatives that are clearly outstanding from a technical point of view. The dominance in profitability that any specific technique may have at some

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[29]Alais, A., et al. (1978).

[30]See Bocchetto, R. (1970); Tandeciarz, I. (1971); and Goldman, O. (1972).

given moment, is not, in itself, a "technological fact," but rather depends upon the input-output price relationships.

Consequently, under the actual set of economic policies, structural conditions, and technical know-how available at the farm level, there appears to be no reason to expect any significant change in the state of technology of the breeding-livestock production systems.

CHAPTER VIII

ESTIMATION OF PRODUCTION FUNCTIONS AND ANALYSIS OF EFFICIENCY

In the two previous chapters, the systems of production were identified, characterized and their behavior in the incorporation of technology was analyzed. The technological diagnosis brought about some indications that there exists an important heterogeneity of efficiency among the farms clustered in each production system. For the whole sample the minimum output of meat per hectare is 47.87 kilograms while the maximum reaches 137.45 kilograms. The standard deviation is 24.13 kilos per hectare.[1] In general, this situation exists for each system of production identified.

The objective of this chapter is to analyze the allocation of resources in the whole sample and in the four systems of production. A production function will be estimated for the whole sample and for each breeding-livestock system. The economic evaluation will be based on the equi-marginal analysis. In each production system two levels of efficiency will be identified using the procedure presented in Chapter IV.

8.1 Data on Outputs and Inputs

The variables used in the construction of the regression models are detailed below. Since some of these variables have been introduced in

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[1]See Table B.1, Appendix B.

previous chapters only their codes are shown indicating the place where the definition can be found.

Endogenous Variable

- Total Revenue (TR): Chapter VII, p. 149-150.

Explanatory Variables

- Land Capital (LK): Chapter VI, Table 6.9.
- Livestock Capital (VK): Chapter VI, Table 6.9.
- Depreciation on Improvements (ID): Chapter VI, p. 105.
- Livestock Salaries (LW): The total payment in salaried staff (permanent and transitory) is determined using current wages and social laws. For "family" wages, the owner receives the equivalent of an administrator's salary, and the remaining members of the family, a farm worker's wage. The sum of these values constitute the total salary. This value is affected by the percentage of total labor hours that correspond to livestock (the same percentage used for LL defined in Chapter VI, p.104).
- Annual Pastures Expenditure (AE): Covers the expenses for making and protecting the annual pastures with owned machinery (repair and maintenance costs of owned machinery are included), and payments to outside contractors.
- Perennial Pastures Expenditure and Supplementary Feeding (PE): Includes depreciation on perennial pastures, with or without fertilizers (equal to 20 percent of the current cost of the pasture), whether done by means of owned machinery or by contractors. This variable also covers the cost of supplementary feeding, which in turn includes any grain purchased, and the cost of fodder reserves.

- Health Expenditure (HE): Includes the expenses made for vaccines, diagnosis of pregnancy, semen analysis, anti-parasite treatments, anti-scab and mineral salts.
- Improvements and Livestock Capital (EK): Comprises the sum of both items of capital, as defined in Table 6.9.
- Feeding Costs (FC): Being the aggregate of AE and PE.

Table 8.1 shows the basic variables utilized in the estimation of the production functions with their principal characteristics from the statistical point of view. These characteristics are obtained for the whole sample of 62 observations.

8.2 Analysis of the Whole Sample

The fit of the data is performed with the least squares method by means of the general linear model with a double logarithmic transformation or Cobb-Douglas function.[2]

The estimated model is the following:

$$\lg\hat{TR} = \lg \hat{B}_0 + \hat{B}_1 \lg LK + \hat{B}_2 \lg VK + \hat{B}_3 \lg ID + \hat{B}_4 \lg LW$$

$$+ \hat{B}_5 \lg AE + \hat{B}_6 \lg PE + \hat{B}_7 \lg HE$$

Table 8.2 shows the statistical results of the multiple regression equation. The matrix of correlation between the explanatory variables is presented in Table 8.3. There is evidence of a high degree of multicollinearity.

The value of R^2 indicates that the Xi explain 94 percent of the variation in Yi. Since the sum of the coefficients of regression is equal to 1.080, indication of constant returns to scale could exist for the whole sample.

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[2]See Chapter IV, pp. 72-74.

Table 8.1

Statistical Measures of Input and Output Variables
Used in the Estimation of Production Functions
Ayacucho County, Argentina, 1977

Variables	Code	Unit of Measurement	Range		Arith-metic Mean	Standard Deviation	Coefficient of Variation
			Low	High			
Total Revenue	TR	Mil pesos	5,933.0	228,160.0	42,989.0	45,100.0	1.049
Land Capital	LK	Mil pesos	61,600.0	1,809,300.0	392,558.0	398,160.0	1.014
Improvements Capital	MK (EK)	Mil pesos	6,258.7	274,981.8	60,941.0	51,461.0	0.844
Livestock Capital	VK (EK)	Mil pesos	12,931.0	458,700.0	96,667.0	97,277.0	1.006
Improvements Depreciation	ID	Mil pesos	736.0	9,797.8	2,983.9	2,252.8	0.755
Livestock Salaries	LW	Mil pesos	821.7	16,339.0	4,082.1	2,984.0	0.731
AP Expenditures	AE (FC)	Mil pesos	0	13,954.0	2,494.3	3,058.8	1.226
PP Expenditures (Without Fertilizer)	EE (PE, FC)	Mil pesos	0	6,011.2	489.5	1,000.2	2.043
Fertilized PP Expenditures	FE (PE, FC)	Mil pesos	0	14,584.0	805.3	2,292.7	2.847
Supplementary Feeding	SF (PE, FC)	Mil pesos	0	9,300.0	516.8	1,542.3	2.984
Health Expenditures	HE	Mil pesos	70.4	7,543.6	2,021.6	1,965.9	0.972

Table 8.2

Estimated Production Function
for the Whole Sample
Ayacucho County, Argentina, 1977

Variables	$\hat{B}_i$	$S_{\hat{B}_i}$	t
LK	0.2128	0.1631	1.305
VK	0.4900	0.1914	2.560*
ID	0.2099	0.1026	2.046*
LW	0.0686	0.0786	0.873
AE	0.0084	0.0034	2.471*
PE	-0.0039	0.0034	-1.147
HE	0.0939	0.0968	0.970

$\lg \hat{B}_0 = -0.5490$ $R^2 = 0.942$ $\Sigma \hat{B}_i = 1.080$

N=62 F = 125.76*

*Null hypothesis rejected at .05 significant level.

Table 8.3

Correlation Matrix for the Regression
Equation with the Whole Sample
Ayacucho County, Argentina, 1977

	LK	VK	ID	LW	AE	PE	HE
LK	1						
VK	0.98	1					
ID	0.88	0.89	1				
LW	0.78	0.78	0.74	1			
AE	0.10	0.14	0.08	0.16	1		
PE	0.31	0.38	0.35	0.31	0.14	1	
HE	0.91	0.94	0.87	0.79	0.20	0.37	1

The values of t indicate that the livestock capital, the value of improvements, and the annual pastures have a significant level in the explanation of output. It does not hold for the remaining variables, although the signs of the coefficients are those expected with the exception of permanent pastures. In the case of LW, it must be admitted that using a salary value does not always quantify correctly the real contribution of labor in the generation of the product.

The negative coefficient of the PE variable deserves a separate comment. First, there exist problems in the definition of the variable. Estimation of the actual quality of the perennial pastures is quite arbitrary. The condition of the pastures is based on their age and the opinion of the producer regarding their quality. A second problem is that inadequate management of the pastures by the producer could reduce their potential productivity. Consequently, those producers that use perennial pastures might not necessarily obtain a higher output than the average of all farms.[3]

The level of significance of the elasticity of production of the inputs that make up the estimated model have been statistically tested. The productivity level of the resources is now analyzed economically. The value of the marginal product of each input is evaluated at the level of the geometric mean, and the equi-marginal relationship indicates:

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[3]The 39 farms that use perennial pastures (with or without fertilizers) have an average output of meat per hectare of 93.5 kilograms, while the average output of the sample is 91.2 kilograms. It has been shown utilizing the sample of producers of this study that the economic result of the enterprise, expressed in gross margin per hectare, does not increase proportionately with the increase in the area dedicated to perennial pastures. Therefore, it is not enough to count upon good forage resources; it is also necessary to use them efficiently. See Gardella, E., et al. (1979), p. 8.

$$VMP_{X_j} = B_j \frac{\overline{lg\ TR}}{\overline{lg\ X_j}} = P_j$$

The price of each input (P_j) is given in Appendix C, Table C.3.

Table 8.4 shows for each input the geometric mean, the value of the marginal product, its price, and the equi-marginal relationship. This relationship indicates that the capital in livestock, improvements, annual pastures and the expenses in cattle health are under-utilized with respect to the economic optimum. Meanwhile, land, labor, and perennial pastures (including supplementary feeding) are over used. Perennial pastures show a negative value of the marginal product. Except for the use of annual pastures and perennial ones, the remainder of the quotients do not appear to indicate any major disequilibrium in reaching equi-marginal conditions.

Consequently, the analysis with the whole sample gives as a first indication that an economic optimum could be approximated by increasing investments in livestock and improvements, as well as expenditures in annual pastures and health practices. Surplus labor should be released and area with perennial pastures diminished. Assuming that these changes would increase output, land productivity in the breeding-livestock region should also increase.

8.3 Analysis by Systems of Production

In this section, the production function of each system is estimated and the allocation of the productive resources is analyzed. Subsequently, two levels of efficiency are identified for each system of production and the major characteristics of these groups of farms are discussed in relation to the incorporation of technology.

Table 8.4

Estimated Ratios Between the VMP and the Price of Each Input for the Production Function of the Whole Sample Ayacucho County, Argentina, 1977

Variables	Geometric Mean (Mil pesos)	VMP_{xj}	P_j	VMP_{xj}/P_j
TR	27,690.0	--	--	--
LK	257,400.0	0.023	0.050	0.46
VK	63,050.0	0.215	0.080	2.69
ID	2,350.0	2.473	1.060	2.33
LW	3,291.0	0.577	1.030	0.56
AE	11.6	19.948	1.043	19.13
PE	1.0	-103.937	1.056	-98.43
HE	1,267.0	2.052	1.030	1.99

With respect to the model estimated for the whole sample, the land capital variable, which showed a high coefficient of correlation with the remaining variables excepting pastures, is not included. Capital in improvements and livestock are grouped in one variable. Annual pastures, perennial pastures and supplementary feeding are included under the heading of feeding.[4]

The model estimated for each one of the four systems of production is the following:

$$\lg\hat{TR} = \lg\hat{B}_0 + \hat{B}_1 \lg EK + \hat{B}_2 \lg LW + \hat{B}_3 \lg FC + \hat{B}_4 \lg HE$$

Table 8.5 shows the estimates of the production function for each system. The corresponding t value is included in brackets under each regression coefficient.

Making a comparative analysis of the four estimated equations, it is seen that the variable EK, which represents the "capital" factor, is highly significant in APS_1 and APS_3, while the .05 significant level is not reached in APS_2 and APS_4. This shows statistically the relevance of an "intensive" proportion of factors for increasing the output of the breeding-livestock enterprise. The labor factors does not reach the .05 significant level in any system. In APS_1 the regression coefficient of labor is negative, which indicates that manpower may be over used in the small enterprises.

The estimated coefficient for feeding is negative in APS_1, APS_2 and APS_3, although in no case does it reach .05 significant level. Experimental

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[4]The reduction of the number of variables increases the "power of analysis" of the model. This has been a necessary action in view of the limited degrees of freedom that were available with more disaggregated models. These were tested, but their results were not satisfactory from the technical point of view.

Table 8.5

Estimated Production Functions for Each Actual Production System
Ayacucho County, Argentina, 1977

APS	Estimated Equation	N	$\Sigma\hat{B}_i$	R^{-2}	F
1	$\lg \hat{TR} = 1.8814 + 0.5090 \lg EK - 0.1045 \lg LW - 0.0045 \lg FC + 0.3403 \lg HE$ (2.802)* (-0.656) (-0.467) (2.533)*	22	0.740	0.607	8.355*
2	$\lg \hat{TR} = -0.4549 + 0.4477 \lg EK + 0.1095 \lg LW - 0.0146 \lg FC + 0.5985 \lg HE$ (0.976) (0.483) (-1.473) (2,885)*	14	1.141	0.576	4.644*
3	$\lg \hat{TR} = -1.3744 + 0.7303 \lg EK + 0.1443 \lg LW - 0.0282 \lg FC + 0.3493 \lg HE$ (2.854)* (0.665) (-0.151) (1.722)*	14	1.196	0.934	40.148*
4	$\lg \hat{TR} = -0.3865 + 0.4280 \lg EK + 0.4627 \lg LW + 0.3509 \lg FC - 0.1312 \lg HE$ (0.598) (0.708) (2.031)* (-0.363)	12	1.110	0.834	12.709*

*Null hypothesis rejected at .05 significant level; t value in brackets.

evidence indicates that fattening operations together with improved pastures should increase the output per hectare. On the other hand, the feeding coefficient is positive and reaches .05 significant level in APS_4. It would appear that producers may not have appropriate knowledge of how to realize an adequate management of improved pastures when fattening operations are performed.

The expenses for health are significant at the .05 level and show a positive sign for APS_1, APS_2 and APS_3. On the other hand, this variable takes a negative value, although not significant at the .05 level, in APS_4. Consequently, there is an indication of inadequate management of animal health in large farms dedicated basically to breeding operations.

Finally, it is interesting to note in Table 8.5 the sum of the production elasticities for each system. Evidences of decreasing returns to "size" (land capital was not included in the model) appear in APS_1 which has the smallest firms.

Table 8.6 shows the economic analysis of the allocation of resources in the breeding-livestock production systems. In all cases, increasing the investment of capital, improvements and/or cattle stock is indicated. For the technological inputs different alternatives of use are specified.

Producers using APS_1 should improve the sanitary level of the herd and lower the labor use. This could cause the VMP for feeding to take a positive value. Producers belonging to APS_2 should increase the health level of the herd and maintain the labor employed, since the equi-marginal relationship is very close to unity. The highly negative value taken by the feeding VMP indicated that this system should produce on natural pastures. Farmers using APS_3 should increase labor and intensify the health plan for the herd. This could help the VMP for

Table 8.6

Estimated Ratios Between the VMP and the Price of Each Input in the Production Function of Each Production System Ayacucho County, Argentina, 1977

APS	Variables	Geometric Mean (1,000 pesos)	VMP_{xj}	P_j*	VMP_{xj}/P_j
	TR	12,050.0	--	--	--
	EK	53,690.0	0.114	0.070	1.629
1	LW	2,142.0	-0.588	1.030	-0.571
	FC	69.7	-0.778	1.051	-0.740
	HE	530.5	7.730	1.030	7.505
	TR	24,140.0	--	--	--
	EK	90.950.0	0.119	0.074	1.608
2	LW	3,130.0	0.845	1.030	0.820
	FC	4.7	-74.261	1.054	-70.456
	HE	1,105.0	9.781	1.030	9.496
	TR	48,990.0	--	--	--
	EK	201,900.0	0.177	0.071	2.493
3	LW	4,695.0	1.506	1.030	1.462
	FC	5,473.0	-0.252	1.050	-0.240
	HE	2,372.0	7.214	1.030	7.004
	TR	76,750.0	--	--	--
	EK	264,200.0	0.124	0.074	1.676
4	LW	5,066.0	7.010	1.030	6.806
	FC	8,104.0	3.323	1.044	3.183
	HE	3,526.0	-2.856	1.030	-2.773

*The input price corresponding to EK and FC is adjusted for each production system according with the proportions among capital items entering in the composition of each variable.

feeding to take a positive value without diminishing the use of improved pastures, provided the interaction among inputs allow the meat output to increase. Farmers belonging to APS_4 should increase the quantity of man-equivalents and the use of improved pastures. If these changes increase meat output, the VMP for health expenses could take a positive value.

This analysis assumes maximization of profits under conditions of perfect competition. Thus, the conditions of congruence are not taken into account. Economic recommendations are established in regards to the actual managerial capacity of the producer. This analysis is also restricted to the technological arrangements comprised by each production function. Consequently, requisites of congruence shown by APS_2 and APS_4 can be a constraint for change towards a more intensive proportion of factors as the analysis of the production function is recommended. For APS_2, failure to use pastures and supplementary feeding is indicated given the actual conditions of management for this input. Finally, an increase in the use of improved pastures is suggested for APS_4 under breeding operation.

Differences in Efficiency Within the Production Systems

There is now a differentiation of two levels in the use of the productive resources for each production system. The deviations from the average production function of each system are used to define them.[5] These differences in "efficiency" are tested statistically at the .05

[5]See Chapter IV, pp. 74-75. These residuals are obtained from the linear model with double logarithmic transformation. Therefore, they are the result of the difference between the logarithm of each observation (Y_i) and the logarithm of its estimated value ($\hat{Y}_i$), i.e., $Y_i/\hat{Y}_i = 10^e$; so $\lg (Y_i/\hat{Y}_i) = \lg Y_i - \lg \hat{Y}_i = e$. The positive residuals define an enterprise as efficient, while a negative value corresponds to an inefficient enterprise.

significant level by incorporating in each model a "dummy" variable, which takes a value of one for positive residuals and zero for the negative ones. The size and sign of the corresponding regression coefficients estimate the "jump" between the production function of "efficients" and "inefficients," while the same slope for each input is maintained. The statistical analysis is shown in Table 8.7.

The t values indicate that differences between the constants for "efficiency" are significant in each system of production. Table 8.7 also shows that the difference is lower in APS_3, greater in APS_4, and even greater in APS_2 and APS_1. The ordering of the standard error of Y_i corresponding to each regression equation (before including the dummy variable) shows that the heterogeneity in "efficiency" is greater in the "small" systems than in the "larger" ones.

It could be that the interaction of livestock enterprises with their socio-economic environment may have a greater influence upon the levels of "efficiency" than on the incorporation of new technology as such. The conceptual framework assigns the differences in "efficiency" to the inadequate technical and economic management of the available resources.[6] The management capacity basically depends on the characteristics of the producer as well as on the "know-how" he can obtain from AR and DCs. Producers using APS_1 and APS_2 have the lowest level of education and predisposition, and show an unfavorable interaction with their socio-economic context. Coincidently, these producers have the greatest differences in "efficiency."

[6]See Chapter IV, pp. 74-75.

Table 8.7

Testing Differences in Efficiency
Within Production Systems
Ayacucho County, Argentina, 1977

APS	"Dummy" Variable $\hat{B}_i$	t	$S_{\hat{Y}_i}$
1	0.2003	7.060*	0.1294
2	0.2075	6.797*	0.1313
3	0.1401	4.451*	0.0998
4	0.1854	4.809*	0.1141

*Null hypothesis rejected at .05 significant level.

This analysis concludes by comparing in Table 8.8 some descriptive attributes between the two levels of "efficiency" by production system. Approximately 70 percent of the area with perennial pastures (with and without fertilizers) is used by efficient producers. The efficient producers of APS_4 have 40 percent of the total area with perennial pastures; in APS_3 the same type of producer uses close to 20 percent of this area. However, inefficient producers have close to 60 percent of the fertilized perennial pastures with APS_4 predominant. Within the efficient level, APS_3, producers have the highest percentage of fertilized pastures (25 percent). The management of pastures through the stocking rate (LS/LA) does not show appreciable differences among the production systems.

The global index of adoption (GI) appears to be similar between "efficiency" groups in APS_1 and APS_2. Efficient producers using APS_3 have a higher index than the inefficient ones; the opposite situation is presented in APS_4. For the whole sample, there is no evidence of association between the technical level of farms and "efficiency" levels. In APS_1 and APS_3 the higher percentage of efficient producers practice some degree of fattening, while in APS_2 and APS_4, efficiency is shown on breeding. At the whole sample level, efficient producers practice more fattening than breeding; conversely, the breeding activity is more prevalent among the inefficients.[7]

The differences in meat output between the two groups is four percent in APS_3. This difference is still much greater in the other systems.

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[7]This conclusion agrees with the one reached by Tandeciarz, I. (1971), p. 128.

Table 8.8

Characterization of Two Levels of Efficiency by Production System
Ayacucho County, Argentina, 1977

Level of Efficiency	APS	$PP+PP_f$* (%)	PP_f** (%)	LS/LA	GI	Activity*** (% of Producers)		Meat/LA (kg/ha)	IK/ha (1,000 pesos)	(NR/IK) .100	NR/ha (1,000 pesos)
						B	PW+F				
Efficient	1	4.22	3.42	0.89	4.82	18.18	81.82	91.35	216.4	5.98	12.95
	2	2.07	0.36	0.83	4.13	62.50	37.50	91.37	146.2	14.39	21.03
	3	18.98	24.18	1.05	9.71	14.29	85.71	112.32	191.8	13.71	26.30
	4	42.34	15.74	0.83	6.14	71.43	28.57	95.16	141.3	16.36	23.11
	Sample	67.61	43.69	0.89	5.97	39.39	60.61	98.53	162.8	13.16	21.43
Inefficient	1	2.92	0.00	1.03	4.27	63.64	36.36	78.09	247.4	1.07	2.66
	2	1.68	2.68	0.95	4.83	50.00	50.00	60.43	164.4	5.25	8.64
	3	10.64	18.71	1.08	8.43	42.86	57.14	107.94	250.2	8.62	21.57
	4	17.15	34.92	0.72	8.40	80.00	20.00	66.24	157.9	7.11	11.22
	Sample	32.39	56.31	0.91	6.10	58.62	41.38	79.66	198.3	6.59	13.06

*Percentages obtained over the total of perennial pastures (with or without fertilizers) for the whole sample.

**Percentages obtained over the total of fertilized perennial pastures for the whole sample.

***Percentages obtained over the total of producers of each APS, at the respective efficiency level.

Key: B (breeding); PW+F (post-weaning plus fattening).

For APS_1 the percentage of increase between the output of the efficient group and the inefficient one is 17 percent, in APS_4 it is 44 percent and in APS_2 it is 51 percent. Consequently, taking into account only increases in the level of physical output gains in "efficiency" are greater in breeding production. It could be shown that efficient producers devoted to fattening activities do not achieve a higher production because there is a lack of know-how at the farm level with respect to overall fattening-cattle management, where the management of improved pastures can be a critical constraint. It was seen that the efficient producers realize more fattening than breeding operations; the highest level of fattening (APS_3) shows the highest adoption index and uses the highest percentage of fertilized pastures. However, the level of meat output per hectare for efficient producers using APS_3 is only 18 percent greater than that for efficient producers belonging to APS_4.

The differences between "efficiency" groups in net return per invested capital unit (NR/IK), and net return per hectare (NR/ha) are outstanding. At the present input-output price ratios, the return in invested capital shows that technological heterogeneity appears without dominance in profitability within each level of efficiency when APS_2, APS_3 and APS_4 are compared. At the same time, this comparison appears to show that high levels of "efficiency" obtain a slightly better profitability when an "extensive" proportion of factors is used. (NR/IK corresponding to efficient producers of APS_4 and APS_2 is compared with APS_3.) This situation reinforces the argument that at the present time APS_3 is not a dominant technological alternative in the breeding-livestock region. However, improvements in the know-how of cattle-fattening management should lead efficient producers using APS_3 to obtain profitability levels

at least similar to the efficient level of APS_4. At both levels of "efficiency" APS_1 continued to evidence the restrictions to profitability from small farm size.

In conclusion, the improvement in management of resources can bring an increase in the physical and economic performance of breeding-livestock enterprises.[8] For the whole sample elimination of overall "inefficiencies" can increase physical output by 24 percent, and the net return per hectare by 64 percent. Both measures indicate that efficient producers operate with an average cost that is substantially lower than the inefficients. Inefficient producers have higher levels of invested capital per hectare (IK/ha) than the efficient ones. Having both groups the same technical level, the reorganization and better management of resources, with more fattening and less invested capital would allow inefficient producers to increase their profitability from 6.6 percent to 13.2 percent (Table 8.8).

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[8]These conclusions are conditioned to the assumption that measurement and specification errors, as well as random errors are not significant within the estimated production function residuals. See Chapter IV, pp. 74-75.

CHAPTER IX

SUMMARY AND CONCLUSIONS

9.1 Conceptual and Methodological Aspects

This study analyzes the overall technological configuration of a particular rural region of Argentina as a means to point out the role that agricultural research-extension institutions should play in inducing innovation at the farm level. This study is composed of two parts. The first part covers conceptual aspects for analyzing the incorporation of technology from an institutional point of view, and at the farm level. The second part applies the conceptual framework to a cross section of breeding-livestock enterprises.

Technological information generated by INTA (National Institute for Agricultural Technology), the principal public research-extension institution serving Argentine agriculture, has essentially been based on increasing land productivity. This objective is an overall social goal for Argentina. However, actual patterns of the farmers' demand for new technology are not necessarily compatible with a substantial increase in land productivity. Consequently, technological gaps cannot be ignored in the Argentine agricultural sector, particularly in the breeding-livestock region. These gaps are the difference between the potential production levels generated by INTA and the state of technology at the farm level. Argentine agriculture, specifically in the Pampean Region, has not experienced a consistent and continuing set of monetary, fiscal and technological policies that favored technical change based on a substantial increase in land productivity, which would have closed these technological gaps.

Closer compatibility between the supply and demand for technology rests upon the degree of coordination that can be established among the government, INTA and agricultural producers. Only within this institutional framework is it useful to analyze if higher levels of output can be achieved.

In order to coordinate the activities of these three participants in the process of technological change, a Model of Mutual Causation for the incorporation of innovation in the Argentine agricultural sector has been proposed. This model is built upon the interaction between an application of the Induced Innovation Model to the Argentine case and the Institution Building Model. The first model focuses attention on the execution of a land market-induced treadmill that induces a dynamic adjustment which closes the breach between the socially desired technical path and farmers' demand for technology. This technological treadmill starts to operate when latent patterns of demand that would increase land productivity are satisfied at the farm level. The second model places responsibility on the public research-extension institutions for detecting those latent patterns of demand and for inducing the government to make policies that would enforce the treadmill effect.

The analysis of the generation of technology in the Argentine agricultural sector reveals that INTA, through the Agricultural Research and Development Centers (AR and DCs), is called upon to act as the catalytic element within the Model of Mutual Causation. INTA should provide to the government a technological diagnosis of the different productive regions of the country, indicating the main factors that limit or delay the incorporation of technology. The lack of this strategic information is one of the factors which has prevented the government from taking appropriate political decisions about the technological path to be followed and , consequently, has deprived INTA from knowing whether the existing gaps can be closed or if other technological alternatives should be developed.

The basic objective of the technological diagnosis is to identify groups of farms within a homogeneous ecological region that show a similar behavior in the assimilation of innovations, i.e., the actual production systems. A conceptual framework was developed to identify, characterize and to make a diagnosis of the technological behavior of the agricultural production systems.

For this purpose, four basic conceptual components are used for analysis. Three of them are endogenous to the agricultural enterprise, i.e., the productive structure, the characteristics of the producer and the technological package. The productive structure is characterized by the endowment of production factors (the farm size) and the proportion of factors used, as well as by the ownership patterns of the resources. The utility function, the entrepreneurial capacity and dedication to the farm are used to characterize the producer. The productive structure and the producer characteristics identify an overall structural component. The technological package comprises the technical inputs and the orientation of the production or activity.

The remaining component is exogenous to the enterprise. This instrumental component defines the interaction of farms with their socio-economic context. This interaction is based on the access to financial resources, factors of production and technical information, as well as farmers' relationship with both the input and output markets.

For a given set of input-output prices, the productive structure and the characteristics of the producer indicate in the short run the patterns of needed technology, i.e., the structural demand for innovations. This demand is defined based upon congruence and profitability conditions. Compatibility must exist among the proportion of production factors used and the dedication of the producer to his farm with the factor ratios and the producer's dedication required by the technological package. Among those technical alternatives that show congruence with structural characteristics, the most profitable is demanded by the producer.

However, unavailability of technological know-how or unfavorable interaction of farmers with their socio-economic context can generate latent demand patterns. In this case, the structural demand and the actual demand for technology are no longer equal. The interaction with the rural environment basically satisfies the condition of articulation between the supply and farmers' demand for technology, as well as the adaptability of the technical information to the structural conditions of the farm.

Consequently, agricultural enterprises falling into groups or clusters in regards to the characteristics of the structural component and the technological package represent a particular system of production. Each system will have a specific interaction with the rural socio-economic context, and will show a definite behavior in the assimilation of technology. The congruence, profitability, articulation and adaptability conditions for the actual supply of innovations, and the availability of needed technology will explain the adoption process. As a result, the systems of production, the interaction of farmers with their rural environment and the available technical know-how determine a technological configuration that identifies the factors that limit or delay the adoption process with respect to the prevailing set of economic policies. Differences in the "efficiency" with which the producer carries out the technical and economic management of the productive resources will explain the differences in output among enterprises belonging to the same production system.

For the implementation of the conceptual framework outlined above the following analytical procedure was used:

1) Identification of the actual production systems.

   a) Exploration of the sample: Principal Component Analysis was used to identify those factors which are most meaningful in understanding the incorporation of technology at the farm level.

   b) Classification of agricultural enterprises: Cluster Analysis was applied on the sample to form groups of farms on the basis of their similarities in the dimensions obtained in the exploratory stage.

   c) Characterization of the production systems: the attributes that identify the productive structure, the producer characteristics, the technological package, and the interaction of farmers with their socio-economic context were used to describe the systems of production. Comparisons between means brought about the most important dissimilarities among the systems.

2) Technological diagnosis.

   A comparative analysis among production systems was developed linking the results of the characterization stage with physical and economic indicators of performance. The tests of hypothesis that comprises this diagnosis are based on the use of Contingency Tables and the Kruskal-Wallis test. The conditions of congruence and profitability for the adoption of technology, and the interaction of farmers with their rural environment were analyzed. The main factors that limit or delay the incorporation of innovations in the production systems were explored, and the perspectives on technical change in the study area discussed.

3) Analysis of resource allocation.

Production functions were estimated for the whole sample and each system of production using the Cobb-Douglas model. Attention was focused on the heterogeneity in "efficiency" within each production system.[1]

The coexistence of different production systems within a homogeneous ecological area means there are different production functions, i.e., technological heterogeneity. Technological heterogeneity based on differences in structural components and input packages could be associated with the absence of dominance in profitability among the existing production functions. In this case, structural characteristics could be the principal factor affecting the incorporation of new technology for the prevailing set of economic policies. Homogeneity in technical inputs but dissimilarities in structural characteristics, when technological dominance is not the case, could indicate that instrumental conditions or lack of needed technology are limiting factors in the adoption process.

A new set of "relative" input-output prices could cause a particular technological arrangement to have dominance in profitability under the prevailing structural conditions. It is also possible that the absence of

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[1]Overall efficiency (technical and price efficiency) is measured by the stochastic residuals of the production function estimated for each system of production. Conclusions upon efficiency are valid if measurement and specification errors, as well as random errors, are not significant.

dominance in profitability might continue under different sets of relative input-output prices. Each situation could require different policy measures for inducing the incorporation of technology.

The technological diagnosis would supply the needed information for improving the performance of the process of technical change. However, an explicit political decision about the conditions and degree of achievement of social goals is a "sine-qua-non" to make the supply and demand for technology compatible.

If actual demands for technology are not compatible with the socially desired technological path, the government could use policy measures to induce technology demands congruent with the social goal. The identification of the limiting factors for adoption within the structural or instrumental component, or in the supply of technology will indicate the most suitable policies for technical change. If increasing land productivity is the goal, INTA should generate technological packages that comprise intensive land-saving/yield-increasing innovations, adapted to farm conditions for the new set of policies. If the governmental decision does not change the prevailing set of policies, the main objective of INTA should be to satisfy the actual demand for technology and to detect latent demands. In that case, the technological treadmill could be activated which would produce a more socially desired situation in the long run.

9.2 Incorporation of Technology in the Breeding-Livestock Region

The conceptual framework for the analysis of the incorporation of technology in the actual production systems, and the corresponding analytical procedure were applied to a sample of 62 producers in Ayacucho County, Province of Buenos Aires, Argentina. This case study was intended to contribute in the generation of information that could help INTA to act as a catalytic force for technological change according with the postulates of the Model of Mutual Causation for the incorporation of innovations in the Argentine agricultural sector.

Ayacucho County is located in the Basin of the Río Salado within the "Pampa Deprimida Bonaerense" which is the most important region dedicated to the breeding-livestock production. In the Río Salado Basin, 60 percent of the total area is dedicated exclusively to cattle, whereas 35 percent includes crops. Among the activities devoted to cattle, the most important is that of cattle-breeding in open fields, while to a lesser degree, post-weaning production is also practiced together with fattening.

Ayacucho County was chosen as the study area because it is representative of the rest of the region in land use and structure of production. Moreover, there is ample information available from economic analyses conducted in the last decade whose main conclusions in regards to technology were also reviewed. This study concentrates exclusively on livestock production.

The exploration with Principal Component Analysis brought about two relevant dimensions regarding the incorporation of technology in breeding-livestock enterprises, the farm size dimension and the intensity of land use dimension. The farm size dimension relates to the incorporation of technical inputs (excluding the type of activity), the propensity to incorporate technology and the level of education of the producer. It is also related to a favorable interaction of farmers with their socio-economic context, based essentially on technical assistance. The intensity in land use dimension is associated with the practice of post-weaning production and fattening, the predisposition to obtain technical information and the time devoted to the farm. It is also associated with the availability of "own funds" for capital investment and incorporation of improved pastures.

The structural features dominate in the explanation of the variance associated with the most important principal components. The instrumental component explains the lowest proportion of this variance.

Applying a clustering procedure using the two dimensions isolated in the exploratory stage, four groups of enterprises were identified. The actual production systems (APS) that represent these groups of farms can be characterized as follows:

APS_1: Small size (300 hectares) - Family farm - Intensive proportion of factors - Low predisposition to technical changes - High dedication - Unfavorable interaction with the rural context - Medium-low technical level - Long post-weaning activity.

APS_2: Medium-small size (700 hectares) - Median salaried relationship - Extensive proportion of factors - Low predisposition to technical changes - Low dedication - Unfavorable interaction with the rural context - Low technological level - Short post-weaning activity.

APS_3: Medium-large size (1200 hectares) - High salaried relationship - Intensive proportion of factors - High predisposition to technical changes - High dedication - Favorable interaction with the rural context - High technological level - Fattening activity.

APS_4: Large size (2300 hectares) - High salaried relationship - Extensive proportion of factors - High predisposition to technical changes - Low dedication - Favorable interaction with the rural context - Medium-high technological level - Breeding activity.

Farms in APS_3 have the highest level of technology in the sample (adoption index: 9.1). This system contains 88 percent of the enterprises that practice fattening. Farms belonging to APS_4 have an adoption index equal to 7.1 which is 44 percent of the highest attainable level. In this system 75 percent of the farms are dedicated to cattle-breeding. The other two systems have a low index of adoption, APS_1: 4.6 and APS_2: 4.4. However, APS_1 used a higher percentage of perennial pastures than APS_2. At the same time, 60 percent of the farms using APS_1 are dedicated to post-weaning operation, meanwhile this percentage is close to 43 percent in APS_2.

The highest level in land productivity (110.4 kilos of meat per hectare) is obtained using an intensive proportion of factors, with high dedication of the producer and devoting to fattening operations (APS_3). However, output per hectare for APS_3 is lower than obtained by INTA. The adoption index for APS_3 is 60 percent of the maximum theoretical level. The analysis of land productivity by system of production also shows that the package of new technology (basically health and management practices together with improved pastures) does not increase farm production unless it is associated with an intensive proportion of factors and the practice of cattle fattening. Long post-weaning production does not generate an appreciable increase in output per hectare unless new technical inputs are incorporated.

Intensive factor proportions and high producer dedication are related to fattening operations (APS_3 and APS_1). Extensive proportion of factors and low producer dedication are associated with breeding activities (APS_4 and APS_2). Consequently, the proportion of factors and dedication of the producer to his farm appear to establish a condition of congruence for the choice of the type of activity. Within the intensive and the extensive productive processes, the presence of different technical levels could be related to farm size, the predisposition of the producer to technical change and to his interaction with the rural environment. However, restrictions imposed by economies of scale in the case of APS_1 (the smallest sized system), and profitability for APS_2, APS_3 and APS_4 appear to be the basic conditions for technological heterogeneity in the study area.

The economies of size define a critical level of economic capacity for the incorporation of technology. All the systems except APS_1 are able to cover their overall costs of production, when the land rent is not included. APS_2, APS_3 and APS_4 are able to generate normal profits while livestock production is unprofitable for APS_1. APS_1 compensates for this situation by using 12 percent of its useful area for crops and the use of family labor.

There is not technological dominance in the study area. Differences in profitability among APS_2, APS_3 and APS_4 are not statistically significant at the .05 level. APS_3 shows the highest land productivity, however, marginal investment for APS_4 to shift toward APS_3 is not profitable. The profitability of marginal investment does not appear sufficient to induce a change in the APS_2 producer.

An extensive mode of production, with the size of APS_4, together with a relatively high use of technical inputs and the practice of breeding, is economically rational given the market conditions prevailing in the period analyzed. This production scheme is seen to be compatible with a producer predisposed to technical change but who spends little time on his farm. At the same time, APS_3 with intensive use of land, with a producer predisposed to incorporate technology and with a full dedication to the farm, fattening appears as the most congruent and profitable alternative. The "type of producer" could be in APS_2 a limiting factor for choosing more intensive technological arrangements.

Each system of production is associated with a particular type of interaction with the rural context. The ordering from a more to less favorable interaction is: APS_3, APS_4, APS_2 and APS_1. This interaction essentially satisfies the conditions of articulation and adaptability between the supply and demand for technology. However, the interaction with the environment is not a basic factor limiting the incorporation of innovations in livestock production. The unfavorable interaction shown by smaller producers may originate at the farm level, i.e., the low economic capacity of APS_1, and the "conservatism" of the APS_2 producer could generate a lack of "incentive" to interact with the rural socio-economic context.

Heterogeneity of techniques is sufficient to postulate that each system of production has a specific behavior in the incorporation of technology. Moreover, the absence of dominance in profitability among their technological arrangements shows, for the prevailing market conditions, that the productive structure is the basic factor affecting such behavior. Therefore, the systems of breeding-livestock production seem to be in a stable equilibrium based on congruence and profitability conditions.

The importance of the structural component provides evidence of the absence of latent demand patterns for the "actual" supply of technology. Technological dominance is absent in the actual supply of innovations.

Data comparisons between 1968 and 1977 show there has not been substantial change in the situation of production of the breeding-livestock region. Yield of meat per hectare for the whole sample changed from 80.1 to 91.2

kilos in the period 1968 to 1977. The percentage of natural pastures over the livestock area has practically not changed. The average adoption index has increased from 3.05 to 3.68 for a maximum theoretical level equal to 11.0.[2]

Under the actual economic policies, structural conditions, and technical know-how already available at the farm level, there appears to be no reason to expect any significant change in the state of technology of the breeding-livestock production systems.

The production function analysis with the whole sample indicates that an economic optimum requires increased investments in livestock and improvements, as well as expenditures in annual pastures and health practices. Labor use and perennial pastures should be reduced. It appears that inadequate management of perennial pastures may be reducing their productivity. If the proposed changes increase output, land productivity in the breeding-livestock region should also increase.

For the whole sample, the elimination of overall "inefficiencies" can increase physical output by 24 percent and the net return per hectare by 64 percent. Having "efficient" and "inefficient" producers at similar technical levels, the reorganization and better management of resources with a greater degree of fattening would lead "inefficient" producers to increase the net return per invested capital unit from 6.6 percent to 13.2 percent, while reducing the intensity of capital use.

The analysis of resource allocation in each system of production shows that producers may not have appropriate knowledge of management

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[2]The Obschatko's adoption index is used as a basis for comparison.

of improved pastures when fattening operations are performed. There is also an indication of inadequate management of animal health on large farms devoted basically to breeding operations.

Differences in "efficiency" are statistically significant for each system of production. However, the heterogeneity in efficiency is greater in the "smaller" systems than in the "larger" ones. Coincidently, smaller producers have less favorable interaction with their rural environment. It could be that this interaction may have a greater influence upon the levels of "efficiency" than on the incorporation of new technology as such.

There is no association between "efficiency" and the adoption of technical inputs. However, there is association between "efficiency" and the degree of fattening.

At the prevailing input-output price ratios, technological heterogeneity appears without dominance in profitability within each level of "efficiency" for APS_2, APS_3 and APS_4. However, high levels of "efficiency" achieve a slightly higher profitability when an "extensive" proportion of factors is used. It is evident that for the actual know-how at the farm level, the fattening alternative is not a dominant technique in the breeding-livestock region.

The removal of inefficiencies depends on the incorporation of technical and economic managerial knowledge. The transfer of this knowledge in accordance with the structural conditions of each major system of production should be one of INTA's main objectives. Moreover, attention should be focused on smaller producers who use production systems that show the greatest difference in overall "efficiency."

Under prevailing conditions of the breeding-livestock production region, extension activities could have a greater gain working on "efficiency" than trying to change technology. This gain should increase land productivity and accelerate the land-market induced treadmill. However, improvements in "efficiency" have, at the sample level, a maximum meat output per hectare of 140 kilograms. Any increase in land productivity beyond that level must consider the conditions of congruence and profitability. The modification of these conditions depend on policies measures directed to farmers or to research-extension activities.

9.3 Technological Policy Implications

The social demand for technology requires a substantial increase in land productivity in the breeding-livestock region. A clear definition of government technological policy, both at the farm level and for research-extension institutions, is a "sine-qua-non" for achieving this objective.

Government can elaborate monetary and fiscal policies that would induce extensive production units to opt for more intensive technological arrangements. Price and credit policy should be directed to creating incentives on "key" land-saving/yield-increasing inputs. Fiscal alternatives could also be used to induce an increase in land productivity. Under this policy alternative, the know-how available at INTA for fattening their own cattle production on fertilized perennial pastures could be an appropriate reference point to develop a suitable land-saving/yield-increasing technological package for breeding-livestock production systems. With the new set of policies this intensive land use package could reach dominance in profitability among the actual technological arrangements.

Alternatively, the political decision could maintain the traditional set of monetary and fiscal policies. In this case, technological policies should be directed to make available at the farm level more congruent and profitable techniques for the specific structural characteristics of each major system of production. This alternative approach to technological change probably would not reach the potential level of output per hectare demanded by social goals, but it could lead to a higher production than the present one. To concentrate exclusively on the generation and transfer of technology which might be the most consistent with the social demand could lead to a low level of adoption in the actual breeding-livestock production systems.

Under the traditional set of agricultural policies latent structural demand patterns could exist for innovations not already available in research centers. The actual supply of innovations may be the base for generating a technological package that could have a greater degree of adaptability for farms using APS_3. Nevertheless, APS_2 and APS_4 demand alternatives that are not precisely defined in the actual supply. This means the research sector must search for a technological package that increases output per hectare, while generating a higher profitability with an "extensive" proportion of factors. In this case, the discussion of the increase in the output of natural pastures becomes more important. Agricultural research has generated for breeding-livestock enterprises a technological package based on the use of fertilized perennial pastures. However, little was done to find complementary alternatives for natural pastures. In the case of APS_1 its productive structure restricts the generation of techniques that would be incorporated to a package of very low cost innovations.

Under the two alternative lines of policies already analyzed, a more favorable input-output price relationship for the producer would provide a general economic incentive for the adoption of new technology. Reducing the extent of the cattle price cycle would induce technological change. However, these price policies are not by themselves adequate tools to change the actual technological heterogeneity at the farm level. This situation requires economic policies that modify the actual cost structure of breeding-livestock enterprises inducing an increase in output per hectare. As a long run term policy the search for technological dominance should be encouraged for research activity.

A political decision of government should define the degree in which divergences between private and social returns in the process of technical change of the breeding-livestock region ought to be closed. As a result, INTA should be able to set up priorities in the planning of research and extension activities according with the structural characteristics of the production systems and market conditions. This coordination should improve the compatibility between the supply and demand for technology, and the social performance of the technological process.

The implementation of the approach developed in this study for the catalytic action of INTA in the process of technical change could be enforced by the creation in the different regional research centers of a Department of Technological Development. A multi-disciplinarian structure and the systems approach should predominate in this work group. This department should define an integrated plan of activities with the transfer sector, the Department of Agricultural Economics, as well as with the work group that makes the programming and evaluation of research-extension activities.

9.4 Limitations and Suggestions for Further Research

The number of observations available and the small variation of the sample were the basic limitations of this study. The lack of degree of freedom made it necessary to aggregate variables when production functions were estimated for each system of production.

The use of indexes for producer characteristics and instrumental variables could lead to ambiguities and errors in the measure of specific aspects. Consequently, more suitable measurement tools should be developed for qualitative variables.

The interpretation of principal component analysis was subject to the presence of bipolarity. Further data processing could have clarified the interpretation of principal components. Validation of farms classification could have been improved analyzing the stability of the clusters obtained.

The main aim of this study was to offer INTA a "pilot experience" for elaborating at the regional level the overall picture of the actual technological situation. In this regard, the conceptual framework and analytical procedures are more important than the conclusions. The simultaneous development of the present approach on different ecological homogeneous areas will facilitate comparisons of how the structural, instrumental and technological components become predominant in the explanation of the production phenomena, helping to adjust the methodology proposed.

The analysis of technological heterogeneity could be improved if a classification scheme is developed for the association among the structural, instrumental and technological components for different policies alternatives. It should be further analyzed how dominance or non-dominance in profitability for different input-output price ratios develop.

This study should also be expanded in its dynamic aspect. Different points in time should be estimated following the development of the cattle prices-cycle, as well as credit and tax conditions. The information gathered would allow measurement of the technical change and estimation of the rate of adoption of innovations in regards to changes in economic policies.

On the conceptual side, the utility function of the producer merits a specific study. The interaction between economic pressure, risk aversion and congruence should be analyzed in relation to the maximization of profits. On the empirical side, this study brought forth two relevant issues. First, the management conditions of improved pastures should be investigated for fattening operations. Moreover, general conditions of fattening production at the farm level should be evaluated. Second, a socio-economic study of the small producer situation is required. This study should come before any technological recommendation.

APPENDICES

APPENDIX A

PRINCIPAL COMPONENT ANALYSIS

Table A.1

Correlation Matrix
Ayacucho County, Argentina, 1977

Conceptual Component	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1. LA	1																						
	2. TLs/TL	0.55*	1																					
Productive	3. LS/LL	0.48	0.49*	1																				
	4. LL/LA	-0.39*	-0.20	0.64*	1																			
Structure	5. LS/LA	-0.22	-0.08	-0.19	0.30*	1																		
	6. ID/LS	-0.47*	-0.33*	-0.56*	0.44*	-0.12	1																	
	7. ID/LL	0.01	0.18	0.58*	-0.48*	-0.27*	0.23	1																
	8. ID/LA	-0.54*	-0.31*	-0.57*	0.63*	0.34*	0.06*	0.12	1															
Producer	9. Objective	0.33*	0.43	0.20	-0.02	-0.07	-0.04	0.15	-0.05	1														
	10. Age	-0.18	-0.04	-0.11	0.02	-0.24	0.02	-0.11	-0.13	-0.08	1													
Charac-	11. Education	0.34*	0.51*	0.30*	-0.23	-0.03	-0.27*	0.14	-0.23	0.36*	-0.34*	1												
	12. Predisposition	0.20	0.12	0.15	0.05	0.10	0.02	0.14	0.08	0.37*	-0.28*	0.34*	1											
teristics	13. Dedication	-0.25*	-0.45*	-0.45*	0.32*	0.35*	0.11	-0.44*	0.22	-0.19	0.04	-0.44*	0.07	1										
Instru-	14. Information	0.18	0.24	0.14	-0.06	0.21	-0.16	0.00	-0.11	0.19	-0.06	0.15	0.17	0.18	1									
	15. Assessment	0.33*	0.38*	0.27*	-0.20	-0.04	-0.29*	0.03	-0.28*	0.34*	-0.13	0.36*	0.33*	-0.20	0.24	1								
mental	16. Own Funds	0.19	0.31*	-0.09	0.26*	0.16	0.00	-0.12	0.05	0.52*	-0.08	0.20	0.28*	0.19	0.27*	0.29*	1							
	17. Access to Credit	0.01	0.07	0.02	0.16	0.13	0.00	0.04	0.15	0.30*	-0.05	0.07	0.08	0.05	0.03	0.10	0.04	1						
Component	18. Credit Use	0.06	0.21	0.27*	-0.14	0.04	0.03	0.31*	0.02	0.25*	0.08	0.18	0.25*	-0.15	0.22	0.35*	-0.01	0.48*	1					
Tech-	19. Activity	0.04	0.05	-0.14	0.15	0.35*	0.00	-0.08	0.15	0.25*	0.17	-0.10	0.03	0.31*	0.35*	-0.08	0.25*	0.13	0.04	1				
	20. Feeding	0.27*	0.31*	0.15	0.02	0.17	-0.16	0.00	-0.07	0.35*	0.07	0.11	0.27*	0.11	0.26*	0.17	0.42*	0.18	0.09	0.34*	1			
nological	21. Health	0.25*	0.40*	0.14	-0.12	0.04	-0.08	0.13	-0.05	0.25*	-0.20	0.48*	0.21	-0.16	0.12	0.27*	0.31*	-0.05	-0.04	-0.05	0.33*	1		
	22. Genetics	0.25*	0.24	0.16	-0.13	0.18	-0.23	-0.03	-0.16	0.18	-0.01	0.27*	0.23	0.02	0.21	0.32*	0.27*	-0.01	0.26	0.28*	0.14	0.07	1	
Package	23. Cattle Management	0.22	0.45*	0.22	-0.25*	0.07	0.01	0.35*	0.03	0.45*	0.19	0.50*	0.38*	-0.23	0.38*	0.46*	0.31*	0.00	0.28*	0.04	0.37*	0.57*	0.16	1

Note: An asterisk indicates a level of significance of five percent.

Table A.2

Principal Component Analysis with the Technological Inputs
Ayacucho County, Argentina, 1977

Variables	Correlation 1st Ppal. Component	2nd Ppal. Component	3rd Ppal. Component
1. Feeding	-0.685	0.028	0.728
2. Health	-0.800	-0.273	-0.303
3. Genetics	-0.316	0.936	-0.142
4. Cattle Management	-0.836	-0.116	-0.252
Eigenvalues	1.907	0.964	0.705
Percentage of Total Variance	47.68	24.10	17.63
Cumulative % of Total Variance	47.68	71.78	89.41

Table A.3

Principal Component Analysis with the Technological Package
Ayacucho County, Argentina, 1977

Variable	Correlation		
	1st Ppal. Component	2nd Ppal. Component	3rd Ppal. Component
1. Activity	-0.375	0.773	0.292
2. Feeding	-0.736	0.167	-0.455
3. Health	-0.722	-0.492	0.078
4. Genetics	-0.397	0.539	0.719
5. Cattle Management	-0.782	-0.350	0.131
Eigenvalues	1.972	1.282	0.832
Percentage of Total Variance	39.44	25.64	16.64
Cumulative % of Total Variance	39.44	65.08	81.72

Table A.4

Principal Component Analysis with the Instrumental Criteria Ayacucho County, Argentina, 1977

Variables	Correlation		
	1st Ppal. Component	2nd Ppal. Component	3rd Ppal. Component
1. Information	-0.554	0.459	-0.241
2. Assessment	-0.679	0.232	-0.348
3. Own Funds	-0.405	0.656	0.592
4. Credit Access	-0.564	-0.597	0.463
5. Credit Use	-0.756	-0.450	-0.175
Eigenvalues	1.822	1.254	0.775
Percentages of Total Variance	36.44	25.08	15.50
Cumulative % of Total Variance	36.44	61.52	77.02

APPENDIX B

CHARACTERIZATION OF THE ACTUAL PRODUCTION SYSTEMS

Table B.1

Range and Standard Deviation of Variables Used
in the Characterization of Actual Production Systems
Ayacucho County, Argentina, 1977

	APS_1			APS_2			APS_3			APS_4			Whole Sample		
Variables	Low	High	St. Dv.	Low	High	St. Dv.	Low	High	St. Dv.	Low	High	St. Dv.	Low	High	St. Dv.
LA	154.00	651.75	154.25	427.67	1,223.00	232.33	297.00	2,881.00	837.54	633.67	4,523.20	1,257.50	154.00	4,523.20	995.39
TLs/TL	0.000	0.748	0.245	0.074	1.000	0.272	0.034	1.000	0.264	0.587	1.000	0.143	0.000	1.000	0.351
LS/LL	0.781	3.032	0.605	1.286	4.670	0.995	1.130	4.558	1.022	2.102	5.264	1.033	0.781	5.264	1.231
LL/LA	0.295	1.842	0.378	0.175	0.550	0.127	0.260	1.146	0.234	0.146	0.866	0.191	0.146	1.842	0.332
LS/LA	0.635	1.631	0.259	0.700	1.141	0.135	0.720	1.425	0.188	0.621	1.057	0.144	0.621	1.631	0.230
ID/LS	2,379.00	9,238.30	1,874.00	1,922.50	5,181.60	864.09	1,502.90	9,006.50	1,915.70	1,923.20	4,814.60	957.82	1,502.90	9,238.30	4,282.70
ID/LL	3,680.10	20,030.00	3,934.00	3,326.60	20,549.00	4,603.00	4,471.10	2,533.70	5,929.90	6,852.90	16,418.00	2,841.60	3,326.60	25,337.00	4,505.00
ID/LA	2,732.00	9,407.00	1,663.40	1,830.70	4,020.40	660.09	2,141.60	8,039.10	1,713.00	1,548.60	3,212.00	545.61	1,548.60	9,407.90	1,810.80
Objective	0.000	1.000	0.294	0.000	1.000	0.363	0.000	1.000	0.426	0.000	1.000	0.492	0.000	1.000	0.487
Age	24.00	76.00	13.95	33.00	71.00	11.61	25.00	65.00	13.62	26.00	62.00	11.40	24.00	76.00	12.95
Instruction	1.000	6.000	1.140	2.000	6.000	1.499	2.000	6.000	1.311	2.000	6.000	1.084	1.000	6.000	1.552
Predisposition	0.000	11.000	3.647	0.000	10.000	4.084	5.000	11.000	2.129	2.000	11.000	2.539	0.000	11.000	3.497
Dedication	6.000	20.000	3.745	1.000	20.000	5.919	7.000	20.000	5.048	1.000	18.000	4.638	1.000	20.000	5.573
Information	1.000	10.000	2.423	0.000	14.000	3.490	2.000	18.000	5.129	1.000	10.000	3.137	0.000	18.000	3.740
Assessment	0.000	5.000	1.703	0.000	4.000	1.151	0.000	9.000	2.433	1.000	7.000	2.103	0.000	9.000	2.231
Own Funds	0.000	7.000	2.550	1.000	5.000	1.311	4.000	22.000	5.271	0.000	8.000	2.623	0.000	22.000	4.313
Credit Access	0.000	3.000	1.283	0.000	3.000	1.492	0.000	3.000	1.069	0.000	3.000	1.337	0.000	3.000	1.274
Credit Use	0.000	9.000	2.363	0.000	4.000	1.232	0.000	15.000	4.521	0.000	11.000	4.033	0.000	15.000	3.212
Activity	1.000	2.000	0.503	1.000	2.000	0.514	1.000	3.000	0.893	1.000	3.000	0.651	1.000	3.000	0.704
AP/LA	0.000	0.296	0.079	0.000	0.184	0.057	0.000	0.335	0.102	0.000	0.196	0.072	0.000	0.330	0.080
PP/LA	0.000	0.334	0.112	0.000	0.125	0.043	0.000	0.356	0.095	0.000	0.594	0.195	0.000	0.590	0.120
PP_f/LA	0.000	0.273	0.068	0.000	0.153	0.041	0.000	0.741	0.221	0.000	0.372	0.123	0.000	0.740	0.130
FI	0.000	4.000	1.177	0.000	3.000	0.929	1.000	5.000	1.038	1.000	3.000	0.739	0.000	5.000	1.166
HI	1.000	4.000	0.959	2.000	4.000	0.756	2.000	5.000	1.089	2.000	5.000	1.004	1.000	5.000	1.082
GG	0.000	1.000	0.294	0.000	2.000	0.579	0.000	2.000	0.650	0.000	2.000	0.651	0.000	2.000	0.541
MI	0.000	2.000	0.666	0.000	1.000	0.469	0.000	4.000	1.177	0.000	3.000	0.779	0.000	4.000	1.045
GI	1.000	9.000	2.241	2.000	7.000	1.399	6.000	13.000	2.235	4.000	10.000	1.677	1.000	13.000	2.728
Meat/ha	50.34	134.70	24.48	47.87	115.27	20.26	76.11	137.45	18.97	55.73	136.48	27.41	47.87	137.45	25.13
NR/ha	-5,703.60	36,733.00	11,311.00	3,733.50	32,370.00	7,880.80	-500.33	34,718.00	11,702.00	-423.95	32,112.00	11,052.00	-5,703.60	26,733.00	11,255.00
NR/IK .100	-5.20	19.70	6.38	1.68	21.73	6.22	0.14	19.08	6.14	-0.40	21.30	7.10	-5.20	21.73	7.02
NR/TK .100	-1.12	6.26	2.03	0.60	5.90	1.48	-0.07	5.87	1.95	-0.08	5.76	1.96	-1.12	6.26	2.02
RE/ha	-39,529.00	23,105.00	15,592.00	-11,950.00	20,833.00	9,065.50	-25,554.00	20,571.00	14,639.00	-8,773.00	20,022.00	10,406.00	-39,529.00	23,105.00	14,380.00

Table B.2

Test for the Difference Between Pair of Means of the Variables That Characterize the Actual Production Systems (Table 6.8), Ayacucho County, Argentina, 1977

Conceptual Components	Variables	"t" Value					
		2-1	3-1	4-1	3-2	4-2	4-3
Productive Structure	1. LA	5.70	4.00	5.47	2.17	4.32	2.56
	2. TLs/TL	3.23	5.45	8.70	1.86	3.44	1.20
	3. LS/LL	4.28	3.05	6.84	-0.90	2.40	3.22
	4. LL/LA	-3.83	-2.07	-4.57	1.74	-1.71	-2.81
	5. LS/LA	-1.00	1.53	-2.21	2.93	-1.58	-4.10
	6. ID/LS	-3.74	-3.09	-5.05	0.85	-2.02	-2.07
	7. ID/LL	1.17	0.96	1.92	-0.01	0.35	0.30
	8. ID/LA	-4.67	-0.43	-7.01	2.25	-3.67	-4.07
Producer Charac-teristics	9. Objective	0.45	5.36	3.71	4.30	3.05	-0.65
	10. Age	-0.02	-1.31	-1.33	-1.27	-1.29	0.04
	11. Education	3.12	4.76	5.65	1.07	1.53	0.44
	12. Predisposition	0.08	2.85	2.25	2.14	1.74	-0.38
	13. Dedication	-2.40	-1.30	-5.02	1.06	-1.91	-3.18
Tech-nological Package	14. Activity	-0.92	2.37	-1.20	2.83	-0.43	-2.90
	15. Feeding	-0.79	3.64	1.09	4.41	1.96	-2.86
	16. Health	0.56	3.26	2.70	2.82	2.42	-0.35
	17. Genetic	0.72	2.22	1.21	1.25	0.49	-0.66
	18. Cattle Management	0.63	4.60	3.46	5.05	4.04	-1.73
Instru-mental Component	19. Information	0.36	2.45	0.81	1.83	0.35	-1.67
	20. Assessment	-0.65	1.85	-6.08	2.38	5.10	1.98
	21. Own Funds	0.32	4.87	0.89	4.93	0.74	-4.08
	22. Credit Access	-0.29	0.38	0.06	0.59	0.31	-0.25
	23. Credit Use	-1.13	0.79	1.26	1.37	1.88	0.33

Table B.3

Variables Used to Define Relationships That
Characterize the Productive Structure
Ayacucho County, Argentina, 1977
(Average Values)

APS	TL (ME)*	TLs (ME)	LL (ME)	LS (AU)**	ID (1,000 pesos)
1	2.05	0.63	1.99	284.46	1,435.45
2	2.32	1.38	2.29	617.24	2,050.39
3	5.61	4.40	5.44	1,278.74	4,858.90
4	5.24	4.62	4.99	1,822.26	4,724.44
Whole Sample	3.54	2.42	3.42	881.76	2,983.92

*ME: man-equivalent.
**AU: animal unit.

Table B.4

Rates of Adoption for Feeding Practices
Ayacucho County, Argentina, 1977

APS	Number of Producers	AP		PP (Total)*		PP_f		FR		MS	
		No	%	No	%	No	%	No	%	No	%
1	22	16	72.72	12	54.55	4	18.18	3	13.64	4	18.18
2	14	12	85.71	5	35.71	2	14.29	0	0.00	1	14.00
3	14	13	92.86	12	85.71	8	57.14	9	64.29	4	28.57
4	12	9	75.00	10	83.33	5	41.67	3	25.00	1	8.33
Whole Sample	62	50	80.64	39	62.90	19	30.65	15	24.19	10	16.13

*It means with or without fertilizer.

Table B.5

Rates of Adoption for Health Practices
Ayacucho County, Argentina, 1977

APS	Number of Producers	AV		BV		BR		PC		VD	
		No	%	No	%	No	%	No	%	No	%
1	22	22	100.0	7	31.82	5	22.73	17	77.27	2	9.09
2	14	14	100.0	5	35.71	3	21.43	14	100.0	0	0.00
3	14	14	100.0	12	85.71	7	50.00	12	85.71	5	35.71
4	12	12	100.0	9	75.00	5	41.67	12	100.0	3	25.00
Whole Sample	62	62	100.0	33	53.23	20	32.26	55	88.71	10	16.13

Table B.6

Rates of Adoption for Genetic Improvements and
Cattle Management Practices
Ayacucho County, Argentina, 1977

		Genetic Improvement				Cattle Management							
	Number of	SE		CB		PT		SS		AW		AI	
APS	Producers	No	%	No	%	No	%	No	%	No	%	No	%
1	22	0	0.00	2	9.09	4	18.18	4	18.18	0	0.00	1	4.55
2	14	1	7.14	2	14.29	3	21.43	0	0.00	1	7.14	0	0.00
3	14	4	28.57	3	21.43	12	85.71	5	35.71	8	57.14	3	21.43
4	12	2	16.67	2	16.67	11	91.67	2	16.67	3	25.00	0	0.00
Whole Sample	62	7	11.29	9	14.52	30	48.39	11	17.74	12	19.35	4	6.45

APPENDIX C

INPUT-OUTPUT PRICES AND ECONOMIC INDICATORS

Table C.1

Output Prices

Item	Category	Current Price (78) per Category	Average (69-78), Deflated (78=100) Price per Category	Average, Deflated, Net Price per Item*
		(Pesos/kilo)	(Pesos/kilo)	(Pesos/kilo)
Cattle	Grown Steer	371.11	511.82	
	Half-Grown Steer	354.85	510.84	
	Heifer	330.94	481.37	438.85
	Cow	240.29	350.02	
	Weaned Calf	349.39	515.77	
	Bull	278.34	417.80	
		(Pesos/head)	(Pesos/head)	(Pesos/kilo)
Sheep	Lamb	13,781.77	14,239.56	
	Mutton	13,517.07	16,421.40	343.29
	Ewe	10,802.67	13,596.92	
	Ram	14,621,67	17,642,46	
		(Pesos/10 kilos)	(Pesos/10 kilos)	
Wool (Fleece)	Thin	15,125.48	17,205.28	-----
	Thin-Cross	13,011.37	15,851.49	-----
	Medium-Cross	17,286.59	17,911.98	-----
	Thick-Cross	15,450.00	15,388.77	-----

Basic Source of Data:
- Consumer Price Index: Gonzalez, C. and Razquín, A. (1979).
- Current Prices:
  - Ministerio de Economía - Junta Nacional de Granos (1976).
  - Ministerio de Economía - Junta Nacional de Carnes (1979).
  - Ministerio de Economía - Instituto Nacional de Estadísticas y Censos (1979).

*The method for calculating this price is presented on the next page.

Method for Calculating Net Prices in Table C.1

Cattle Meat Price

The total kilos of meat sold by category are obtained for each enterprise. The percentage corresponding to each category with respect to the total kilos sold is calculated. The sum of the product between the price of each category and the respective percentage define a single beef price for the whole sample. The price of each category corresponds to an average of the current price per kilo during 1969 to 1978 in the Liniers cattle market, adjusted by the consumer price index (1978=100). From the price of each category is discounted the freight cost to the market; the remainder of the selling costs are calculated at the level of the production costs.

Sheep Meat Price

The price used for each category corresponds to an average of the current price per head during 1969 to 1978 in the Avellaneda market, adjusted by the consumer price index (1978=100). Selling costs are included in the costs of production. To obtain a single price per kilo of sheep meat, the price of each category is divided by the average selling weight per head estimated with the sample data. The same procedure used to calculate the beef price is applied.

Fleece-wool Price

The price used to value the production of different crossing of wool corresponds to an average of the wholesaler price per ten kilos during the period 1969 to 1978, adjusted by the consumer price index (1978=100). A percentage equal to six is deducted for selling costs.

Belly-wool Price

It is calculated as 50 percent of the fleece-wool price.

Table C.2

Basic Data for the Computing of Economic Indicators
Average Values (1,000 pesos)
Ayacucho County, Argentina, 1977

APS	TR	OC	DE	QC	NR
1	13,390.7	8,636.9	2,074.6	10,711.5	2,679.1
2	26,673.21	12,450.3	3,184.7	15,635.1	11,038.1
3	64,944.3	27,698.5	7,913.4	35,611.9	29,332.4
4	90.673.0	38,565.8	8,441.8	47,007.6	43,665.3
Whole Sample	42,989.0	19,594.9	4,876.1	24,471.0	18,518.0

APS	FK	OK	IK	TK
1	65,278.09	2,159.2	67,437.3	187,642.6
2	104,713.6	3,112.6	107,826.2	388,139.9
3	255,458.3	6,924.6	262,382.9	744,666.4
4	327,787.5	9,641.4	337,428.9	1,255,572.6
Whole Sample	167,935.1	4,898.7	172,833.8	565,391.9

APS	I (IK)	I (TK)	RE	TC_I	TC_{II}
1	4,856.6	10,866.8	-2,177.4	15,568.1	21,578.3
2	8,135.8	22,151.5	2,902.4	23,770.9	37,786.6
3	19,121.5	40,111.6	10,210.9	54,733.4	75,723.5
4	25,449.0	71,356.1	18,216.4	72,456.6	118,363.8
Whole Sample	12,803.8	31,726.2	5,714.2	37,274.8	56,197.3

Table C.3

Input Prices for the Whole Sample

Input (Variable)	Annual Cost of One Peso		Input Price (P_j)
	Stock	Flow	
LK	5%	---	0.050
VK	8%	---	0.080
ID	--	1 + 6%	1.060
LW	--	1 + 3%*	1.030
AE	--	1 + 3%.0.735 + 8%.0.265**	1.043
PE	--	1 + 6%.0.486 + 3%.0.293 + 8%.0.222***	1.056
HE	--	1 + 3%	1.030

*Twelve percent over 25 percent of one peso in operating capital.

**0.735 and 0.265 are respectively the proportions at the whole sample level between the operating capital in AE expenditures and machinery capital devoted to annual pastures.

***0.486, 0.293 and 0.222 are respectively the proportions among improvements capital in ($PP+PP_f$), operating capital in supplementary feeding and machinery capital devoted to ($PP+PP_f$).

APPENDIX D

CONTINGENCY TABLES ANALYSIS

Table D.1

Contingency Table I:
Basic Information for Table 7.4

Interaction with the Rural Environment*	Observed (O) and Expected (E) Values	APS 1	2	3	4	Total
A (Unfavorable)	O	16	11	6	5	38
	E	13.48	8.58	8.58	7.35	
B	O	6	3	2	6	17
	E	6.03	3.84	3.84	3.29	
C	O	0	0	4	1	5
	E	1.77	1.13	1.13	0.97	
D (Favorable)	O	0	0	2	0	2
	E	0.71	0.45	0.45	0.39	
Total		22	14	14	12	62

*A, B, C and D represent the clusters exhibited in Figure D.1 in this Appendix.

Table D.2

Contingency Table II:
Basic Information for Table 7.4

Interaction with the Rural Environment*	Observed (O) and Expected (E) Values	APS		Total
		"Small" ($APS_1 + APS_2$)	"Large" ($APS_3 + APS_4$)	
Unfavorable (A+B)	O	36	19	55
	E	31.94	23.06	
Favorable (C+D)	O	0	7	7
	E	4.06	2.94	
Total		36	26	62

*See Table D.4 in this Appendix.

Table D.3

Contingency Table IV:
Basic Information for Table 7.4

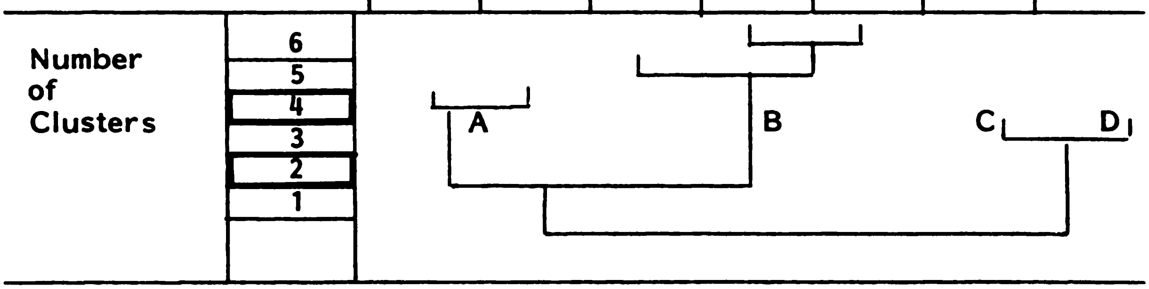
Interaction with the Rural Environment*	Observed (O) and Expected (E) Values	APS "Small" $(APS_1 + APS_2)$	APS "Large" $(APS_3 + APS_4)$	Total
Unfavorable (+ -) (++)	O	28	8	36
	E	20.90	15.10	
Favorable (--) (- +)	O	8	18	26
	E	15.10	10.90	
Total		36	26	62

*The ordering of the quadrants of the component space for the instrumental criteria, from the less to the most favorable interaction, is as follows: (+ -), (++), (--) and (- +).

Table D.4

Typification of Enterprises Upon the Instrumental Component, Ayacucho County, Argentina, 1977

Clustering Unit	1st and 2nd Principal Components						
Cluster Number	1	2	3	4	5	6	7
	1	10	6	19	20	45	47
	27	23	9	46	34	53	50
	40	26	43	55	24	21	
	2	41	16		30	54	
	57	11			37	60	
	59	13			33		
	62	51			63		
	15	28			35		
	25	12			38		
	3	39			58		
	7	22					
	31	36					
	56	61					
	4	49					
	14	52					
	5						
	8						
	17						
	29						
	48						
	32						
	42						
	44						
Number of Observations	23	15	4	3	10	5	2



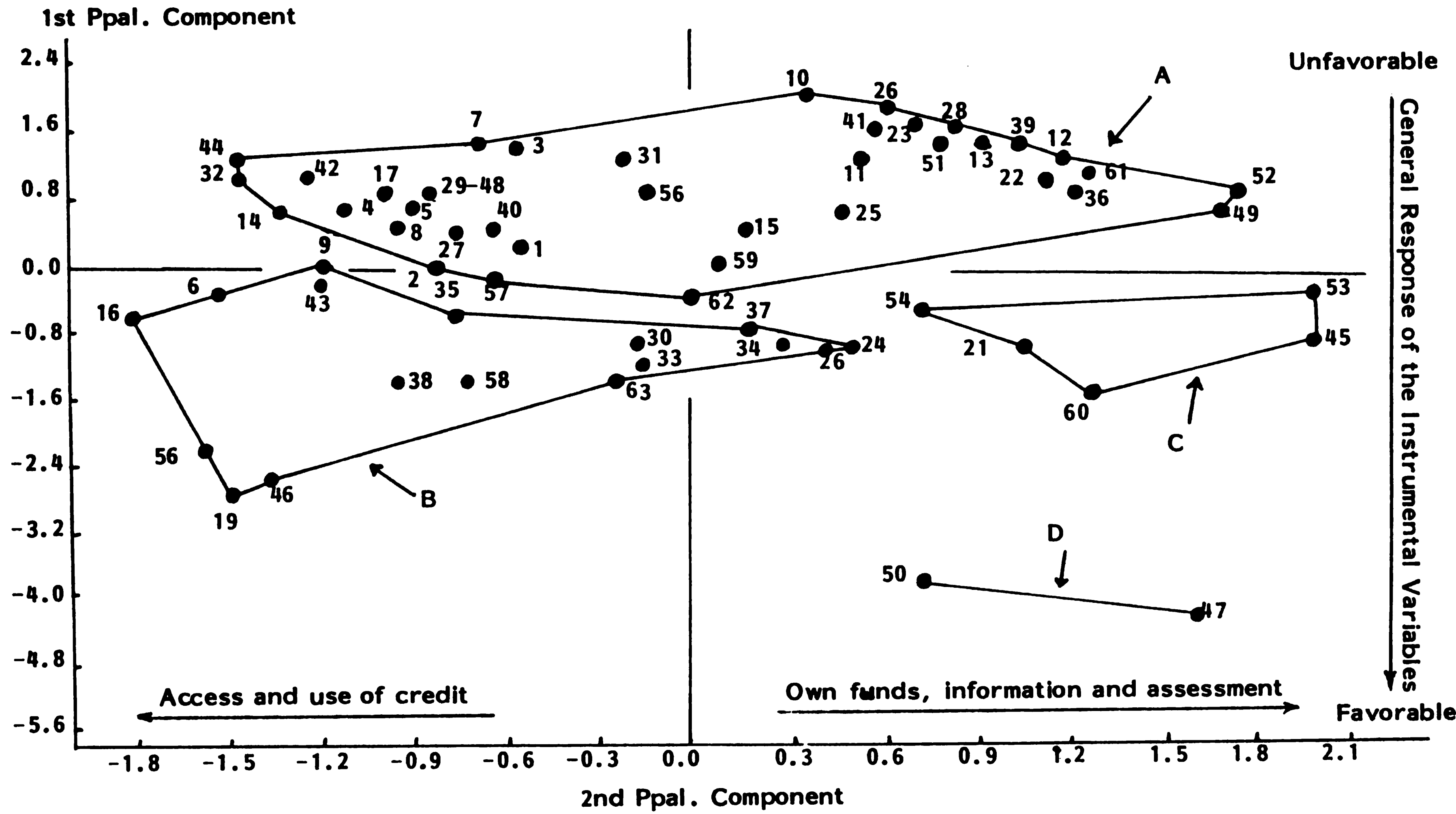


Figure D.1 Projection of the Observations into the First Two Principal Components of the Instrumental Criteria, Ayacucho County, Argentina, 1977

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