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Technical Efficiency and Changes in Alentejan Farming Systems

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Thechnical Efficiency and Changes in Alentejan Farming Systems

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To Tio Albano and Tia Maria
from Guadramil

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ABSTRACT

Following the entrance of Portugal into the EC in 1986, the agricultural sector faced important challenges in implementing the agreements for the first stage of the transition period, the rules that were agreed for the second stage, and the 1992 CAP reform. These last two developments accelerated the integration of Portuguese agriculture into the Community, and their long term impact will differ from region to region and will probably demand improvements in management skills and efficiency, adjustments in farm size and in the crop-livestock activities, and changes in the path and pattern of farm growth.

The objectives of this study were: 1) to analyze the characteristics of farm growth, 2) to estimate and measure the levels of technical efficiency, and 3) to predict farm development under the CAP reform for the period 1992-2000. This analysis was undertaken on four of the ten agricultural systems (intensive, semi-intensive, extensive and poor lands) that comprise the Alentejo region. The methodologies employed were a covariance model to analyze the characteristics of farm growth, parametric and non-parametric methods to estimate and measure technical efficiency and a multiperiod growth model to predict farm performance on 9 farms in the four selected farming systems.

The results showed that: 1) the process of farm growth of Alentejan farms was farm and farming system specific and that small farms grow faster than larger farms, 2) there is room to improve technical efficiency in converting inputs into agricultural outputs and that it will be more important for farms belonging to the extensive and semi-intensive farming systems to show improvements in efficiency, and 3) farm income will decrease for all the farming systems analyzed and extensification will probably take place based on livestock activities (sheep and cattle). The intensive farming system is the one that shows a higher ability to survive in the long run. The capacity to survive of the other three farming systems will depend on farm size, with larger farms showing a better performance. These predicted changes will affect farm size structure in the long run and the capacity of agriculture to employ agricultural labour at the present levels.

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CHAPTER I - INTRODUCTION

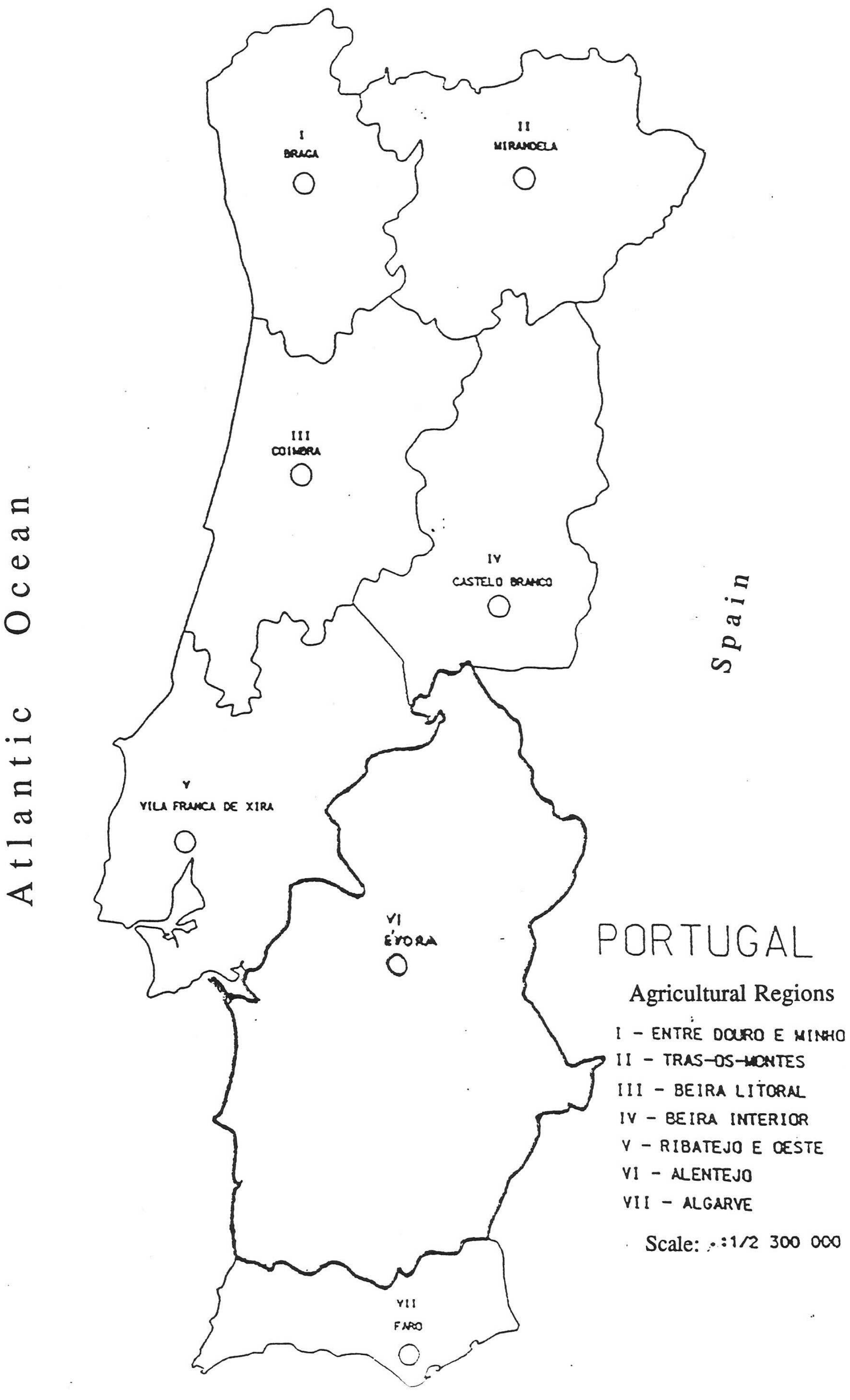
The entrance of Portugal into the European Community (EC) in 1986 was the beginning of the process of integration of the Portuguese economy into a more developed and competitive economic space. This integration process was negotiated so as to be gradual and to last for a period of ten years for the most important economic sectors and activities, and has been an important challenge for an economy that was still based on low wages and characterized by low productivity levels.

Among the economic sectors that would face the economic integration challenge, agriculture was an important one, because in 1986 it still employed around one fourth of the active population, was in general characterized by low levels of technology, and had an inefficient agrarian structure in the major part of the country. Farmers' skills and age structure presented a serious limitation to a quick and rational answer to a changing and unfavourable economic environment, and agricultural markets had been protected from outside competition for more than half a century. The challenges that the agricultural sector faced were reinforced by the decision taken by the Portuguese government during 1990-1992 to accelerate the integration process of Portuguese agriculture into the Community.

Agricultural systems in Portugal vary significantly across the country and the impact of the integration into the EC will be dependent on the region considered. Four main agricultural systems can be defined considering rural and agrarian differentiation: the northern-central coastal (Minho and Beira Litoral) regions, the northern-central interior (Tras-os-Montes and Beira Interior regions), the southern flat fields (part of Ribatejo and Alentejo region), and the southern part of the country (Algarve region) and some municipalities surrounding Lisbon (Baptista, 1993). The first two agricultural systems occupy the North part of the country above the Tagus river, while the last two occupy the southern part of the country as can be seen in Map 1.1.

The northern-central coastal agricultural system is characterized by small-scale irrigated agriculture, based on multiple crop and livestock farming systems in which milk, beef, wine, maize and potatoes are the most important activities. The farming systems are mainly non-specialized with a significant role of home consumption, use principally family labour, and part of the farm family has off-farm jobs in industry and services. In the last two decades these small-scale agricultural systems have been opening up to the market and farms have become more specialized, principally in milk, maize and wine production. The northern-central interior agricultural systems show similar characteristics to the northern-central coastal system, regarding farm size, the use of family labour, home consumption and non-specialization, although in some

Map 1.1 - Portuguese Agricultural Regions



delimited areas, specialized systems can occur such as vineyards on the banks of the Douro river for the production of port wine. The farming systems based on multiple crop and livestock activities are of the dryland type and the most important activities are wine, olive oil, beef, small ruminants, fruits, potatoes and cereals. The weak industrialization has been unable to create alternative jobs, and in many cases imigration to urban centres or foreign countries has been the only option available for members of farmer families during the last decades.

The agricultural system that occupies the southern flat fields (most of Ribatejo and Alentejo regions) is characterized by farming systems that are more specialized, with a marketing orientation, where in many cases, small family farms are substituted by larger entrepreneurial farms. In the irrigated areas of the Ribatejo and the Alentejo, farming systems are intensive with high technological levels, where the most important activities are rice, tomatoes and processing fruits and vegetables. The dryland farming systems which are dominant in the Alentejo region have been based on cereal production along with natural pastures that feed livestock activities (beef and sheep), and where agricultural intensification is dependent on soil potential. There are important concentrations of vineyards and olive trees as well as of cork trees and other forestry activities. The Alentejo region is also characterized by a low level of industrialization, low population density, and with a significant percentage of hired workers in the agriculturally active population.

The last agricultural system, which occupies the southern part of the country (Algarve) and some municipalities around Lisbon, is characterized by specialized and market-oriented farming enterprises in which wine, fruits and vegetables are the main activities.

Since 1986 Portuguese farmers have been facing an adjustment process in their farming activities regarding the new economic conditions created by the application of the rules for the first stage of the transition period in which output prices for the majority of agricultural commodities have decreased in real terms. The revision of the agreements for the second stage of the transition period, the 1992 reform of the CAP and the single European market led to further decreases in output prices which are expected to produce additional adjustments in Portuguese agricultural systems. These adjustments will be even greater if, as result of the General Agreement on Tariff and Trade (GATT) agreement, additional changes in the common agricultural policy (CAP) are introduced later.

One of the agricultural systems and regions in which the process of agricultural adjustment is expected to be felt with relative intensity is the Alentejo region. The 1992 reform of the CAP, which led to further decreases in cereal prices and encouraged extensive farming activities, accelerated the need for reconversion and adaptation of the dryland farming systems of the Alentejo region to the new economic conditions derived from that policy reform. Among the dryland farming systems in which the CAP reform will have stronger repercussions are the ones in which cereal activities have represented in the past an important source of revenue and income.

It is expected that the application of the rules for the second stage of the transition period and the 1992 CAP policy reform will affect the Alentejan agricultural sector in terms of the profitability of the crop and livestock activities practised, family and hired labour use, farmers' willingness to invest, and farmer incomes. The survival of the Alentejan farmers in the economic environment derived from the agricultural policy reforms would probably require a significant degree of adjustment in their crop and livestock activities, farm size, farm growth, direction of agricultural investment and labour use. The new economic environment is more competitive and with less protection than before, and this will demand from farmers an up to date knowledge of the agricultural policies and markets, in order to be able to generate and even anticipate, quick and rational answers to their farming activities when changes are observed in the agricultural policies and markets. In overall terms the above predictable changes would require improvement in the management skills of Alentejan farmers in order to increase their levels of efficiency in agricultural production.

The expected changes at farm level will also have a particular effect on the capacity of agriculture to employ the agricultural workers that still represent a significant percentage of the Alentejo agriculturally active population. The upstream and downstream sub-sectors that are directly and indirectly connected with agriculture, as well as the overall economic performance of the region, will also be affected by the changes observed in the levels of agricultural activity.

The majority of the previous studies undertaken about Alentejan farming systems such as the ones by Fox (1987), Marques (1988), Serrão (1990) predicted a significant reduction in farm income under the conditions of the initial transition agreements agreed between Portugal and the Community. However, the majority of these studies do not include the new policy framework derived from revision of the agreements for the second stage of the transition period and the 1992 CAP reform, they were conducted in a comparative static framework not taking into consideration the role of flow of funds in the process of farm growth and adjustment to the new economic conditions, and they were biased towards the study of larger farms (> 200 Hectares) excluding the small (< 50 hectares) and medium (51-200 hectares) sized farms that represent a significant proportion of Alentejan farms and agricultural output.

Due to the low levels of education and professional training of Alentejan farmers, the need for improvements in farmers' management skills and consequently in the level of efficiency of agricultural production has been recognized as an important goal to be achieved, either by the studies undertaken or by governmental policy through the professional training programs implemented, in order to increase the capacity of Alentejan farmers to adapt and to survive in the new economic conditions of European integration. However, no specific studies have been undertaken to evaluate the present levels of efficiency of Alentejan farmers and find out the extent to which inefficiency has been a restriction in the performance of Alentejan farmers. Machado (1993) in a study of the Northeast and Central Portuguese regions found that technical inefficiency was not a significant problem for the farms located in that regions and those the objective of the agricultural policies must be to promote the adoption of more modern technologies and expand the production frontier.

In order to address some of the issues and concerns mentioned above about the development of Alentejan agriculture, it was considered of important to examine at the Alentejo's agriculture from the viewpoint of its farming systems with the main aim of studying the following aspects: 1) the characteristics of the growth process of Alentejan farming systems, 2) to evaluate the individual levels of technical efficiency of Alentejan farms and 3) to predict the performance of Alentejan farming systems under the recent developments of the CAP.

The objectives described above were performed on four of the ten Alentejan farming systems. The farming systems selected were the intensive (IS), semi-intensive (SIS), extensive (ES) and poor lands (PLS) which account for 62.7 percent of the Alentejo agricultural area, 77.2 percent of cropped area and 48.5 percent of permanent crop area. The data used was individual farm level data collected by the Ministry of Agriculture through the EC's RICA (agricultural information and accounting system) accounting system. For the first and second objective a panel data of Alentejan farms for the period 1985-1991was used, while the RICA data for 1988 was the only data set available and used to accomplish the third objective.

The first objective was to analyze the process of farm growth of Alentejan farms and to give some insight about the relationship between farm growth and farm size. The methodology used was a covariance growth model that allowed us to test if farm growth depends on farms and farming systems and if farm growth was independent of farm size (Chapter IV). This corresponds to a test of Gibrat's law of proportionate effect.

The second objective was to measure individual levels of technical efficiency for the farms belonging to the farming systems selected and two methodologies were used: the parametric and nonparametric approaches (Chapter V). The parametric approach estimated individual levels of technical efficiency with a Cobb-Douglas production frontier using three panel data methods for its estimation, while the nonparametric approach measured individual levels of technical efficiency through the construction of a piecewise linear production frontier using linear programming techniques. The nonparametric measure of technical efficiency was further decomposed in its three components, and pure technical, scale and congestion efficiency measures were evaluated.

The methodological approach followed to measure technical efficiency allowed us to compare: 1) individual levels of technical efficiency and the ranking of farms by efficiency levels estimated by the three parametric estimator techniques used and to select the parametric estimator method that best described the data using a formal statistical test, and 2) individual levels of technical efficiency and the ranking of farms by efficiency levels for the parametric and nonparametric methods. The individual levels of technical efficiency evaluated were used to test the relationship between efficiency and farming system, farm size, farmers' experience, land ownership, irrigation and labour characteristics, and livestock and product specialization as well as the relationship between efficiency and the farm growth measures derived from the covariance growth model.

With respect to the third objective, to evaluate the performance of Alentejan farming systems under implementation of the rules for the second stage of the transition period and 1992 CAP reform, the methodology employed consisted of building farm growth models using multiperiod linear programming techniques for the period 1992-2000 (Chapter VI). These farm growth models were applied to nine farms with different area sizes that were selected based on the 1988 RICA data set. The input-output coefficients were derived based on the 1988 RICA data and on interviews made with the selected farmers. Farm development was evaluated for two basic scenarios 1) assuming that farms maintained their size and technology equal to that observed for 1988, and 2) assuming that farmers take opportunities for growth and introduce improved technologies and new activities. Additional simulations were performed for the introduction of minimum tillage techniques, adoption of the Community set-aside scheme and a reduction on sheep prices.

The predictions of the nine farm growth models built for the scenarios considered will help us infer the capacity of Alentejan farms to survive in the long-term, to anticipate the main directions in their process of farm growth or decline, and to collect evidence about the activities and technologies that will better suit them in the future. Although recognizing that the GATT agreement will introduce changes in the level of support of the common agricultural policy, this agreement come out after the main modelling exercise was concluded.

It is expected that the results obtained from the research framework designed above will 1) answer directly some of the issues and concerns raised previously and which are a consequence of the application of the 1992 CAP reform, such as the best strategies for farm growth and optimum enterprise combinations for Alentejan farms, 2) help to make some inference about the process of farm growth of Alentejan farms (need to be cautious in generalizing the results obtained for the other farms of the region), and 3) evaluate the importance of improvement in the present levels of management and efficiency as well as identifying for which groups of farms improvements in efficiency are more relevant.

In the next chapter a brief description of the main developments in Portuguese agricultural policies during the periods before and after integration into the EC is undertaken and this is complemented with a summary of the most relevant changes observed in the Portuguese agricultural sector during that period. In chapter III a characterization of the changes observed in the agricultural resources of the Alentejo region during the last decade is undertaken, while in chapter IV the farming systems studied are selected and characterized along with the analysis of the growth of some farm variables for the period 1987-1991. Chapter V evaluates individual levels of technical efficiency for the farming systems selected using a parametric and nonparametric approach, compares the different methods used, and tests the relationship between efficiency and different farm characteristics. Chapter VI starts with a literature review focusing on the programming models developed with similar objectives and on the previous studies about Alentejan farming systems, and this is followed by the presentation of the growth programming model utilized to predict the performance of Alentejan farms, the selection of the nine farms used and the verification of the model results, and ends with the presentation of the farm results for the scenarios considered. The last chapter addresses the principal conclusions derived from this study, its limitations and opportunities for future research.

CHAPTER II - CHANGES IN PORTUGUESE AGRICULTURAL POLICIES

The objectives of this chapter are to make a summary of the evolution of Portuguese agricultural policies before and after the entrance in the EC and at the same time to give a brief overview of the changes that have occurred in Portuguese agriculture.

2.1 - PORTUGUESE AGRICULTURAL POLICIES

The intervention of the Portuguese government in agricultural prices and markets goes back at least to the end of last century and started with the protection of the national cereal market from international competition. After the establishment of the Republic in 1910, government intervention was reinforced in 1914-1915 with the control of the domestic cereal markets, but it was with the military coup of 1926 and the installation of a dictatorship in 1928 based on corporatism (in which economic and political activities of all individuals and groups were under government control) that a strong set of corporate policy measures was implemented to regulate the agricultural sector (Lucena, 1991). After 1974, with the overthrow of the dictatorship, changes to the corporate system were introduced to adapt to the new political conditions. Significant changes occurred with the agrarian reform in the southern part of the country and the dismantling of the corporate system of farmers' organizations, but the main core of the corporate structure, principally in terms of output prices and markets, remained almost unchanged until Portugal's entrance into the EC in 1986. After 1986, with the entrance into the EC a set of new rules were put in place in accordance with the transition rules agreed between Portugal and the Community. These transition rules, revised in 1990, along with the approval of the 1992 CAP reform defined the framework for the development of Portuguese and Alentejan agriculture until the end of this decade.

2.2 - PORTUGUESE AGRICULTURAL POLICIES BEFORE 1986

Portuguese agricultural policies before the entrance into the European Community were dominated by the set of corporate rules that were established during the thirties. Avillez, Finan and Josling (1993) in a study of Portuguese agricultural pricing policies, divided the period before 1986 into the following sub-periods: 1) Salazarism, 1930 - 1964, 2) agricultural crisis, 1965 - 1973, 3) the revolution and land reform, 1974 - 76, 4) a new order and macroeconomic crisis, 1977 - 82, and 5) reform measures and accession to the EC, 1983 -86. For each one of these periods the main characteristics and changes in agricultural policies are summarized below.

From the thirties until 1974 the Portuguese agricultural sector was regulated by a set of corporate rules established during the thirties after the installation of the dictatorship known as Estado Novo. During this period agricultural production, organization, marketing and trade were controlled by a set of regulating bodies called organizations of economic coordination, and a set of farmers' organizations called grémios and federations. Specific governmental incentives for the development of the agricultural sector, or to improve individual farmers' conditions, were reduced during the first period of the Estado Novo (1930-1959) because the development strategy adopted from the thirties was in general concentrated on infrastructure building for the whole agricultural sector or regions (EFTA, 1965). Excluding the commodities programmes introduced with the objective of reaching certain domestic production goals of self-sufficiency, such as the wheat campaign in the thirties and a forestry programme in the forties, the government's aim was to raise the economic status of agriculture through economic development plans to expand the national economy, including the agricultural sector (OEEC, 1961).

The period between the sixties and 1973 was characterized by rapid industrialization and high economic growth, which was followed by high inflation, an increasing deficit in the trade balance, and migration from rural areas to urban centres and foreign countries. The internal migration, together with a rise in the standard of living of the urban population, increased the demand for agricultural products. The agricultural sector was not able to satisfy this increasing demand for food increasing the trade balance deficit cited above. As a result, land consolidation schemes and commodity programmes for cereals, livestock and milk, with input (modern inputs and capital) and output price incentives were introduced to induce technical change and expand production, while for the first time specific development strategies were drawn up for the agricultural sector in the last economic development plan defined before the 1974 revolution.

The revolution of 1974 occurred in the middle of the first oil price shock and a world recession and caused the return of several hundred thousand Portuguese emigrants from the former African colonies. These circumstances increased the costs of food imports and created an unfavourable economic environment to reform the fifty year old social and economic corporate structure. During the period 1974-1976 the most important changes in agricultural policies were: 1) the abolition of the corporate structure of control of prices and markets and its substitution by parastatal marketing boards with similar or even more interventionist functions than before 2) the abolition of the corporate structure of farmers' organizations and the creation of farmers' organizations independent from the state such as the marketing cooperatives and agricultural confederations, and 3) the called "agrarian reform" in the southern part of the country, principally in the Alentejo region. This reform was initiated by landless farmers and agricultural workers who occupied the big estate farms and organised the land into collective and cooperative production units.

The period between 1976 and 1982, that corresponded to the first constitutional governments (the first parliamentary elections took place in 1976), was characterized by increasing levels of output and input subsidies which led to budget difficulties, the introduction of commodity and development programmes such as the dairy, PCAA (Alentejo agricultural credit programme) and PDRITM (Tras-os-Montes Development programme) with some of these programmes being financed by external sources such as the World Bank, USA and EC, the reformulation and concentration of the incentives for agricultural investment (short and long-term subsidized credit) in a new institution called IFADAP, and the approval of new land reform laws directed to the agrarian reform zone and new tenancy laws.

The last period before the entrance into the Community was mainly characterized by budget pressures which led to the abolition of input subsidies (fertilizer, feedstuffs and short-term subsidized credit) and followed by the government's decision to rise output prices. In general, Portuguese output price increased in proportion more than the input prices and transferred the subsidy burden from taxpayers to consumers. During the same period there was a gradual introduction of a more flexible output price policy similar to the one observed in the EC, the negotiations for entrance into the EC were accelerated and concluded in 1985, and the programmes resulting from the EC pre-accession aid were applied.

2.2.1 - Agricultural Policies and the Agricultural Sector

The wheat campaign of the thirties which had the objective of expanding wheat production to reach self-sufficiency through guaranteed prices and input subsidies, bringing to cereal production new agricultural land principally in the Alentejo region, was able to reach the main governmental goal of self-sufficiency in cereals, principally wheat (Lucena, 1991). However, it had some harmful consequences because in many cases the new agricultural land brought into production did not have enough production potential for cereals, or resulted from deforestation of natural forests leading to erosion problems and a decrease in the land's future agricultural capacity.

Avillez, Finan and Josling (1993) studied the direct and indirect effects of the agricultural pricing policies between 1960 and 1985, and evaluated the nominal protection rates for this period. These results are shown in Table 2.1 and from them one can conclude that in general the agricultural products that are important for the Alentejo region, such as maize, wheat, tomatoes, beef and sheep, had positive rates of protection during the periods considered by the authors, meaning that prices were higher than they would have been without the agricultural policies. The rates of protection were higher for maize, wheat, beef and sheep and show a decreasing tendency through time. These varying rates of protection would have caused relative output changes depending on the price elasticities and relative price ratios experienced.

Table 2.1 - Nominal Protection Rates due to Direct and Indirect Price Intervention

	Milk	Wine	Rice	Tomatoes	Maize	Wheat	Beef	Sheep
1960-64	4	10	4	10	31	60	54	10
1965-73	11	1	14	4	26	62	53	29
1974-76	11	-1	-18	37	12	-11	109	32
1977-83	8	-10	-11	5	28	14	85	21
1984-85	-2	-14	4	-1	18	24	26	6

Source: Avillez, Finan and Josling (1993)
a positive number indicates a rise in price for producers

The decomposition of the nominal protection rates into its direct and indirect effects allowed the authors to conclude that regarding the direct effects: maize, wheat, milk, sheep, and tomato prices, would have been lower in the absence of the price support programmes, while wine and in some years rice prices yielded farmers less than the world price. With respect to indirect effects, the undervalued escudo in the sixties acted as an implicit subsidy, offsetting some of the negative effects and amplifying the positive effects, while in the seventies the overvalued escudo had the opposite effect.

The same authors also analyzed the policy effects on individual representative Portuguese farms for the same period and concluded that the larger farms in the centre and south (Alentejo region) benefited much more from the agricultural policies pursued than the small and medium sized farms in the north and centre because they tended to use more modern inputs which were subsidized, and had a production structure directed to the market. It was also noted that they had greater influence in the political decision making process. Their results showed that the larger farms in the Alentejo region each received on average 100 times as much as a northern small farm, in governmental annual transfers due to the direct and indirect pricing policies.

In a study of the Alentejo region, Fox (1987) analyzed for 1983 the private and social profitability and net policy effects of the following Alentejan activities: wheat, sunflower, rice, tomato, lamb and beef. The methodology used by the author was whole farm activity budgets, in which private profitability (receipts minus input and factor costs) and social profitability (using social prices) were calculated. The results summarized in Table 2.2 show that, with the exception of sunflower and rice, the input and output policy effects were high, meaning that for the other commodities studied there was a significant difference in private and social costs and private and social revenues, principally in terms of labour, capital, fertilizer and other input prices and output prices, meaning that in the absence of the pricing policies the profitability of those activities would have been much lower.

Table 2.2 - Private and Social Profitability and Net Policy Effects for Crop and Livestock Commodities in the Alentejo - 1983 (Returns to Land and Management)

Item	Private Profitability	Social Profitability	Net Policy Effects[c]
Wheat Good Soils[a]	20.9	5.9	+15
Wheat Poor Soils[a]	6.2	-5.3	+11.5
Sunflower[a]	1.4	2.0	-0.6
Rice[a]	55	54.5	+0.5
Tomatoes[a]	58.9	16.2	+42.7
Lamb Medium Management[b]	91	-260	+351
Lamb High Management[b]	136	-193	+329
Beef Feedlot[b]	38	-15	+53
Beef Pasture[b]	81	-34	+115

Source: Fox (1987)
[a] thousands of Escudos per hectare
[b] Escudos per kilogram of carcass weight
[c] (+) equals a subsidy and (-) equals a tax

Regarding the role of output and input price incentives in farmers' response and agricultural output, Soares (1987) in a cross-section supply study of Alentejan farms for the sixties concluded that farmers responded more positively to output than to input prices and that output prices were more efficient in stimulating the growth of agricultural output. Costa (1987), in a study of input use for the period 1950-1980, concluded that the favourable price evolution of modern inputs (machinery, equipment and fertilizers) when compared with traditional ones (land and labour), was not able to induce a sufficient increase in the use of modern inputs to offset the reduced use of traditional inputs and at the same time increase significantly the agricultural output. Machado (1993) reached a number of important conclusions regarding the development of the agricultural sector during the period 1963-1987, such as that productivity growth was significantly positive and technical change followed the directions induced by movements in factor prices.

The agricultural population has been decreasing during the last decades, accounting for 23.3 per cent of the total labour force in 1986, and it was characterized by an old age structure and low levels of educational skills. The aging process of the Portuguese agricultural population started in the sixties when migration from rural areas to urban centres and foreign countries took place. Between 1960 and 1989 the age pyramid was inverted. In 1960 the percentage of active population in agriculture less than 45 years of age accounted for 62.0 per cent and in 1989 for 22.2 per cent, while the population older than 65 years of age accounted for 9.6 and 27.2 per cent, respectively. Another consequence was a significant reduction in the farm population: from 42.2 percent in 1960 to 30.0 in 1970 (Estácio, 1982 and INE, 1989). The levels of educational skills of Portugal's labour force had barely changed in the preceding decades with only a slight decrease in the illiteracy from 29.8 percent in 1979 to 25.9 percent in 1989. In 1989, most of the farm population (70.4 percent) had elementary education and only 3.7 percent had secondary or higher education (INE, 1979 and INE, 1989).

The agrarian reform after the 1974 revolution took place mainly in the Alentejo region. The principal effects were a change in land ownership from private farmers to cooperatives, an increase in average farm size in the large area classes due to the merger of different farms into cooperatives, and an increase in the levels of regional employment, principally the change from part-time to full time jobs of many agricultural workers. There were no significant changes in the pattern of crop and livestock activities and technologies used before and after the agrarian reform. After 1976, the following development occurred: 1) the approval of the land reform law of 1977 in which part of the land occupied illegally during the revolution was gradually returned to the old landlords due to increases in the area that could be claimed by landlords, 2) in the early eighties some of the nationalized land was distributed by the government to landless farmers, and 3) the approval of the land reform law of 1988 that created the conditions for the return of the majority of the land to the old landlords. The production cooperatives argued that with the implementation of the last land reform law the majority of the occupied land would return to the former owners. They pointed out that only 25 cooperatives would remain, and they predicted that the social consequences would be that thousands of illiterates and aged cooperative members would be unemployed in the near future (Agra-Europe, 1988). As a consequence of these changes, the number of production cooperatives and collective units, the areas farmed and the number of agricultural workers employed by them, have been decreasing. By 1989, the number of cooperatives was one third of the number observed in 1975, the area occupied was around 21 percent, and the number of agricultural jobs supplied by the cooperatives around 17 percent (Fenca 1989).

After 1976, some development and commodity programmes were implemented at national and regional level with the objective of reorganizing production structures, improving technologies, constructing basic infrastructures and improving the processing and marketing of agricultural products. Among them the dairy programme for the Northwest financed by the EC is cited as an example of success, in which the pricing and marketing policies directed towards that region had an important contribution for the success of that programme. The agricultural programmes implemented in the Alentejo in the late seventies and early eighties were the PCAA funded by the World Bank (which financed agricultural projects to expand the forage, pasture and livestock capacities of Alentejan farms), the funds of the PL480 that financed individual agricultural and agro-industrial projects in the region and also the regional component of the national programme PROCALFER. The objectives of PROCALFER were to invest in new facilities for the production and distribution of lime and to finance agricultural investment projects to improve land fertility through the correct use of fertilizers and rotations.

With respect to subsidized agricultural credit, the creation of IFADAP in 1977 meant that the lending activities of the Ministry of Agriculture ended, and that all credit to the agricultural sector was supplied by parastatal or commercial banks, while the role of IFADAP was to approve subsidized investment projects. Among the lending institutions, the contribution of the credit cooperatives to the financing of agricultural investment projects increased substantially during the eighties and reached more than fifty per cent of the total subsidized credit to the farm sector following the relaxation of institutional constraints. Although the creation of IFADAP in 1977 had the objective of improving the supply of subsidized investment funds, the IFADAP credit lines had high transaction costs due to the bureaucratic procedures involved, which led to a discrimination against some farm categories, principally small farms (Monke et al., 1983).

During the eighties, Portugal received aid from the EC pre-accession aid which had the objective of preparing its productive structures for integration. The agricultural projects were mainly financed at governmental level such as the farm accounting, definition of representative market and a system to record market prices, professional training, re-forestation and the establishment of a viticulture land register. Only one project at farm level received pre-accession aid: the dairy programme. As Dauderstädt (1987) states, the pre-accession aid did not make the modernization process socially more acceptable, because the EC aid was biased towards big investment projects instead of more continuous interventions through the support of small and medium sized enterprises, and agriculture only received a small share of the funds available. Furthermore, the agricultural funds were mainly directed at infrastructures, and not at farm level.

Although the number of agricultural incentives had increased and the amount committed to them has risen from around 15 in the sixties to around 30 percent of the agricultural GDP in the eighties (Avillez, Finan and Josling, 1993), the agricultural sector was not able 1) to respond in terms of agricultural output to the increasing internal demand for agricultural products, which resulted a worsening trade deficit with a cover rate that was 61.7 per cent in 1973 and 37.2 in 1980, and 2) to modernize in such a way as to become more competitive in comparison with the other Community members or to countries with similar agro-ecological conditions. Table 2.3 to 2.6 compare yield levels, farm structure, input consumption, and agricultural product per labour unit, hectare of agricultural land, and farm for Alentejo, Portugal, Spain and the EC. Yield levels for Alentejo and Portugal are very similar and smaller than the ones observed in Spain and in the EC. These low yield levels are due not only to lower soil potential and lower rainfall but also to lower input use as shown in Table 2.5. Other explanations are the age structure of Portuguese farmers, low levels of education and professional training and a deficient farm structure with an average area of around 6 hectares with the majority of the farms belonging to the 0-4 hectares farm size classes, while in the EC the majority of the farms are greater than 4 hectares. As a result of these factors, agricultural product per labour, land and farm are much lower when compared with Spain and the EC as shown in Table 2.6. In 1986 Portuguese agricultural product per labour, land and farm was around 16, 39 and 21 per cent of the average Community levels respectively.

Table 2.3 - Average Yield Levels for Alentejo, Portugal, Spain and EC-10
(average 1976/1977)

Item	Alentejo	Portugal	Spain	EC-10
	(100 Kilograms per Hectare)			
Cereals	15.6	15.4	23.4	50.7
Soft Wheat	17.4	16.5	23.2	55.8
Durum Wheat	-	16.6	25.9	26.2
Maize	9.8	24.2	65.3	70.4
Barley	11.1	10.4	19.6	47.9
Rye	6.4	8.3	12.0	39.5
Rice	45.0	46.1	62.3	57.6
Sunflower	6.8	7.1	9.7	22.7
Horticulture	-	185.0	207.5	272.5
Potatoes	75.3	88.5	176.0	328.0
Tomatoes	274.2	347.5	420.0	496.0
Fruit Trees	-	16.0	36.5	106.5
Vineyards 100l/ha	-	28.0	24.6	70.7
Table Grapes	-	100.0	72.0	164.5
Milk 100kg/cow	-	33.9	33.1	44.4

Source: Lourenço, 1988 and INE

Table 2.4 - Farm Structure (number of Farms and area) of Alentejo, Portugal and EC-10 (1980)

Farm Size Classes (Ha.)	Alentejo		Portugal		EC-10	
	Number (%)	Area (%)	Number (%)	Area (%)	Number (%)	Area (%)
0-4	55.5	2.0	82	15	47	7
4-20	27.4	6.5	15	17	32	21
20-50	7.8	6.4	2	7	15	30
>50	9.2	85.1	1	51	6	42

Source: Silva (1989b) and INE

Table 2.5 - Input Use and Average Farm size for Alentejo, Portugal and the EC

Item	Alentejo	Portugal	EC-10
Nitrogen Kg./Ha.	-	34.0	74.0
Phosphorus Kg./Ha.	-	18.0	41.0
Potassium Kg./Ha.	-	9.0	41.0
Tractors Number/100 Ha.	0.54	1.9	4.9
Average Farm Size Ha.	42.3	5.6	13.2

Source: Henriques, 1987 and INE
- not available

Table 2.6 - Land, Labour and Farm Productivity for Portugal, Spain and EC-12 in 1985

Item	Agricultural Product/Labour	Agricultural Product/Agricultural Area	Agricultural Product/Farm
	ECU per labour unit	ECU per hectare	ECU per farm
Portugal	3095	1087	4106
Spain	16052	1341	11481
EC-12	19583	2757	19704

Source: EC (1994)

2.3 - PORTUGUESE AGRICULTURAL POLICIES AFTER 1986

Portugal applied for accession to the European Community in 1977. The official negotiations which started in 1978 and were concluded by 1985, defined the procedures to integrate the Portuguese economy into a larger and more developed economic space. For agriculture a transition period of ten years was agreed. There was to be a gradual adoption by Portugal of the Community price, marketing and trade policies, as well as structural measures to correct the deficiencies in the structure and organization of agricultural production, so that Portugal would be able to operate the full mechanisms of the CAP by 1996.

The adjustments required for agricultural commodities were divided into two types, a classic and a two-stage transition. The products included in the classical transition were the ones: 1) produced domestically in which no problems existed in adopting the Common Organization of Markets (COM) rules after 1986, and 2) not produced domestically. For these products, the rules of the Community's COM were applied, with the exception of the dispositions agreed in the Treaty of Accession regarding harmonization of prices, trade, and national aids. The products included were sheep and goat meat, oilseeds, sugar and glucose, olive oil, processed fruits and vegetables, tobacco, dried fodder, peas, seeds, silkworms, flax, cotton, flowers, bee-keeping and hops.

The products subject to a transition by stages were the ones for which significant changes were needed in marketing practices or institutions, production and prices before Portugal could start operating the CAP mechanisms. The products included were cereals, pork, milk and milk products, poultry and eggs, beef and veal, fresh fruit and vegetables, bananas, pineapples, potatoes and wine. The first stage that lasted a five year period (1986-1990) was designed to prepare the production, processing, marketing and trade structures for the Community rules, while the second stage was devised to harmonize price levels. Rules for the first and second stage were defined for each commodity with respect to production, marketing structure, price harmonization, trade and national aids. However, the Treaty of Accession required at the end of the first stage an analysis of the specific evolution of each commodity and an examination of the main development of CAP policy during the same period, with the objective of incorporating into the second stage new adjustments. As a result, the negotiations that took place in 1990 decided to anticipate the price harmonization for the commodities subject to transition by stages. Later, during the Portuguese presidency of the Community in 1992, a CAP reform was approved introducing a new set of rules mostly regarding the cereal and oilseed sectors. As a consequence of these reforms and the beginning of the single European market in 1993, a new set of arrangements was agreed the main effect of which was to accelerate the integration of Portuguese agriculture.

With respect to structural measures, EC structural Regulations were implemented after 1986 as well as two specific development programmes for Portuguese agriculture. The objectives of these specific programmes were to improve different aspects of Portuguese production structures which were not covered by other EC structural Regulations.

2.3.1 - The Period 1986-1990

The strategy followed by the Portuguese government in implementing the transition rules for the products subject to transition by stages was the creation by the end of 1985 of national market organizations (NMO) for fresh fruit and vegetables, cereals, milk and milk products, wine, beef, pork, poultry and eggs. The NMO for each product followed the same structure of the Community's COM and contained the basic dispositions agreed upon in the Treaty of Accession. The general objectives of the NMO were: to gradually harmonize the prices of the different commodities following the rules defined in the Treaty of Accession, to introduce the Community price scheme, to open Portuguese agricultural markets, to stimulate the development of producer organizations, to match supply with demand, to stimulate producer organizations for the management of the different markets, and to ensure a fair income for producers. These objectives aimed to prepare and gradually adapt Portuguese production, marketing and trade structures to the ones established in the Community. The rules defined for each NMO were applied until the end of the first stage of the transition period and allowed the Portuguese government to protect the domestic market from EC and third country competition.

For potatoes, sweet peppers, pineapples and bananas, individual NMOs were also created to regulate production, marketing and trade. The objective was to protect the domestic market from the competition of Community partners for those products not covered by a COM, and the NMO were expected to last until 1995.

For each NMO a price system similar to the Community COMs was created: a market indicative price, a border protection price and an intervention price. All the products that were covered by the NMO were protected from the EC, Spanish and third country markets by a variable levy to equate the import price to the internal price, and could benefit from an export refund to compensate the difference in prices between Portugal and EC and third countries.

During the first stage the Portuguese government could have implemented exceptional measures to protect the products covered by the NMOs whenever there were extraordinary reasons, but this mechanism was not used during the first stage. On the contrary in 1990, a law with the objective of safeguarding the supply of agricultural markets with good conditions of price and quality and respecting the transition agreements was approved. This law allowed the government to suspend or alter the application of quantitative restrictions on imports, the elimination or reduction of variable levies or other compensatory taxes, the total or partial elimination of custom duties on imports and the suspension of export refunds. This law was applied in 1990 to imports of pork, live pigs, milk and milk products, poultry and eggs, table wine and wine brandy to stabilize market supply and prices, with the temporary elimination of import levies, and quantitative restrictions. The reasons pointed out by the government in liberalizing the markets of those products were: to keep control on the rate of inflation, to regulate market supply and to benefit consumers with lower incomes.

For each commodity, a set of specific policy measures to be executed during the first stage was agreed. Some of these policy measures were common for all commodities subject to transition by stages such as the elimination of marketing boards and the creation of an intervention agency, application of Community quality standards, free price formation, the definition of representative markets on which to record and collect market prices.

Market liberalization was gradually adopted during the first stage for the different agricultural products when the monopolies of the marketing agencies were abolished, private traders were allowed to import and export, and fixed marketing margins were abolished. For cereals, the market liberalization started in 1986 with the entry of private operators in the cereals trade and the introduction of a production aid to cover the difference between the national reference and guide prices. For milk, the monopsony of exclusiveness of milk collection and pasteurization by processing cooperatives was gradually abolished after 1987 and ended in 1990. Institutional prices and export refunds were established in accordance with the transition rules, although for some products they were only set towards the end of the first stage. Community quality standards were not obligatory during the first stage, but the Community legislation was approved for all products, representative markets were defined and an information agency in prices and markets was established (Commission, 1990a).

With respect to the products subject to classical transition, for sheep, goat and sunflower the prices were harmonized and the COM rules fully applied in 1986. For olive oil and processing tomatoes, the seven year transition rules were applied, and in trade with the Community and third countries the supplementary trade mechanism (STM) and Accession Compensatory Amounts (ACAs) were used.

3.3.1.1 - STRUCTURAL POLICIES

The structural measures applied in Portugal after 1986 were EC Regulations available for all EC members and two specific agricultural development programmes: the programme for the development of Portuguese agriculture (PEDAP), established under EC Regulation 3828/85, and the programme to improve the wine-growing structures in Portugal under EC Regulation 2239/86. The objectives of these specific programmes were to correct the differences between Portuguese agricultural production structures and those of other EC members. Indirectly the agricultural sector also benefited from the Community integrated development operations (OIDs), later called operational programmes (OP), which after 1989, with the reform of the structural funds, were incorporated into the regional development programmes. Portugal was considered one region and achieved objective 1 classification, as applied to those regions with a GDP per capita lower than 75 percent of the Community average. As a result, the first regional development programme was applied in Portugal between 1989-1993, and the second between 1994-1999.

With respect to the PEDAP program, its initial scope agreed in 1985 was later enlarged to cover more regions and areas of intervention but the ten year period of duration and the Community financial contribution of 700 million ECU were not modified. PEDAP was composed of several sub-programmes that cover areas of intervention for which the structure of Portuguese agriculture is inefficient. The main areas of intervention are: 1) development of vocational training, extension and research, 2) improvement of the efficiency of agricultural production structures through improvement of land structure and infrastructures, 3) production re-orientation and management of land use, 4) marketing of agricultural products and 5) specific sectorial interventions in olive and forestry production. These areas of intervention can be divided into two groups: those designed to improve farmers' production structures such as land consolidation, irrigation capabilities, electrification and sanitary control, and those addressed to an improvement in agricultural infrastructures such as agricultural training centres owned by public institutions, and incentives to establish private institutions, agricultural schools, agricultural research structure, and agricultural production organizations.

Other EC structural Regulations available after 1986 were the following: EC Regulation 797/85 with the objective of improving the efficiency of agricultural structures, EC Regulation 355/77 with the purpose of improving the conditions of processing and marketing of agricultural commodities, EC Regulation 1360/86 with the objective of stimulating the development of producer groups and associations, and EC Regulation 1360/78 to encourage the formation of producer groups in the sector of fruit and vegetables.

After 1986, Community Regulations replaced the IFADAP subsidized credit lines as the main incentive to induce agricultural investment, subsidized interest rates were replaced by capital grants, and IFADAP was designated the institution responsible for the approval of investment projects, the granting of investment subsidies, and management of all financial flows of the guidance section of FEOGA.

2.3.2 - 1991 to Present

The negotiations between Portugal and the EC in 1990 undertaken to analyze the first stage of the transition period and to revise the rules for the second stage, resulted in an agreement that anticipated for the products subject to transition by stages, the harmonization with the Community rules. As a result of these agreements, support prices were harmonized in 1991-1992 with those of the Community with the exception of wheat. Temporary production aids were established for cereals, and trade continue to be regulated by accession compensatory amounts and the supplementary trade mechanisms.

Later, as a result of CAP reform approved in 1992 and the 1993 European single market, new arrangements were agreed principally in terms of trade, which further accelerated the integration of Portuguese commodities. As a consequence of these new agreements, wheat support prices were harmonized with EC support prices, and for cereals the temporary production aid agreed in 1990 was extended until 2003 to compensate Portuguese farmers for income losses due to price harmonization.

The 1992 CAP reform was based on the Mac Sharry proposals elaborated in 1991 intended to reform the support arrangements for cereals (oilseeds and protein crops), tobacco, milk, beef and sheepmeat, together with an Agri-Environmental Action Programme and plans for the afforestation of agricultural land, and to encourage early retirement. The key elements of the 1992 CAP reform were a decrease on cereals price, the introduction of arable area payments, the obligation of set aside requirements, beef and sheep headage payments with their respective quotas, maximum stocking rates for beef, and a livestock extensification premium. These policy measures were tested in chapter VI in nine selected farms of the Alentejo region using a multiperiod linear programming growth model. The output prices, area and headage payments used are shown in section 6.7.

The GATT agrement of 1993 and implemented in 1995 will transform variable import levies and other import barriers in tarifs and will impose constraints on the level of support that the CAP can provide to its farmers. If as a result of GATT agreement future changes in the CAP are needed for the EC to comply with it, then it will be expected that the present level of CAP support will be reduced and this reduction in support will produce further changes on Portuguese agriculture.

2.3.3 - THE EFFECTS ON THE AGRICULTURAL SECTOR OF THE INTEGRATION OF PORTUGAL INTO THE EC

As expected, the integration of Portugal into the EC brought changes to the agricultural sector in aggregated terms, by products and for the different agricultural regions. Several studies were conducted to predict the impact of the adoption of the CAP on Portuguese agricultural systems such as the ones undertaken by Pearson, Avillez, Bentley, Finan, Fox, Josling, Langworthy, Monke, Tangerman, published in Portuguese Agriculture in Transition (1987) in which the most important farming systems of the Alentejo, Ribatejo, Azores and the Northwest regions were analyzed, the study by Henriques (1987) about some Northwest farming systems, and the studies referred to in section 6.2 where a literature review is presented of the studies of the impact of the integration of the Alentejan agriculture into the EC. In general, all these studies have a common prediction, a reduction in the returns to farm activities and farm income, which would condition the future development of Portuguese farms putting at risk their survival. In this section the objective is to make a comparative analysis between the periods 1980-1985, 1986-1990 and 1991-1993, whenever data is available from the agricultural statistics, for the changes observed in agricultural prices, product, income, trade, investment and labour.

Regarding output prices, between 1985 and 1993, Portuguese agricultural output prices were harmonized with Community prices. This harmonization was done in three phases due to the following factors: 1) the mechanisms agreed and applied for the first stage 2) the new rules agreed for the second stage of the transition period for the commodities subject to the transition by stages, and 3) the 1992 CAP reform and 1993 European single market. Table 2.3 compares Portuguese and Community institutional output prices for 1985 and 1991 which excludes the factor 3) of price harmonization. The price differences that were still observed in 1991 for horticultural crops, wheat, rice, butter, milk, olive oil and tomatoes were further reduced until elimination in 1993.

Table 2.7 - Comparison of Institutional Prices between Portugal and the EC
for 1985 and 1990

Item	85/86			90/91		
	Portugal	EC	Portugal/ EC (%)	Portugal	EC	Portugal/E C (%)
	(ECU per Tonne)					
Oranges	-	-	77.3	246.4	309.6	79.6
Apple	-	-	74.8	257.5	320.1	80.4
Pears	-	-	61.6	188.9	276.5	68.3
Soft Wheat	308.0	179.4	171.6	210.8	174.0	121.1
Durum Wheat	354.8	312.1	113.7	243.7	221.8	109.9
Barley	277.6	179.4	154.7	165.4	165.4	100.0
Maize	282.6	179.4	157.5	174.1	174.1	100.0
Rye	283.7	181.2	156.5	165.4	165.4	100.0
Sorghum	265.7	179.4	148.1	165.4	165.4	100.0
Rice	344.2	314.2	109.5	344.6	314.2	109.7
Milk	356.5	274.3	130.0	320.5	268.1	119.5
Butter	3132.0	3132.0	100.0	2839.9	2927.8	97.0
Milk Powder	3317.6	1740.4	190.6	2070.0	1724.3	120.0
Red Wine[a]	2.4	3.4	68.7	3.2	3.2	100.0
White Wine[a]	2.2	3.2	67.8	3.2	3.2	100.0
Beef	3041.1	3439.3	88.4	3444.0	3444.0	100.0
Pork	2239.8	2033.3	110.2	1897.0	1897.0	100.0
Olive Oil	2125.4	2276.2	93.4	2079.4	2162.4	96.2
Sunflower	516.7	573.5	90.1	583.5	583.5	100.0
Tomatoes	57.8	97.2	59.5	77.9	88.9	87.6

Source: Varela (1987) and Commission (1990b)
- not available
[a] - ECU per hectolitre

The evolution of Portuguese agricultural products prices during the first stage of the transition period was defined by a general decrease in prices, expressed in real terms, as shown in Figures 2.1 to 2.4. The exceptions were horticulture, permanent crops and calves that benefited from price increases in real terms. Between 1985 and 1990, agricultural prices decreased 9.0, livestock products 27.9, while crop products increased 13.6 percentage points as a result of the price increases of horticulture and permanent crops, although all the other crop prices have decreased. During the same period variable input prices decreased 22.9, while fixed input prices increased 5.7 percentage points. The data available for the second stage show that between 1990 and 1993 total output prices had a further reduction of 30.0, crop products 40.4 and livestock 20.7 percentage points. To compensate to a certain extent the output price reductions, the price of variable and fixed inputs had further decreases of 16.1 and 15.3 percentage points respectively.

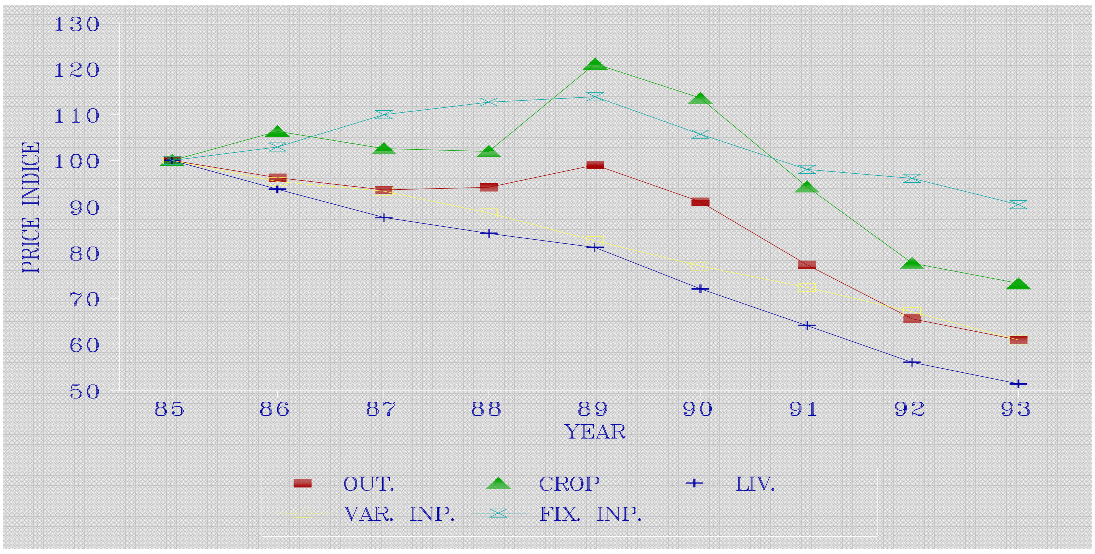


Fig. 2.1-Output and Input Real Price Indices (1985=100)

Source: INE

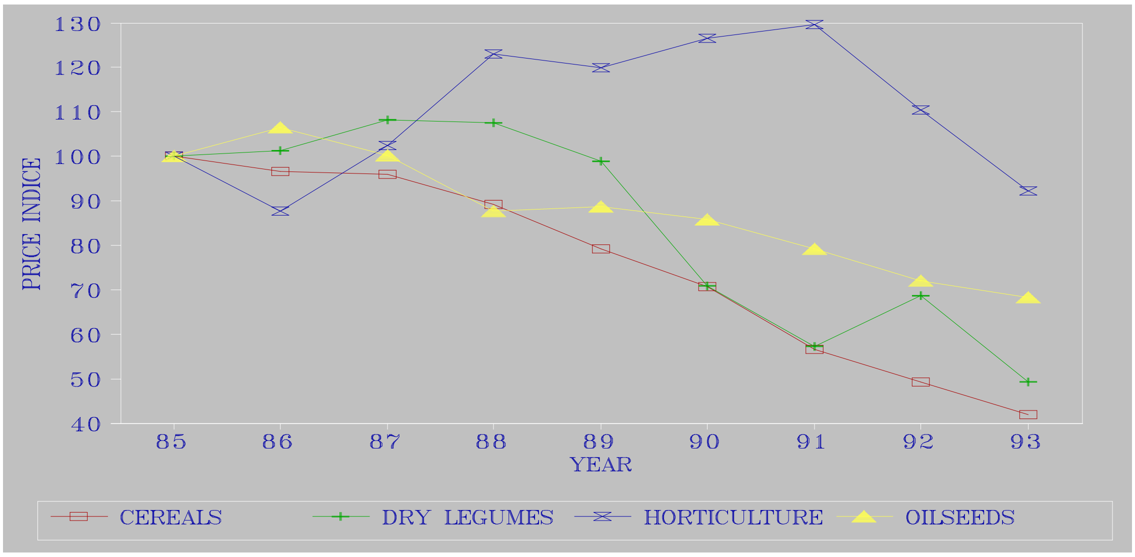


Figure 2.2 - Annual Crops Real Price Indices (1985=100)

Source: INE

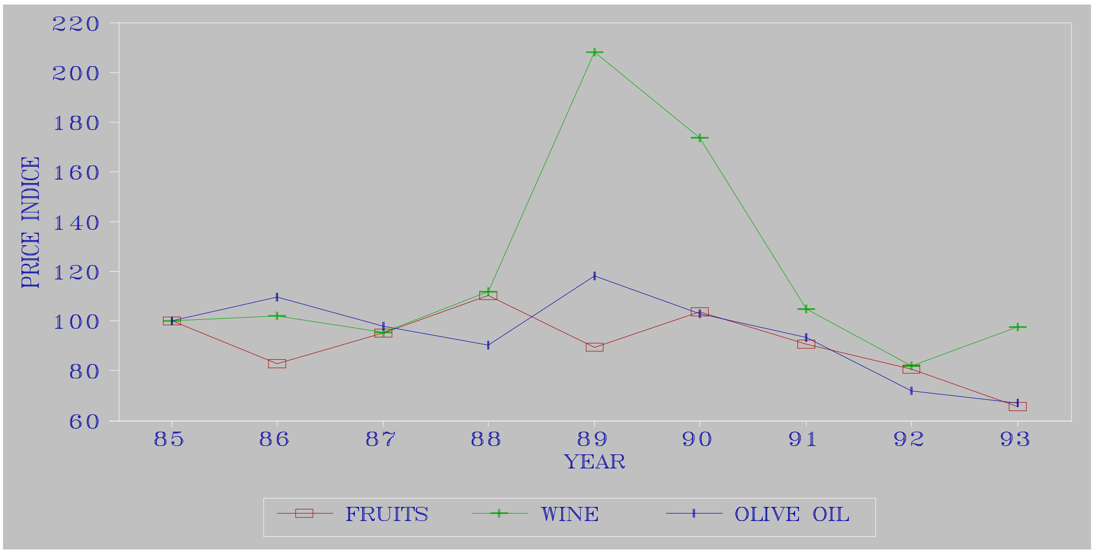


Fig. 2.3- Permanent Crops Real Price Indices (1985=100)

Source: INE

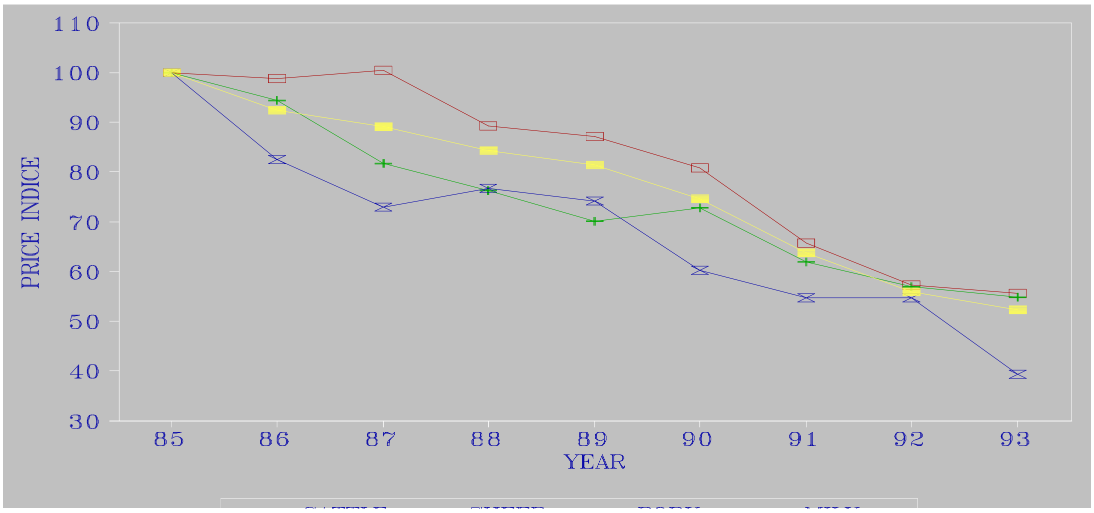


Figure 2.4 - Livestock Real Price Indices (1985=100)

Source: INE

Regarding agricultural product, the period between 1980-1992 was characterized by a decrease in total agricultural product expressed in real prices as shown in Figure 2.5. The comparison of average values for the periods 1980-1985, 1986-1990 and 1991-1992 shows that total agricultural product decreased 3.0 percent in the first stage of the transition period, and 18.0 percent in the first two years of the second stage. Between 1986-1990 the decrease in agricultural product was due to a reduction in the crop product of 7.5 percent (the livestock sector increased 0.2 percent), while during the second stage both sectors showed a decrease of 16 percent and 21.3 percent respectively. Cereals, processing crops, horticulture and milk were the sub-sectors that showed a positive evolution during the first stage, and fresh vegetables and olive oil in 1991-1992. The proportion of crop and livestock product to total product did not suffer changes during the period of analysis and their share in total product is similar. However, as shown in Figure 2.6 by sub-sectors, vegetables, and milk increased their shares by 3.8 and 3.5 percentage points, while wine and meat decreased their shares by 5.6 and 2.5 percentage points respectively.

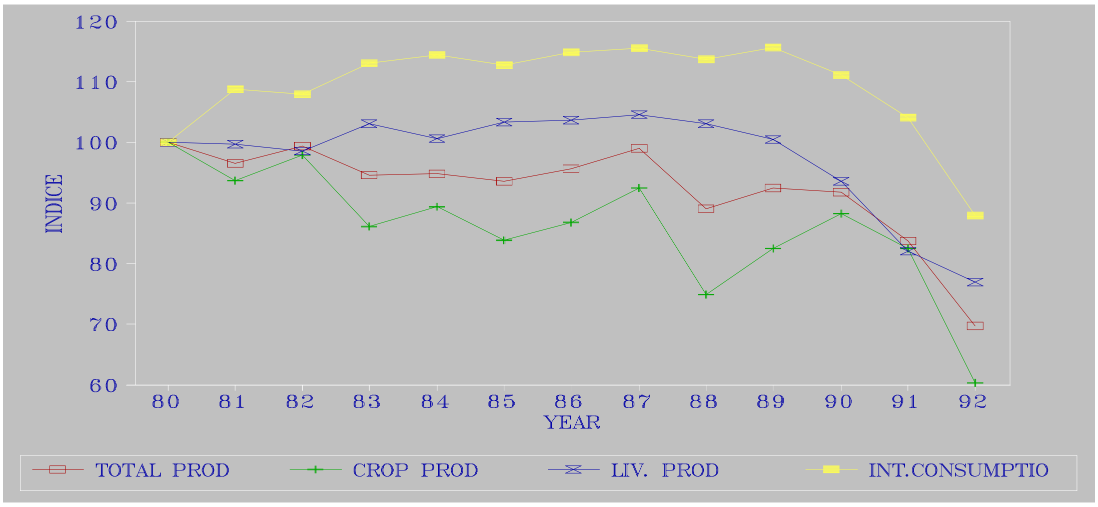


Figure 2.5 - Real Indices of Total, Crop and Livestock Output (1980=100)

Source: INE

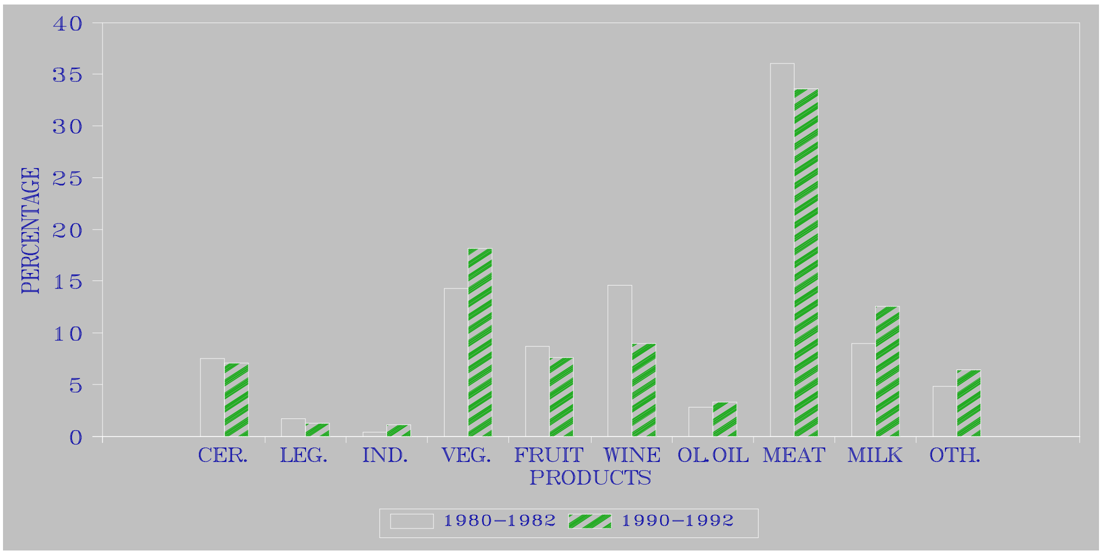


Figure 2.6 - Structure of Agricultural Production in 1980-1982 and 1990-1992

Source: INE

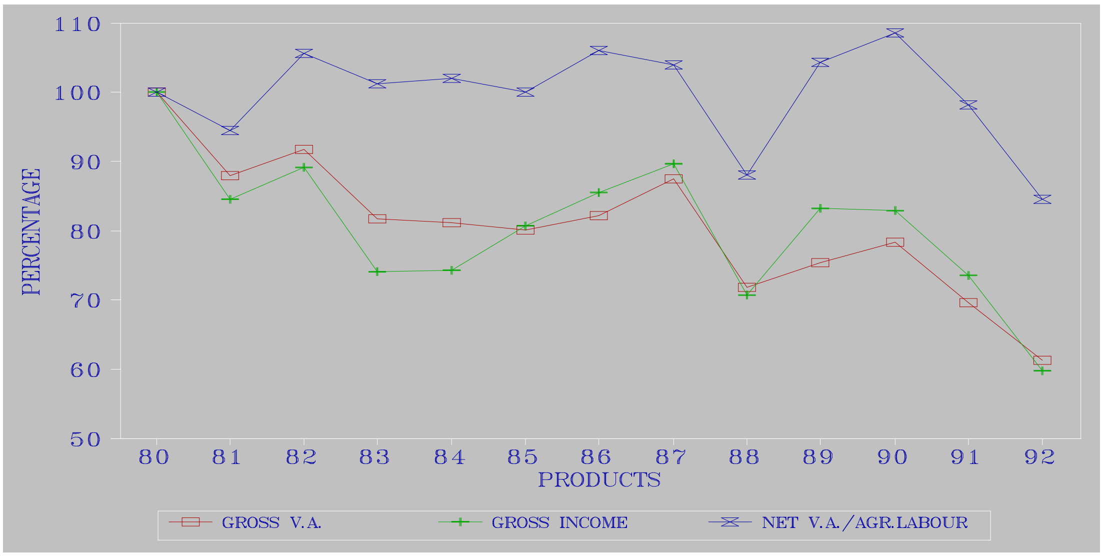


Figure 2.7 -Real Indices of Gross Value Added, Gross Income and Net Value Added per Agricultural Labour (1980=100)
Source: INE

With respect to income, on average total gross income generated in agriculture decreased 1.7 percent during the first stage and 19.1 in the first two years of the second stage, while the net value added per total labour unit increased 1.6 percent during the first stage and decreased 10.6 percent during the second stage (Figure 2.7). The amount of total direct subsidies increased four times during the first stage and represented on average 9 percent of the total gross value added. The importance of direct subsidies that have been increasing since 1986 accounted for 21 percent of the gross value added generated by agriculture between 1991-1992 (INE).

The comparison of agricultural product per labour unit, hectare and farm between Portugal, Spain and the EC for the period 1981 -1993, as well as the gap between Portugal and the EC is shown in Figures 2.8 to 2.10. For labour and farm productivity there was not a significant improvement in the productivity levels of Portuguese agriculture when compared with the EC as can be seen by the increasing absolute gap and the maintenance of the ratios Portugal/EC around 16 and 22 per cent respectively. This means that the amount of labour employed and number of farms are a barrier to improvements in productivity levels, although as seen below during that period considered there was a substantial reduction in the amount of labour utilized and in the number of farms. Land productivity increased from around 40 per cent in 1985 to 50 percent of the EC average after 1990, reaching levels similar to the ones observed in Spain.

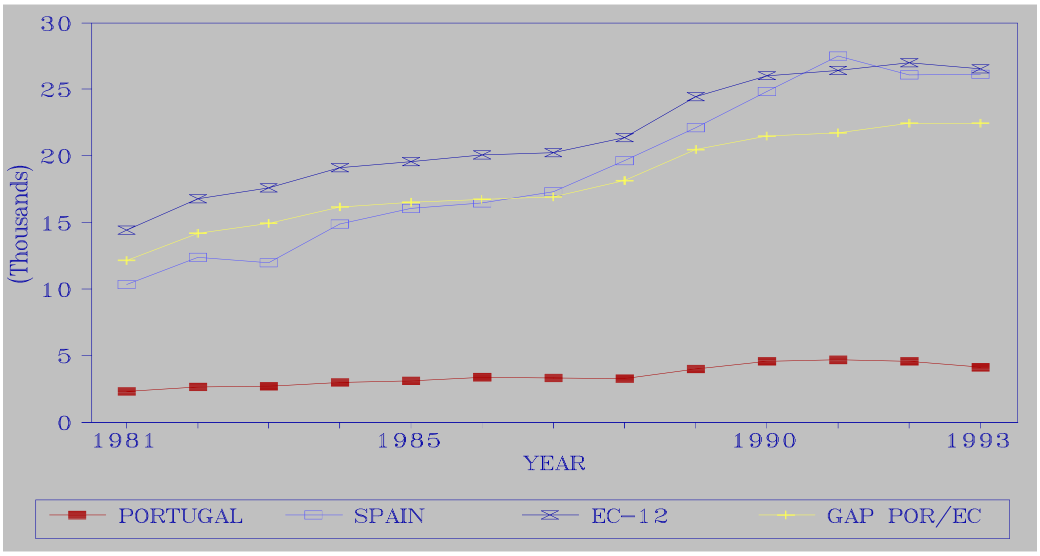


Figure 2.8 - Agricultural Product per Labour Unit for Portugal, Spain and the EC

Source: EC (1994) and EC (1995)

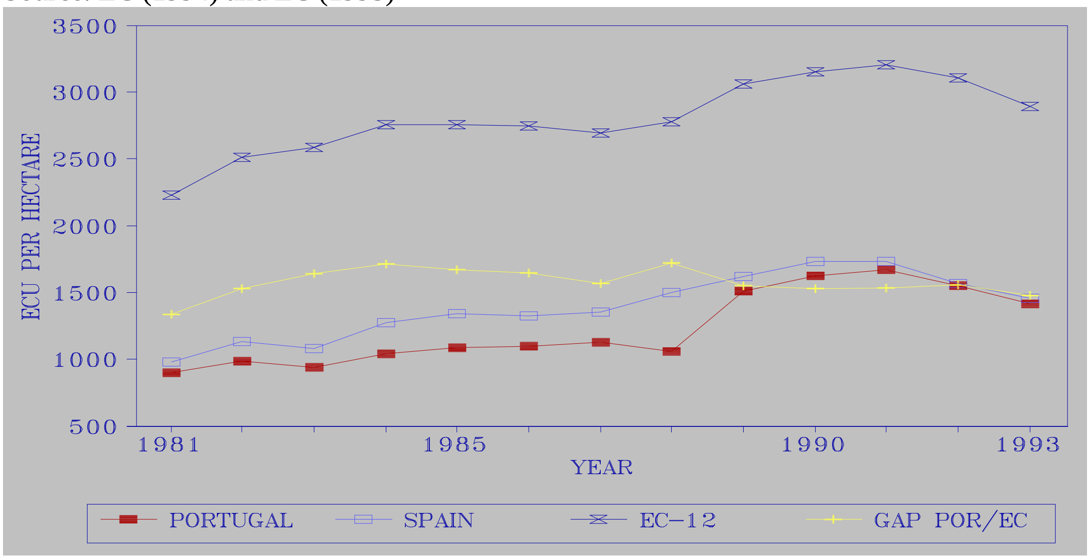


Figure 2.9 - Agricultural Product per Hectare for Portugal, Spain and the EC

Source: EC (1994) and EC(1995)

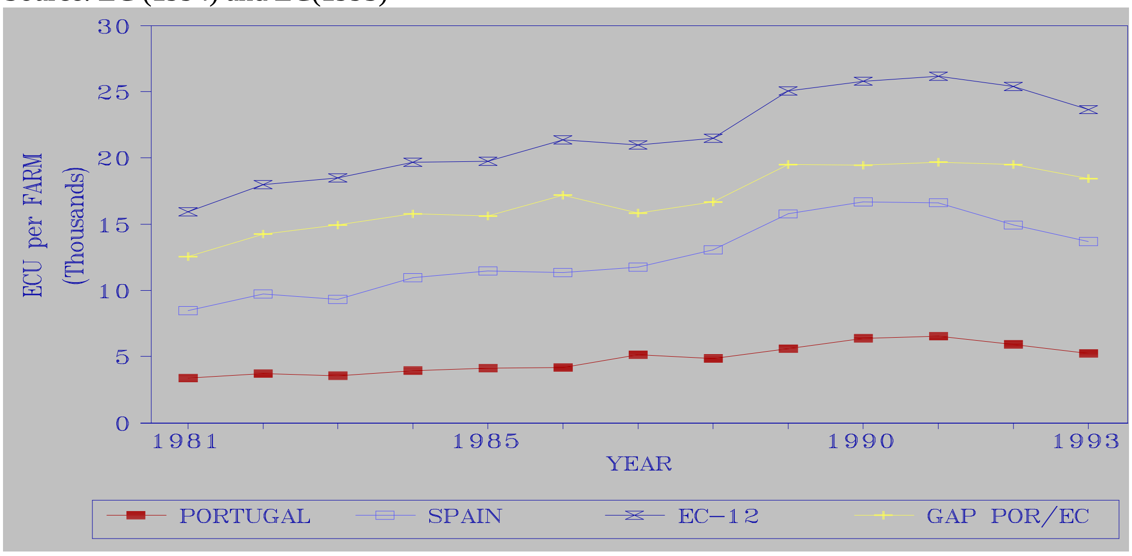


Figure 2.10 - Agricultural Product per Farm for Portugal, Spain and the EC

Source: EC (1994) and EC (1995)

The application of EC Regulations after 1986 was associated with a substantial increase in agricultural investment. Total agricultural investment expressed in real terms increased three times during the period 1986-1991 when compared with the period 1980-1985, while agro-industrial investment increased 5 times. These values show that Portuguese farmers responded very positively to the investment incentives contained in EC Regulations and to the positive economic environment observed between 1985 -1990. However, after 1990 total investment showed a tendency to decrease, possibly reflecting the deterioration of the economic environment and the uncertainty resulting from the application of the transition rules negotiated for the second stage. The majority of the agricultural investment through Regulation 797 was directed to machinery and equipment (49.7 per cent), agro-industrial investment through Regulation 355 was concentrated in the fruits and vegetables, wine, milk and livestock sectors that accounted for 86.5 percent of the total, while the investment projects financed by the PEDAP programme were mainly directed to electrification and rural roads, forestry, irrigation and drainage, and animal disease control which represented 72.9 percent of the total. Joaquim (1994), in a study about the impact of agricultural investment after 1986, concluded that during the period 1987-1993 capital productivity increased 40 percent, which helped to offset partially the reduction in income due to the negative evolution of agricultural prices.

After 1986, agricultural investment in the Alentejo was on average around 25 per cent of total investment in agriculture excluding the PEDAP programme. The Alentejo contribution was greater for the Regulation 797 (31.1 per cent) and lower for the Regulation 355 (12.7 per cent) and the wine programme (11.2 percent). The Alentejo share for total investment in machinery and equipment and livestock was around 38 and 50 per cent respectively. The composition of the agricultural investment in Alentejo through Regulation 797, machinery and equipment was dominant with 62.7 per cent, greater than the national average of 49.7 per cent, while livestock and buildings contributed with 13.8 and 12.7 per cent respectively. It is usually pointed out that a significant proportion of the investments in machinery and equipment were for substitution of old machinery and equipment. Among livestock, cattle for beef and sheep were dominant with 59.6 and 32.8 per cent respectively.

The amount of total labour in agriculture has been consistently decreasing during the last decades. During the period 1980-1985 total agricultural labour decreased 15.1 percent, 10.9 per cent in the period 86-90, and 8.6 per cent between 1991-1993. The labour changes seen between 1980-1985 and 1986-1990 were mainly due to decreases in agricultural family labour, while during the period 1991-1993 labour decrease was shared between family and hired labour. In the Alentejo region, the total labour engaged in agriculture decreased around 17 per cent during 1980-1985 and around 30 per cent in 1986-1990. It is believed that further reductions in total labour employed in agriculture have occurred after 1990 reflecting continuing economic trends reinforced by the agricultural measures applied in the second stage resulting in a tendency for extensification of agricultural production in the region. This is confirmed by the social crisis that has emerged in certain municipalities with a significant proportion of the active population being unemployed.

The number of farms in Portugal has been decreasing with a substantial reduction in the last two decades as shown in Table 2.8. Between 1979 and 1989 the number of farms decreased around 30 per cent and between 1989 and 1993 around 20 per cent. This decrease in the number of farms is essentially concentrated on the smaller farm size classes (0-1 and 1-5 hectares) while for the larger farm size classes the number of farms have increased (20-50 and >50 hectares). The evolution of the number of farms in Alentejo region is slightly different as will be shown in the next chapter.

Table 2.8 - Number of Farms in Portugal in 1968, 1979,1989 and 1993

Area Classes	Number of Farms				Percentage Change		
	1968	1979	1989	1993	68-79	79-89	89-93
0-1	316440	348386	148467	91720	10.1	-57.4	-38.2
1-5	356100	329150	301182	253328	-7.6	-8.5	-15.9
5-20	116440	86455	78867	78149	-25.8	-8.8	-0.9
20-50	17716	12068	12557	13659	-31.9	4.1	8.8
>50	9233	8485	9050	9287	-8.1	6.7	2.6
Total	815929	784544	550123	446143	-3.8	-29.9	-18.9

Source: INE

With respect to trade, entrance into the EC was associated with an increase in trade with the other members of the Community (Table 2.10) and an improvement in the Portuguese balance of trade. There is considerable evidence of trade diversion. The ratio of total exports over imports improved between 1980-1985 and 1986-1990, passing from 55 to 67.1 percent, while the agricultural ratio only improved slightly from 40.6 to 42.2 percent (Tables 2.9). During the period 1980-1990 the contribution of the agricultural deficit to the total deficit of the trade balance remained around 22 percent. The total deficit decreased on average 5.2 percent between 1980-1985 and 1986-1990 while the agricultural deficit increased 5.1 percent. The agricultural deficit increased despite an 11.3 percent increase of agricultural exports compared to a rise in agricultural imports of 7.6 percent. Between the periods 1980-1985 and 1986-1990 the weight of agricultural imports and exports in the total has decreased 2.7 and 3.4 percentage points respectively, and represented during the period 1986-1990 an average of 12.5 percent of total imports and 7.7 percent of total exports.

Table 2.9 - Evolution of the Ratio Exports/Imports

Period	Total Exports/Imports (%)				Agriculture Exports/Imports (%)			
	Total	EC	Spain	Other	Total	EC	Spain	Other
80-85	55.0	81.1	33.6	38.7	40.6	180.4	71.3	24.9
86-90	67.1	74.2	53.5	54.5	42.2	68.3	39.3	27.4
92	61.2	61.5	54.1	57.8	37.2	39.0	35.1	34.2

Source: INE

Table 2.10 - Evolution of the Share of Imports and Exports by Origin

Period	Imports						Exports					
	Total			Agriculture			Total			Agriculture		
	EC	Spain	Other	EC	Spain	Other	EC	Spain	Other	EC	Spain	Other
80-85	38.9	6.3	54.9	10.4	3.1	86.5	56.7	3.8	39.6	45.1	4.7	50.1
86-90	65.3	12.9	21.8	40.2	11.5	48.4	71.9	10.5	17.6	61.4	10.5	28.1
92	73.8	16.6	9.6	61.7	15.5	22.8	75.0	14.8	10.2	64.7	14.6	20.7

Source: INE

The Community share of total Portuguese imports and exports increased from an average of 38.9 and 56.7 percent in the period 1980-1985 to 65.3 and 71.9 percent in the period 1986-1990 respectively. Trade of agricultural products followed this trend and the Community market share of imports and exports increased from 10.4 and 45.1 percent in 1980-1985 to 40.2 and 61.4 percent in 1986-1990 respectively. Trade diversion is a consequence of adoption of the CAP. This increase in market share was accompanied by an increase in the trade deficit with the Community in both total and agriculture. The ratio of total exports over total imports with the Community decreased from 81.1 percent to 74.2 percent, while the agricultural sector that used to have a surplus before 1986 showed an average deficit of around 30 percent between 1986-1990. Between 1980-1985 and 1986-1991 imports from the Community increased 326.8 and exports 52.8 percentage points, while trade with the rest of the world decreased 29.2 in imports and 22.8 percentage points in exports, indicating that the entrance into the Community originated trade creation and diversion.

The composition of the agricultural trade changed between 1980-1985 and 1986-1990 (Table 2.11). Regarding imports there was an increase in the share of livestock (13.8 percentage points) and agricultural processed products (7.9 percentage points), while crop products that constitute the main source of imports decreased their share by 21.8 percentage points, from 66.2 to 44.4 percent. Agricultural exports dominated by processed products (around 70 percent of total exports) showed an increase in the share of livestock (10.9 percent) and crop products (2.5 percent), while oils and processed products decreased 7.7 and 5.7 percentage points respectively. Between 1980-1985 and 1986-1990 there were slight improvements in the deficit trade balances of livestock and crop products, while the surplus in oils and processed products was reduced drastically, explaining to a certain extent the increase in the trade deficit of agriculture. For livestock both the import and export share increased, leaving the trade coverage (exports:imports) largely unchanged. For crop product the import share declined significantly, as did the trade coverage. For processed products the import share increased and the export share decreased, worsening the trade coverage.

Table 2.11 - Agriculture Exports/Imports Proportion and Composition of Agricultural Trade

Period	Exports/Imports (%)				Imports (%)				Exports (%)			
	Livestock	Crop	Oils	Processed	Livestock	Crop	Oils	Processed	Livestock	Crop	Oils	Processed
80-85	19.8	5.2	262.3	204.2	15.8	66.2	2.1	15.9	7.5	8.6	13.2	70.7
86-90	23.9	8.7	151.0	125.0	29.6	44.4	2.2	23.8	16.8	9.0	6.9	67.3
92	21.4	11.0	102.1	83.9	31.9	37.3	2.0	28.8	18.4	11.1	5.5	65.0

Source: INE

2.4 - SUMMARY

The entrance into the EC in 1986 sets an important mark in terms of development of Portuguese agricultural policies and the agricultural sector. Before 1976, the most important changes in the agricultural policies occurred with the creation of a corporate structure that regulated the agricultural sector from the thirties until 1974, the incentives established in the sixties when the agricultural sector was not able to follow the development of the other sectors of the economy, the changes which occurred as a consequence of the revolution of 1974 such as the abolition of the corporative bodies and the agrarian reform. The period 1974-1986 was characterized by the abolition of input subsidies and the expectation of entrance into the EC. After 1986, Portuguese agricultural policies were limited by the transition agreements until 1990, and after that period the decision taken to accelerate the integration meant that EC rules were almost fully applied to Portuguese agriculture.

As a result of the agricultural policies implemented since the sixties, Portuguese prices and the profitability of the agricultural activities were higher than would have been the case in the absence of the policies as established by Avillez, Finan and Josling (1993). Although the incentives used to induce modernization of the agricultural sector had grown since the sixties, the gap between Portuguese and EC agriculture was still substantial before the entrance into the Community. A substantial proportion of the active population was still employed in agriculture, farms were small, yield levels were low, and labour, land and farm productivity indices were well below the Community average.

The entry into the EC brought significant changes for Portugal regarding the agricultural policies pursued and the political decision-making process. After 1986, the development of Portuguese agricultural policies was guided by the transition measures agreed in the Treaty of Accession in which the common agricultural policies were gradually adopted. The result was the dismantling of what remained of the corporative organizational structure in terms of prices and markets, an increase in the level of competition faced by Portuguese agricultural markets and the adoption of the common structural policy.

The options taken by the Portuguese government in the 1990 negotiations regarding the second stage of the transition period, the reform of the CAP in 1992, and the implementation of the 1993 internal market, led to an acceleration of the integration of Portuguese agriculture into the Community. As a result, the price harmonization as well the market integration of Portuguese commodities were faster than what was initially agreed between Portugal and the Community.

As a result of the integration, the decision-making process of Portuguese agricultural policies gradually passed to Brussels and Portuguese interests considering its specific agricultural conditions had to be shared and reconciled with the other European members' interests. The degree of manoeuvre for the Portuguese government was successively decreasing as the different stages of the transition agreements were reached and diminished significantly with the acceleration of the integration of Portuguese agriculture decided upon between 1990-1992.

As was expected, the integration of Portugal into the Community had a significant impact on several aspects of the agricultural sector such as prices, income, output, trade, labour and investment. Agricultural investment increased substantially after 1986, but this inflow of resources into the agricultural sector did not correspond to an increase or even maintenance of the level of overall agricultural output. Farmers were induced to make investment after 1986 due to the favourable conditions of the EC regulations, but it appears that they did not have full information about all the changes that were supposed to occur after 1990 in the agricultural policies and the correspondent impact on the profitability of their activities and farms.

After 1986, Portuguese output prices decreased in real terms, which led to a decrease in returns to crop and livestock activities, agricultural income, and in labour profitability as well as greater demands in terms of competitiveness and marketing penetration. With respect to trade, a substantial increase in the market share of Portuguese agricultural imports and exports by Community members and a change in the trade balance from an excess to a trade deficit with the Community was observed. In spite of a substantial rise in the investment in agriculture through the EC Regulations after 1986, increases in yield levels as shown in the next chapter, and decreases in the number of farms and the agriculturally active population, land labour and farm productivity indices when compared with those of the Community are still very low and the gap between Portugal and the Community average has not diminished since 1986.

Since 1986, the Portuguese agricultural sector has been going through a period of structural adjustment in which two of the main visible consequences are the reduction in the agriculturally active population and in the numbers of farms. The agricultural policies agreed in 1990-1992 with the Community and that will be applied until the beginning of next century will have the role of accelerating this adjustment, eliminating the activities and farms that are inefficient and unprofitable.

The capacity of agriculture to adjust to the new conditions of competition without any social disruption will depend on the capacity of the other sectors of the economy to absorb the excess of labour that agriculture will gradually be releasing. This process will have a relative higher importance for the rural areas in which a significant proportion of the active population is made up of agricultural workers when compared with the areas in which farming is dominated by self-sufficiency agriculture and in those regions in which the level of industrialization is very incipient.

During 1992-1994, the first signs of a social crisis in the rural areas occurred with particular relevance for the Alentejo region. This region is characterized by having a significant number of the active population involved in the agricultural sector with a significant weight of agricultural workers and low levels of industrialization. The application of the Agreements for the second stage and the 1992 CAP reform has already caused a decrease in agricultural activity in the region and a significant increase in the number of unemployed agricultural workers without any viable alternative job because of the incapacity of the other economic sectors to generate new jobs and the limitations that these workers have in terms of age and skills.

The next chapters will be dedicated to characterize Alentejan agricultural resources and farming systems, to analyze the growth of Alentejan farms in the period 1987-1991, to evaluate the need to improve the levels of management and efficiency of Alentejan farmers and to simulate the effect of the 1992 CAP reform on nine selected Alentejan farms.

CHAPTER III - BASIC CHARACTERISTICS OF ALENTEJAN AGRICULTURE

This chapter examines the basic features of Alentejan agriculture, with the objective of identifying its main limitations and the constraints on the process of agricultural development. First an overview of the importance of the Alentejan economy in the national context is made and this is followed by the identification of Alentejo's agricultural resources and production characteristics as well as a description of their comparative changes in the last decade.

3.1 - THE ALENTEJO IN THE NATIONAL CONTEXT

The Alentejo region is located in the mid-south of Portugal as can be seen in Map 1.1. It is one of the seven Portuguese regions, has an area of around 30 percent of mainland Portugal (excludes the autonomous regions of Madeira and Azores) and contributes to around 6 percent of Portuguese total population. This results in a low population density of about 20, when compared with the national average of around 107, inhabitants per square kilometre. The low population density was the result of the emigration exodus which occurred during the sixties and the beginning of the seventies, which resulted in a demographic decline of 26 percent during that period, while in Portugal the population grew at a rate of 2 percent. The emigration resulted in one of the most aged active populations in the country and its rejunevation will be a long and difficult process. The percentage of retired people accounts for 31.3 percent of the total, while the percentage of total population aged more than 50 years is 37.9 percent.

In 1986 the Alentejo's contribution to national employment was around 5.6 percent (Table 3.1). By sectors of activity the primary sector (agriculture, forestry and fisheries) accounts for about 10.7 percent, while the secondary (which includes minerals extraction) and tertiary sectors had a very modest share of the total national employment at 3.0 and 4.7 percent respectively. The regional distribution of the active population by the different sectors of activity shows that agriculture still has the largest share with around 46.4 percent, followed by the tertiary sector with 36.0 percent and by the secondary sector with 17.6 percent (Table 3.2). The rate of unemployment of 12 percent in 1986 was very high by national standards, representing twice the national average.

Economic activity is modest in national terms. In terms of value added the region represents a national share of around 5.3 percent, while by sectors of activity agriculture shows the highest contribution with 19.4 percent. In the past, agriculture was the main activity in the region. However, during the last decades the tertiary and secondary sectors have emerged as the most important sectors of economic activity with around 40.6 and 31.2 percent of regional value added. Although industry and services emerged as the most important sectors, the agro-industrial sector contributes 43 percent, and retail and public administration represents more than 70 percent, of the value added of the secondary and tertiary sectors respectively. Economic activity is dominated by very small enterprises (less than 4 employees) which represent 99.1 percent of the total enterprises of the region.

Regarding labour productivity (value added per unit of labour), the Alentejo's primary and secondary sectors show higher levels than the national average, when comparisons are made within the same sectors, as shown in the last two columns of Table 3.2, but employment in the tertiary sector is less productive than in the economy as a whole. The comparison of labour productivity between the different sectors for Alentejo, shows that labour productivity on the primary sector is only around 60 per cent of the regional average, and 34 per cent of the value added per capita in the secondary sector. Nevertheless, in comparison with the primary sector in Portugal as a whole, that of Alentejo appears to be relatively prosperous.

Table 3.1 - The Alentejo's Contribution to Portuguese Value Added and Employment by Sectors of Activity

Sectors	Value added (%)		Employment (%)	
	1980	1986	1980	1986
Primary	17.1	19.4	10.8	10.7
Secondary	4.0	4.4	3.6	3.0
Tertiary	4.2	3.9	4.5	4.7
Total	5.4	5.3	5.9	5.6

Source: INE (1987)

Table 3.2 - Comparison between Portugal and the Alentejo by the Sectors of Activity for Value Added, Employment and Value Added/Employment (1986)

Sectors Activity	Value added (%)		Employment (%)		V. A./Labour Unit[1]	
	Alentejo	Portugal	Alentejo	Portugal	Alentejo	Portugal
Primary	28.2	7.7	46.4	24.1	678.2	375.6
Secondary	31.2	37.5	17.6	32.8	1967.4	1361.8
Tertiary	40.6	54.8	36.0	43.1	1264.2	1510.3
Total	100	100	100	100	1116.4	1187.8

Source: INE (1987)
[1] -10^6 Escudos

3.2 - AGRICULTURAL RESOURCES

The Alentejo region is a rolling plain with an average altitude between 200 and 250 metres. The climate is typically Mediterranean characterized by a prominent hot and dry season which coincides with summer. The annual rainfall is between 500 and 800 mm and concentrated mostly during the period October-March (80 percent). The average annual temperature is around 16 degrees centigrade but with maximum and minimum temperatures reaching values greater than 40 and below zero degrees centigrade during Summer and Winter respectively (Cary, 1985).

The annual distribution of rainfall, with a lack of rain at the end of Spring and during Summer, is a serious limitation in terms of agricultural production. With the exception of the irrigated areas, annual crops are of the Winter-Spring type (cereals, forages), while permanent crops are adapted to the Mediterranean conditions (olive trees and vineyards). In irrigated areas rice, maize, tomatoes and vegetables have been the dominant crops. The principal livestock activities are cattle, sheep and pig in general associated with dryland farming systems either as a principal or complementary activity.

3.2.1 - Soils Capability, Land Use Patterns and Average Yields

The Alentejo region shows a large diversity of soil types because they originate from a large variety of rocks. On average, soils are thin, with low levels of organic matter and poor drainage. Their potential for agricultural production can be judged from Table 3.3, where soils are divided into 5 land-use classes considering their suitability for cereal production. The first two classes, which account for 20 percent of the total area, are suitable for intensive agriculture, while class C with 17 percent of the total area shows limitations for intensive cereal production. Soils belonging to land-use classes D and E (63.2 percent) show drastic restrictions for agricultural production and are mainly recommended for pasture and forestry use. Although only 37 percent of the soils are recommended for direct agricultural use, agricultural systems based on cereals are found on 60 percent of Alentejan soils (Sobral e Marado, 1987). The reasons for this are found in the Portuguese price policies pursued before 1986, referred to in the last chapter, regarding cereals and livestock activities, which made possible cereal production in marginal areas.

Table 3.3 - Land Use Classes of Alentejo Soils

Land Use Classes	% of Total Land	Agricultural Use
A	10.1	Intensive Agriculture
B	9.5	Moderate Intensive Agriculture
C	17.0	Low Intensive Agriculture
D	24.0	Pasture and Forestry
E	39.2	Forestry and Natural Vegetation

Source:Sobral e Marado (1987)

Land-use patterns are directly related to the agricultural systems practised in the region. The majority of the agricultural systems are of dryland type, although irrigated systems are present. The dryland agricultural systems are based on rotations in which cereals have been the dominant economic activity. The duration of the rotations depends on soil potential. In zones with the best soils, rotations are short (two to three years), in which forages and fallow are almost absent and livestock activities when present are mostly restricted to sheep as a complementary activity to cereal production. In zones with poor soils, rotations are longer and forages and fallow have an important role in terms of livestock production, dominated mainly by cattle and sheep activities.

The irrigated systems are mostly confined to zones where public dams were built, which correspond to 80 percent of total irrigation capacity, and the total irrigated area accounts for 4.2 percent of agricultural land. However, 43.6 percent of the irrigation capacity has not been used (Avillez et al., 1988). The reasons underlying the under use of irrigation capacity are the adoption of agricultural systems not adjusted to the natural conditions of soil and climate, the expansion of the irrigation to soils with inadequate characteristics, inefficient land structure, lack of knowledge of irrigation technologies by farmers and deficient irrigation infrastructure (Cary, 1985).

Considering the distribution of crop production and forestry, and based on the nineteen agro-ecological zones defined by Sobral and Marado (1987), Silva (1990) aggregated the nineteen agroecological zones in ten Alentejan agricultural systems. The agricultural systems defined can be divided into two groups: six crop systems and four forestry systems as shown in Map 4.1 in next chapter. Five of the crop systems are located in the interior region of the Alentejo, being four made up of annual crops and one composed of permanent crops, while the remaining crop system is a mono-cultural irrigated system located on the coast and based on rice. The forestry crop systems are located in the coastal region with the exception of the mountain system, which is dispersed over the region. These agricultural systems will be characterized in more detail in the next chapter where the agricultural systems to be studied are selected.

Land-use patterns in 1979 and 1989 are shown in Table 3.4, based on the 1979 and 1989 agricultural censuses. In general terms, there was a decrease in the area of fallow land, permanent crops and forestry. The decrease in fallow has not been reflected in an increase in annual crops, indicating that overall the relative importance of land use in annual crop production has declined. The area of permanent pastures reported are not directly comparable because of changed definitions in the census forms, but it seems likely that marginal lands were taken out from the production of annual crops and put into permanent pastures.

Table 3.4 - Comparison of Land-Use Patterns Between 1979 and 1989 in the Alentejo Region

Activities	1979 (Ha.)	1989 (Ha.)	% Change
Permanent Crops	176255	169037	-4.1
Permanent Pastures[1]	35150	392060	1015.4
Annual Crops	593929	660920	11.3
Fallow	867874	669399	-22.9
Forestry	737208	576365	-21.8
Permanent Crops			
Fresh Fruits	7080	8835	24.8
Dried Fruits	900	1886	109.6
Vineyards	12343	12790	3.6
Olive Trees	154698	144957	-6.3
Annual Crops			
Cereals	479627	424335	-11.5
Legumes (Grain)	29120	6215	-78.7
Processing Crops	40160	63592	58.3
Annual Forages	59679	127413	113.5
Temporary Pastures	39059	28544	-26.9
Fresh Vegetables	18243	12846	-29.6

Source: INE (1979) and INE (1989)

[1] - the values of 1979 and 1989 are not directly comparable because of changed definitions.

Regarding annual crops, the significant increases in the area of annual forages and processing crops indicates that farmers have consolidated the use of annual forages and sunflower in their rotations. Sunflower, accounting for around 80 percent of the area of processing crops, has been increasing steadily in the last two decades, showing that its profitability and competitiveness has an important role in the present and future development of some Alentejan farming systems. The area of cereals decreased 11.5 percent mainly due to a decrease in the area of rye and oats, while the area of wheat, accounting for around half of the area of cereals, decreased slightly (2 percent).

When annual data (not reported here) is used to analyze changes in the area of winter cereals during the last two decades, one can conclude that a structural break occurred between the period 1976-1977. Wheat was the cereal that contributed most to the substantial reduction seen, while the area of summer cereals showed a structural break during the period 1982-1983.

Between the two census dates, the area of fresh vegetable crops decreased 29.6 percent, and this could be partially associated with the decrease in the number of very small farms. The area of permanent crops is occupied mainly by olive trees (85.7% percent) and the decrease observed was due to reductions in the area of olive trees and figs as a result of taking out of production old plantations and marginal areas of those activities. The area decrease was compensated to a certain extent by increases in the area of apples, peaches, citrus and dried fruits.

With respect to irrigated activities, rice, tomatoes, corn and horticulture crops are the most important. Rice occupies around 48.3 percent of the irrigated area and is cultivated as a mono-rotational activity. During the last decade there has been a tendency for a decrease in the area of tomatoes and slight increases in the area of summer cereals, but they have never reached the levels observed before 1983. After 1983, the area of maize has increased, while the area of rice showed significant inter-annual variations which are principally associated with water availability (Avillez, 1988).

Regarding crop yields in Alentejo region, Figures 3.1 to 3.3 show the average yields between 1970 and 1990 for wheat, barley, sunflower, maize, rice and tomatoes. The values reported are three year moving averages to reduce the effects of annual weather variations and other random factors. For wheat, barley, rice, maize and tomatoes there was a downward trend in yield levels between the mid seventies and beginning of the eighties and after that period yields have been with an upward trend. For rice the average yield levels have been with an upward trend, while for sunflower average yield have not shown an obvious trend mainly as a result of weather variations.

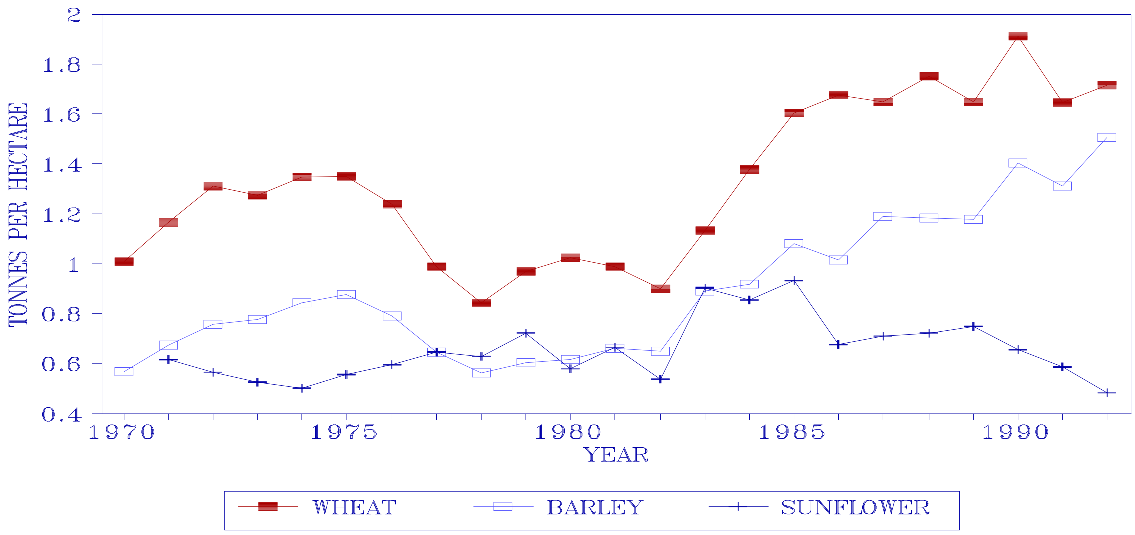


Figure 3.1 - Average Yields Between 1970 and 1992 for Wheat, Barley and Sunflower

Source: INE

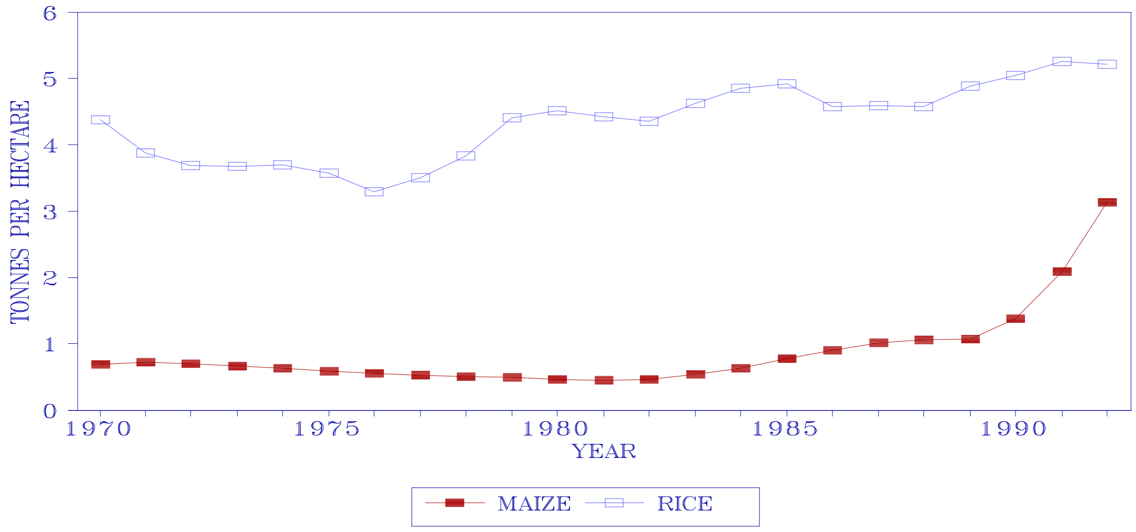


Figure 3.2 - Average Yield Levels Between 1970 and 1992 for Rice and Maize

Source: INE

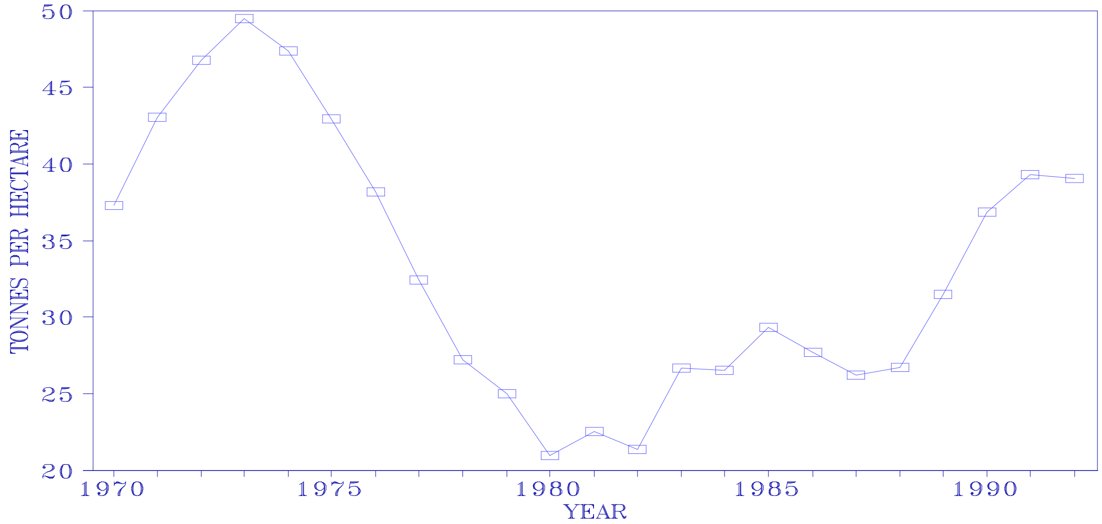


Figure 3.3 - Average Yield Between 1970 and 1992 for Tomatoes

Source: INE

3.2.2 - Farm Structure

The Alentejan farm structure has experienced changes during the last two decades, due to the agrarian reform that took place in the region during the middle seventies as noted in the last chapter, while during the eighties most of the land occupied and nationalized was returned to the old landlords. The effect of these changes on farm structure was an increase in the number of farms belonging to the larger farm size classes between 1979 and 1989. The medium (50-200 hectares) farms increased 16 percent and the large ones (> 200 hectares) 31 percent (Table 3.5). The reason underlying those increases are based on the fact that: 1) the farms that were occupied in the seventies to create the agricultural production cooperatives were in general the larger ones, and in many cases agricultural production cooperatives were the result of merging one or more of the occupied farms and 2) in some situations the farms that were returned to the previous landlords during the eighties were divided among the heirs either because of family reasons or to maximize in legal terms the return of the occupied land. Thus, average farm size in the > 200 hectares category fell from 814 hectares in 1979 to 527 hectares in 1989.

Table 3.5 - Number and Area of Farms, and Percentage Changes by Farm Size Classes between 1979 and 1989

Farm Size Class Ha.	1979				1989				% Change 79-89	
	Number	%	Area	%	Number	%	Area	%	Number	Area
< 1	11643	23.2	6436	0.3	6147	13.1	5800	0.3	-47	-10
1-50	33497	66.9	233008	11.0	34863	74.1	328350	16.4	4	41
50-200	3145	6.3	400085	18.9	3651	7.8	415442	20.7	16	4
>200	1816	3.6	1477570	69.8	2388	5.1	1257683	62.7	31	-15
Total	50101	100	2117099	100	47049	100	2007275	100	-6	-5

Source: INE (1979) and INE (1989)

The number of farms in the small (1-50 Ha.) farm size class also increased 4 percent, and the total area farmed by these farms by 41 percent. It is believed that in part the factors referred to above contributed to this change, but also the land distribution schemes implemented by the government, principally in irrigated zones, were important. Regarding the very small farms (< 1 hectare), the number was reduced almost fifty percent and two reasons could explain this outcome. First the methodology used in the agricultural censuses of 1979 and 1989 was different regarding the minimum area considered for the enquiries, and second it is believed that many of these small economic units were naturally abandoned because of financial reasons. In overall terms, the number of farms fell by 6 per cent between 1979 and 1989 and recent data (INE, 1995) that is displayed in Table 3.6 shows that a further reduction of 20.3 per cent occurred between 1989 and 1993, with the vast majority of the farms that disappeared (98.7 per cent) being smaller than 50 hectares.

Table 3.6 - Number and Area of Farms, and Percentage Change between 1989 and 1993

Farm Size Classes	1989		1993		% Change 89-93	
	Number	Area	Number	Area	Number	Area
0 -1 Hectares	6147	5800	5026	7587	-18.2	30.8
1-50 Hectares	34863	328350	26553	276338	-23.8	-15.8
>50 Hectares	6039	1673125	5911	1605247	-2.1	-4.1
Total	47049	2007275	37490	1889172	-20.3	-5.9

Source: INE (1989) and INE (1995)

In 1989, average farm size in the Alentejo was 42.7 hectares and the number of farms with two or less plots accounted for 77.8 percent of the number and 61.5 percent of the area, which indicates a low level of farm dispersion. The distribution of the number of farms and their size by the different farm size classes in the Alentejo region is skewed towards small farms and large farms respectively. Small farms (less than 50 hectares) accounted for 87.2 percent of the number of farms and used 16.7 percent of the land, while large farms accounted for 5.1 percent of the number and used most of the land (62.7 percent).

The land policies implemented in the region during the last two decades has had an impact not only on the number of farms but also on land ownership and types of agricultural producers. The percentage of land rented has decreased from 58.5 to 35.7 percent, while the percentage of land owned has increased proportionally (Table 3.7). In absolute terms these changes correspond to a decrease of 49.4 and an increase of 28.7 percent in the area rented and owned, respectively. By farm size, small and large farms own the majority of their land, while for medium sized farms land owned and rented is represented in almost equal proportions. Short term land renting is irrelevant since 94.3 percent of rented land is under long term agreements.

Table 3.7 - Area Owned and Rented in 1979, 1989 and by Farm Size Classes

Year	Owned		Rented	
	Area	%	Area	%
1979	853006	41.5	1204468	58.5
1989	1097677	64.3	609021	35.7
% Change	28.7		-49.4	
By Farm Size Classes (Ha.) - 1989				
0-50	184504	70.3	78108	29.7
50-200	187976	51.8	175245	48.2
>200	725197	67.1	355668	32.9

Source: INE (1979) and INE (1989)

Agricultural producers have been classified for the agricultural census in different types: autonomous producers, entrepreneurial producers, cooperatives and corporations. Autonomous producers are typified by using mainly family labour in their farm operations, entrepreneurial producers are characterized by employing principally hired labour, while cooperatives and corporations are defined in accordance with the general laws for cooperatives and corporations. Regarding changes observed in the type of agricultural producers, the first effect of the changes in the land policies in the region was the reduction in the number of agricultural cooperatives from 427 in 1979 to 139 in 1989. Agricultural cooperatives were not important in terms of the number of total farms but only in terms of agricultural land utilized. As a result the percentage of land held by cooperatives was reduced from 39.1 in 1979 to 8.6 percent in 1989 (Table 3.8). During the same period the number of entrepreneurial producers decreased, while the number of autonomous producers and corporations increased. The total area controlled by entrepreneurial producers increased by 15 percentage points. Autonomous producers are concentrated in small and medium farm size classes, while entrepreneurs, corporations and cooperatives belong principally to the large farm size class.

Table 3.8 - Percentage of Number of Farms and Area by the Different Types of Agricultural Producers in 1979, 1989 and by Farm Size Classes

Year	Autonomous		Entrepreneur		Corporations		Cooperatives		Others	
	Number	Area	Number	Area	Number	Area	Number	Area	Number	Area
1979	87.0	26.8	9.9	24.4	2.1	5.4	0.9	39.1	0.2	4.3
1989	89.4	37.2	7.7	39.5	2.3	13.5	0.4	8.6	0.2	1.2
Farm Size Classes (Ha.) - 1989										
0-50	94.9	90.8	3.5	7.1	1.5	1.9	0.0	0.1	0.1	0.2
50-200	71.7	67.9	24.0	27.5	3.6	4.0	0.4	0.4	0.2	0.2
>200	23.4	14.9	55.2	50.9	14.6	19.3	5.9	13.2	0.8	1.8

Source: INE (1979) and INE (1989)

3.2.3 - Labour Characteristics

The most important labour features of Alentejan producers did not undergo substantial changes during the last decade. The comparison of the data reported in the agricultural census of 1979 and 1989 shows with respect to age and education levels that agricultural producers remain an aged population and still exhibit low levels of education. The number of farmers more than 40 years of age was maintained (around 90 %) almost unchanged (Table 3.9). However, the Alentejo's farmers got older since the percentage of farmers more than 65 percent years of age increased from 27.7 to 33.2. Agriculture was not able to recruit young farmers since their percentage remained almost equal between 1979 and 1989. The age structure between male and female farmers is very similar but for farmers more than 40 years of age female agricultural producers are slightly older than their male counterparts because of the higher longevity of the female population. It is relevant to note that between 1979 and 1989 the number of female producers increased 36.3 percent in the region and nowadays account for 11.0 percent of all producers. Although smaller, this change is similar to the one observed in other Portuguese regions and can be generalized to other categories of family labour and the agriculturally active population. The main cause for this phenomenon was the emigration of the male population to dynamic economic centres, while the female population stayed in the countryside because of family and economic reasons.

Table 3.9 - Percentage of Farmers By Age Classes and Sex

Age Classes	1979	1989	1989	
			Men	Women
< 25	0.9	0.9	1	1
25 - 39	9.3	9.8	10	10
40 - 64	62.1	56.1	57	50
> 65	27.7	33.2	33	39

Source: INE (1979) and INE (1989)

Regarding education levels, a reduction of 14 percentage points in the numbers of illiterate and 'able to read and to write' producers was observed (Table 3.10), while the producers with secondary and higher education doubled in percentage, but their representation is still very low (6.7 per cent). There is no significant difference between male and female producers, and by age classes the structure of the education levels is as one would expect. The illiterate and 'able to read and to write' producers are concentrated in the older age classes, while the younger age class are dominated by producers with elementary education. This means that the majority of new farmers have only the minimum obligatory levels of education.

Table 3.10 - Percentage of Farmers by Levels of Education in 1979, 1989, by Sex and Age Classes

Year	Illiterate	Able to Read and to Write	Elementary	Secondary	Superior
1979	37.2	27.0	32.2	2.4	1.2
1989	30.6	19.5	43.2	4.7	2.0
By Sex - 1989					
Men	30.0	19.3	44.3	4.4	2.0
Women	35.2	20.3	34.9	7.4	2.2
By Age Classes - 1989					
< 25	1.0	2.8	69.2	24.9	2.1
25-39	1.6	4.7	70.6	18.5	4.7
40-64	25.1	19.0	49.9	3.9	2.1
> 65	49.2	25.1	23.2	1.4	1.1

Source: INE (1979) and INE (1989)

Both the age structure and education levels displayed show that in general terms they could be a limitation not only in terms of farmers' capabilities to adapt to new economic environments and to introduce innovations, but also in their ability to improve their own management skills either through professional training or other processes. The number of farmers with a complete professional training course is almost insignificant (1 percent) and this outlook does not suffer significant changes when analyzed by farm size classes (Table 3.11).

Table 3.11 - Professional Training by Farm Size Classes and Total - 1989
(Number of Farmers in Percentage)

Farm Size Classes (Ha.)	Without	Elementary	Complete
0 - 50	99	1	0
50 - 200	92	6	3
> 200	84	7	9
Total	98	1	1

Source: INE (1989)

Regarding the time spent working on the farm, the comparison of 1979 and 1989 data shows that in general terms the time spent farming has decreased. Regarding farmers spending less than 50 percent of their time farming, their percentage increased 9 percentage points, while the percentage of full-time farmers decreased 12 percentage points (Table 3.12). In 1989 the majority of farmers belonging to the small farm size class dedicated less than 50 percent of their time to working on the farm (67 percent), while in the medium and large farms size classes almost 50 percent of farmers were full-time. These results could be an indication that the percentage of part-time farming is increasing in the region. However, the percentage of producers with another earning activity decreased from 50 percent in 1979 to 39 percent in 1989. The substantial decrease in the number of farms less than 1 hectare could to a certain extent explain these contradictory results. Producers with an earning activity outside the farm are principally employed in the tertiary sector, while agriculture and industry accounts for 32 and 20 percent respectively.

Table 3.12 - Time Spent on Farm in 1979, 1989 and by Farm Size Classes
(Number of Farmers in Percentage)

Year	Time Spent on Farm (% of Full Time)		
	0 - 50	50 - 100	Full Time
1979	53	20	27
1989	62	24	15
By Farm Size Classes (Ha.) - 1989			
0 - 50	67	23	10
50 - 200	23	32	45
> 200	25	27	48

Source: INE (1979) and INE (1989)

With respect to hired labour, Table 3.13 summarizes the main changes that occurred between 1979 and 1989 concerning hired permanent and temporary jobs in agriculture. The Alentejo's hired labour is dominated by males (80 percent) in permanent jobs and by females (65 percent) in temporary jobs. During the period of analysis the number of permanent workers increased 1.8 percent, while the number of labour standard units of temporary jobs decreased 11 percent. In both cases the female population employed in agriculture decreased, by 0.4 percent in permanent jobs and 12 percent in temporary jobs.

Table 3.13 - Characteristics of Hired Labour

Item	% Change between 1989 and 1979	Item	% Change Between 1989 and 1979	Farms with Hired Permanent Labour (1989)	
				Farm Size Classes	% of farms
Hired Permanent Labour		Hired Temporary Labour		0 - 50 Ha.	23
Number of Farms	-0.3	Men	-8	51 - 200 Ha.	29
Men	2.4	Women	-12	> 201 Ha.	48
Women	-0.4	Total	-11	% of Total Farms with Permanent Labour	
Total	1.8				8

Source: INE (1979) and INE (1989)

The population of permanent workers is younger than the population of the Alentejo farmers. The percentage of permanent workers with less and more than 45 years of age accounts for 44 percent and 56 percent respectively. During the period of analysis the number of farms with permanent workers remained almost unchanged (-0.3 percent), accounting for 8 percent of total farms in the region, and around half of these farms belong to the larger farm size class.

3.2.4 - Capital

Alentejan agriculture accounts for around 16 percent of the total capital stock of Portuguese agriculture (Table 3.14), while by capital classes the contributions are higher than the average for plantations and livestock capital with 23 and 21.1 percent respectively. The capital structure of Alentejan agriculture is similar to that observed in Portugal and is dominated by land with around 62 percent of the total, while livestock and buildings have the smaller share with 5.7 and 7.0 per cent respectively.

The capital structure by the different capital classes shows that the contribution of the Alentejo to total Portuguese capital is around 45 percent regarding forestry and sheep, while in terms of irrigated land, and agro-industrial buildings and equipment, its contribution is very modest, representing less than 5 percent (Table 3.15). The structure of land capital in the Alentejo is dominated by dryland in the land class; plantations's capital is almost equally distributed between permanent crops and forestry, while machinery and cattle represent the majority of the capital in the machinery and equipment, and livestock classes, respectively. With respect to capital output and labour ratios, there is no difference between the Portuguese and the Alentejo capital output ratio, while the Alentejo capital labour ratio is around 44 per cent higher than the

Portuguese average, meaning that Alentejan agriculture is more capital intensive. when compared with Portuguese agriculture.

Table 3.14 -Percentage of Alentejan Agricultural Capital in Portugal and Capital Structure of Alentejan Agriculture in 1980

Capital Classes	Alentejo/ Portugal (%)	Percentage in Total	
		Alentejo	Portugal
Land, Plantations and Buildings	15.3	86.9	87.9
Land	14.8	61.6	64.3
Plantations	23.0	18.3	12.3
Buildings	9.6	7.0	11.2
Machinery, Equipment and Livestock	16.7	13.1	12.1
Machinery and Equipment	14.4	7.4	7.9
Livestock	21.1	5.7	4.2
Total Capital	15.5	100.0	100.0

Source: Rolo and Cordovil (1988)

Table 3.15 - Capital Structure of Alentejan Agriculture by Capital Classes and its Percentage in Portugal in 1980

Capital Classes	Alentejo/ Portugal (%)	% in Capital Class	Capital Classes	Alentejo/ Portugal (%)	% in Capital Class
Land			Machinery and Equipment		
Dry Land	25.3	89.0	Machinery	17.5	74.8
Irrigated Land	3.4	11.0	Equipment	11.8	21.6
Plantations			Agro-Industry	4.4	3.6
Permanent Crops	16.6	55.8	Livestock		
Forestry	44.1	44.2	Cattle	20.0	62.7
Buildings			Sheep	44.9	23.9
Livestock	16.1	26.9	Pigs	16.5	8.5
Agro-Industry	1.0	0.7	Other	8.9	5.0
Others	9.1	72.4			

Source: Rolo and Cordovil (1988)

The lack of data on the evolution of the level of capital of Alentejan farms does not allow a rigorous analysis. The data available was limited to the area of permanent crops in terms of fixed assets and to stock numbers of machinery and equipment, and livestock numbers regarding intermediate assets. Based on the area of permanent crops shown in section 3.2, one can say that no significant changes occurred in terms of this category of capital while for intermediate assets the levels of capital of Alentejan farms increased between 1979 and 1989.

Regarding machinery and equipment, there was a substantial increase in the number of tractors, forage combine, mowing and cereal combines between 1979 and 1989 (Table 3.16) and it is believed that the clarification of land ownership problems during the eighties, the development of the agricultural financing scheme (SIFAP) later substituted by the application of EC structural regulations, and a stable economic environment after 1985 were the main factors responsible for this positive change. As mentioned in the last chapter, more than 60 per cent of the investments made in the region under the EC Regulation 797/85 were for machinery and equipment, while 13.8 per cent were for livestock and 12.7 for buildings. The distribution of machinery and equipment by farm size shows that specific equipment is mainly concentrated in large farms, while the absolute number of tractors is more concentrated in small farms. However, analysing the number of farms that own tractors one concludes that large farms have their own tractor power and this percentage decreases to 36.4 and 17.9 for medium and small farms respectively, suggesting that for these farms, machinery and equipment hiring has an important role in their production structure.

Table 3.16 - Changes in Machinery and Equipment between 1979 and 1989 and Distribution by Farm Size Classes

Item	Tractor	Rotovator	Forage Harvester	Mowing	Cereal Harvester
% Change Between 1979 & 1989	53.4	234.6	64.0	42.8	18.8
By Farm Size (ha.) - 1989					
0 - 50	49.1	83.3	13.8	21.6	16.5
50 - 200	12.6	8.4	21.5	26.5	27.2
> 200	38.4	8.2	64.6	51.9	56.3

Source: INE (1979) and INE (1989)

With respect to livestock, the number of the most important livestock categories (cattle and sheep) increased in the region by 11 and 50 percent respectively, while the number of heads and farms of goats and pigs decreased (Table 3.17). The reasons underlying the increase in cattle and sheep were due to a relative increase in their profitability when compared with cereals in the late eighties, the positive investment environment observed after 1985 and specific to sheep and goats, the compensatory amounts that started to be paid after 1986. The decrease in goats and pig heads were due mostly due to sanitary problems faced by these activities, principally the Malta and African swine fever respectively. During the same period a reduction in the number of cattle farms was observed due to a decrease in the number of dairy cows (-37.4 per cent) and the end of cattle activities based on intensive feeding schemes which led to specialized cattle activities in more extensive production schemes based on forage.

Table 3.17 - Changes in Livestock Numbers and Farms between 1979 and 1989 and Distribution by Farm Size Classes

Item	Cattle		Sheep		Goats		Pigs	
	Number		Number		Number		Number	
	Farms	Heads	Farms	Heads	Farms	Heads	Farms	Heads
% Change between 79 and 89	-28	11	37	50	-37	-19	-36	-8
By Farm Size Classes (Ha.) - 1989								
0-50	70	20	74	27	79	33	84	48
50-200	16	19	14	21	13	26	10	17
>200	14	61	11	52	8	41	6	35

Source: INE (1979) and INE (1989)

3.3 - AGRICULTURAL PRODUCT

3.3.1 - Product Structure

The Alentejo represents around 17 percent of the Portuguese agricultural GDP (Table 3.18) and its contribution by sector of activity is greater for the forestry sector with around one fourth and followed by the livestock sector with 18.8 per cent. The importance of the forestry sector is mainly due to cork production, that represents around 58 percent of the Alentejo forestry GDP (Table 3.18).

The Alentejan agricultural GDP structure by sectors of activity is very similar to the one observed in Portugal. The crop sector represents more than half of the total agricultural GDP, while the livestock and forestry sectors have similar contributions: 22.3 and 24.9 for the Alentejo and 19.9 and 16.9 for Portugal respectively. The role of irrigated activities in total product is very high when compared with the area it occupies. The irrigated agricultural GDP contributed 19.3 percent of the total and it is on average 5.2 times the agricultural GDP observed in dryland areas (Avillez et al., 1988).

By sub-sectors of activity and regarding the crop sector, cereals are predominant with 31.4 percent in which the contribution of wheat is 19.4 percent. As expected olive oil has a significant weight in the crop sector with around 17 percent and is followed by vegetable crops with 15.2 percent, while fresh fruits and wine have similar contributions: 11.7 and 10.8 respectively. The livestock sector is dominated by beef and sheep products with 64 percent, while milk and pork have individual contributions around 12 percent. In the forestry sector, cork and wood for the cellulose industry are the significant products.

Table 3.18 - Contribution of Alentejo to National Agricultural GDP and Agricultural GDP structure (Average 1979-80-81)

Sector	Alentejo/ Portugal (%)	Agricultural GDP Structure	
		Alentejo (%)	Portugal (%)
Crop	14.0	52.8	63.2
Livestock	18.8	22.3	19.9
Forestry	24.8	24.9	16.9
Total	16.8	100.0	100.0

Source: Cordovil and Rolo (1987)

Table 3.19 - Alentejo Agricultural GDP by Sub-Sectors of Activity (Average 1979-80-81)

Crop	(%)	Livestock	(%)	Forestry	(%)
Cereals	31.4	Beef	34.9	Cellulose Industry	37.6
Horticulture	15.2	Milk	12.5	Cork	57.7
Fresh Fruits	11.7	Sheep	29.1	Others	4.7
Wine	10.8	Goat	4.1	Total	100.0
Olive Oil	17.0	Pork	11.8		
Others	13.9	Others	7.7		
Total	100.0	Total	100.0		

Source: Cordovil and Rolo (1987)

The distribution of the Alentejan agricultural GDP by area classes shows that production is dominated by small and large farms that account for 85 percent of the total product, while medium represent around 15 percent. This structure is maintained for all sectors of activity with the exception of the forestry sector. In this sector the weight of small farms is very small, around 8 percent, while large farms have the larger share with 77.7 percent. The importance of small and medium farms can be seen by their contribution for GDP, 46.3 per cent of total and 51.7 per cent if forest activities are excluded.

Table 3.20 - Alentejo Agricultural GDP Structure by Area Class (Average 1979-80-81)

Farm Size Classes	Crop (%)	Livestock (%)	Forestry (%)	Total (%)	Total Without Forestry (%)
0-50 Ha.	39.2	26.1	8.0	31.3	35.5
50-200 Ha.	15.7	13.8	14.3	15.0	15.2
> 200 Ha.	45.1	60.1	77.7	53.9	49.4

Source: Cordovil and Rolo (1987)

The importance of irrigated activities in the agricultural product generated by small farms is shown in Table 3.21. In terms of irrigated area, large and very large farms represent around 57 percent of the region's total irrigated land, but the contribution of irrigation activities to their agricultural product is small because dryland farming systems are still dominant for the farms in those farm size classes. On the contrary, irrigation activities have an important role in the product generated by small farms, although they only account for 22.2 percent of the total irrigated land.

Table 3.21 - Irrigated Land and Crop Irrigated Product by Farm Size Class

Farm Size Classes	Irrigated Land (% of Total)	Irrigated Product in Crop Product (% of Total)
0 - 50 Ha.	22.2	26.6
50 - 200 Ha.	21.3	6.1
200 - 500 Ha.	8.5	3.9
> 500 Ha.	48.0	2.9

Source: Adapted from Avillez et al. (1988)

Although the analysis made in this section used average data for the period 1979-80-81, it is believed that significant changes did not occur by the end of the eighties regarding the product structure of the crop sector because, as seen in section two, land-use patterns and production structure of the most important crop activities was maintained fairly constant. With respect to the livestock sector, it is believed that the importance of beef and sheep production increased as a result of the increase in their numbers, while the importance of pork, goats and milk production decreased. The cork disease that appeared in the eighties, causing the death of many cork trees, could have contributed to a decrease in corks' relative importance in the forestry sub-sector, and if specific measures are not taken to tackle this disease, the future of cork production in the region could be seriously affected.

3.3.2 - Marketing

Self-consumption does not have a significant role in the production characteristics of Alentejo farmers. Farmers that only produce for self-consumption represent more than 25 percent only for maize, fresh vegetables, olives, wine, milk and pig producers (Table 3.22). Regarding farmers that sell their agricultural production through market channels, the majority of them (more than 60 percent) sell more than 75 percent of their agricultural production.

The data available from the 1989 agricultural census, which excludes cereals, shows that the market channels of the agricultural products are still dominated by the middle salesman both in the crop and livestock sector. The exceptions are fresh fruits and vegetables, olives, wine and milk and cereals. Fresh fruits and vegetables are mainly marketed directly to processing enterprises in the case of processing crops or sold by farmers through direct sales in the case of fresh products. Cooperatives, established during the fifties and sixties still have the larger marketing share for olive oil, wine and milk. Cereals are a special case because until 1990 the public marketing enterprise for cereals EPAC dominated almost entirely the cereals market. This situation changed during the first stage of the EC accession when the mill and feedstuffs industries were granted access to the cereal market on an equal basis.

Table 3.22 - The Importance of Self-Consumption, Marketing, and Marketing Channels for Different Products - 1989

Products	% of Farms that only Produce for Self Consumption	Farms Marketing Agricultural Products					
		% of Farms that Sell more than 75 Percent	Marketing Channels				
			Direct Sales	Middle Salesman	Cooperatives	Industry
Corn	40	61	20	50	24	5
Fresh Fruits Vegetables	28	60	45	54	0	0
Processing Vegetables	0	98	2	5	29	64
Dried Fruits	23	89	20	79	1	0
Table Olives	18	92	4	74	19	3
Olive Oil	27	91	1	34	55	10
Wine	41	93	4	23	64	9
Cattle	13	90	4	92	1	2
Sheep/Goats	20	75	13	86	1	1
Pork	55	76	22	76	0	2
Milk	83	83	21	23	50	6

Source: INE (1989)

3.4 - SUMMARY

The Alentejo region represents a small share of Portuguese economic activity, but in terms of national averages agriculture is the Alentejan economic sector that shows the highest contribution in terms of national employment and economic activity. The productivity (value added per labour unit) of Alentejan agriculture is higher than the Portuguese agricultural sector as a whole, while the productivity of Alentejan agriculture is still around two thirds of the regional average.

In terms of area farmed, Alentejan agriculture is mainly of dryland type. Land shows significant limitations for intensive crop production. Farms have on average a reasonable dimension, farmers are elderly with low levels of education and professional training, cereal, beef and sheep activities have been the dominant activities in the crop and livestock sectors respectively, and agricultural products are mainly sold for the market. Although the area of irrigated activities (rice, tomatoes, maize and horticultural crops) only accounts for around 4.2 of total agricultural land these crop activities have an important contribution for total product of the smaller farms (less than 200 hectares).

Between 1979 and 1989, Alentejan agriculture changed principally in terms of farm structure due to the process of agrarian reform which resulted on increase in the number of farms in the medium and large farm size classes, although the total number of farms have decreased 6 per cent. The last data available shows that a further 20 per cent reduction in the number of farms was observed between 1989 and 1993, mostly in the farm size class lower than 50 hectares.

The capital structure improved during the last decade regarding machinery and equipment, which could be an indication for labour substitution, since the number of hired temporary jobs has decreased. Regarding livestock, the number of sheep and cattle units increased while the number of pigs, goats and milk cows decreased. The production structure was maintained without significant changes with respect to the crop sector, while the livestock sector showed a tendency for an increase in sheep and cattle activities, principally after the mid-eighties. Between the end of the seventies and beginning of the eighties average yield levels for the most important crop activities showed a downward trend, while afterwards yields start to rise again.

After this general analysis of the changes in the Alentejo agricultural resources and production characteristics during the eighties, the next chapter will look at the Alentejo region from the view point of its agricultural systems to take into consideration the differences in production potential and crop and livestock activities that are found in its different zones.

CHAPTER IV - CHARACTERISTICS AND GROWTH OF ALENTEJAN FARMING SYSTEMS

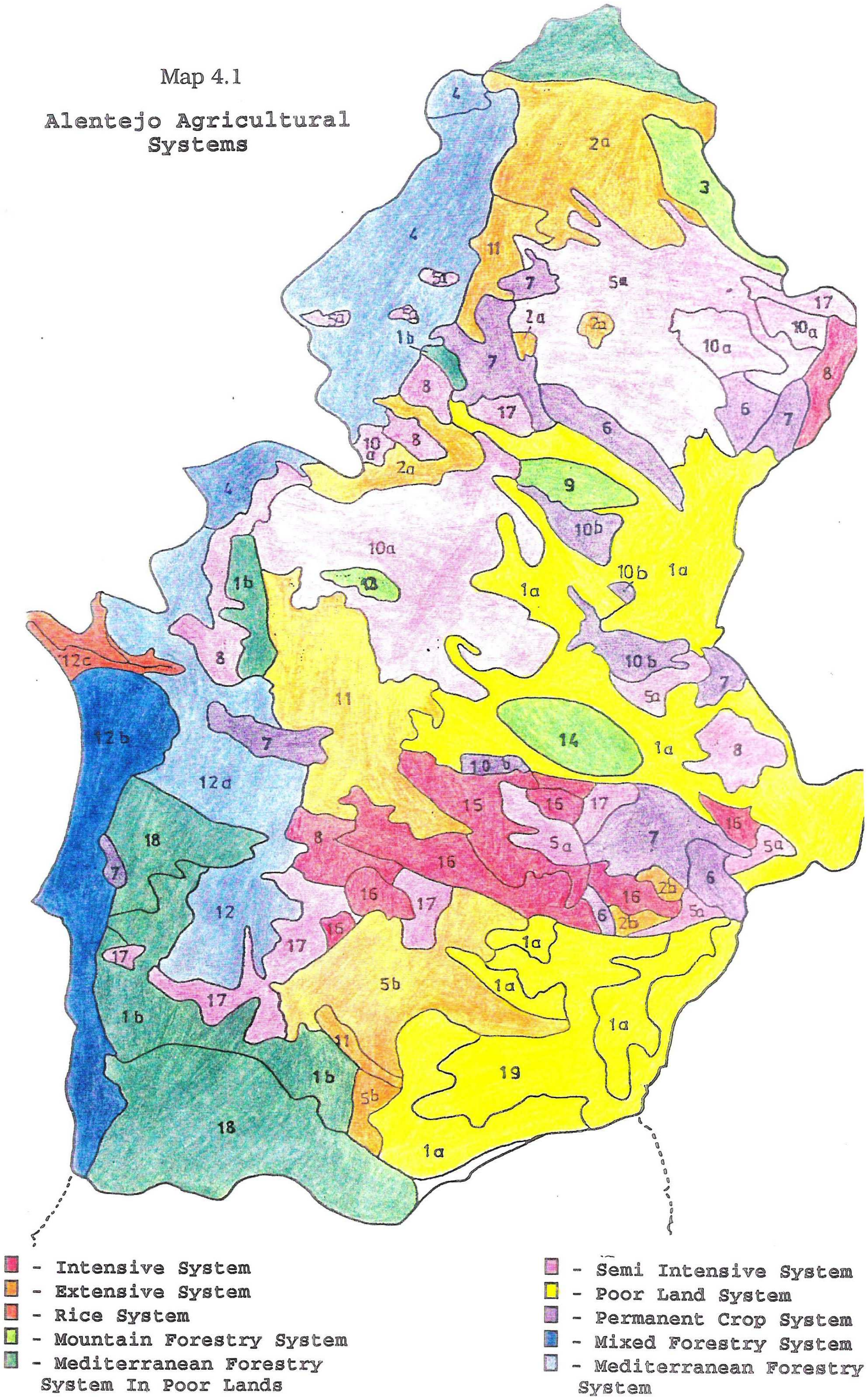
The objectives of this chapter was to characterize the Alentejo farming systems, to identify the recent changes that have occurred in the four farming systems selected and to evaluate the growth of some variables considered important at farm level. The identification and characterization of Alentejo agricultural systems was based on previous studies about Alentejo agro-ecological zones and on a sample of the Farm Accounting System (RICA) implemented by the Ministry of Agriculture for 1988. A panel data built for 1987-1991 was used to analyze the recent changes in the four farming systems selected using a set of selected farm indicators, while the analysis of the growth of some farm variables was based on a covariance growth model.

4.1 - ALENTEJAN FARMING SYSTEMS

The Alentejo region comprises an area of 2,696 thousand hectares, which corresponds to about one third of the total area of Portugal. The Alentejo shows a diversity in ecological conditions basically due to differences in topography, soil types, climate and natural vegetation. Based on these characteristics, Sobral and Marado (1987) divided the region into nineteen agro-ecological zones. The farming systems practised in each agro-ecological zone show differences and similarities essentially in the potential of soil for agricultural production. Taking into consideration the similarities among farming systems practised in each agro-ecological zone and their soil potential, Silva (1990) aggregated the nineteen agro-ecological zones into ten larger homogeneous zones. Each of these zones represents an agricultural system that show similar production potential and activities between farms.

Map 4.1 shows the ten different agricultural systems of the Alentejo and Table 4.1 summarizes the main land use types observed in each agricultural system. The agricultural systems could be divided into two groups. The first group is composed of those systems in which annual crops have a major role in production activities, and the second group aggregates the systems in which permanent crops and forestry account for a significant proportion of land use. The agricultural systems of the first group are composed of production systems based on dryland and irrigated cereal rotations, while the agricultural systems included in the second group are based on permanent crops and forestry systems associated with traditional rotations based on cereals. The agricultural systems of the first group are: cereal intensive system (IS), Map 4.1

Alentejo Agricultural Systems



cereal-livestock semi intensive system (SIS), cereal livestock extensive system (ES), cereal poor land system (PLS), rice system (RS) and mixed forestry system (MFS). For the second group the agricultural systems are: Mediterranean Forestry System on Poor Lands (MSPL), Mediterranean Forestry system(MS), Permanent Crop System (PC) and Mountain Forestry system (MF).

Table 4.1 - Alentejo Agricultural Systems - Land Use Patterns

Agricultural System	Total Area		Cropped Land %	Permanent Crops %	Mediterranean Forest %	Mixed Forest %	Uncultivated Land %
	Ha.	%					
Intensive (IS)	137950	5.1	72.2	15	12.2	1.1	0.0
Semi Intensive (SIS)	578100	21.4	40.6	10.5	46.9	1.5	0.6
Extensive (ES)	390250	14.5	45.0	7.6	38.3	2.6	6.5
Poor Land (PLS)	584900	21.7	42.2	4.7	37.8	1.9	13.9
Mediterranean Forest on Poor Land (MSPL)	304800	11.3	25.0	3.3	60.9	1.9	8.9
Mediterranean Forest (MS)	296000	11.0	10.9	6.8	67.7	13.5	1.2
Permanent Crop (PC)	197800	7.3	22.5	48.7	26	0.5	2.2
Mixed Forest (MFS)	102750	3.8	54.3	6.0	8.0	27.0	4.7
Mountain (MF)	93300	3.5	5.8	15.4	52.0	20.8	6.0
Rice (RS)	10900	0.4	88.0	0	0	0	12.0

Source: Sobral and Marado, 1987, and Silva, 1990.

The PLS and SIS agricultural systems occupy the largest proportion of area corresponding to 21.7 and 21.4 percent respectively, while the rice system represents only 0.4 per cent of the total area. With respect to land use patterns, the IS and RS systems have a higher percentage of area occupied by annual crops (72.2 and 88.0 respectively) while the PC system shows the largest percentage of area dedicated to permanent crops (48.7 per cent). Olive trees and vineyards are the most important permanent crops cultivated in the region and occupy 34.9 and 13.6 per cent of the area of the PC system. Olive trees are also the most representative permanent crop in the other agricultural systems. Irrigated rice occupy the majority of the area the RS system, while other irrigated activities are mainly present in the IS farming system.

The mediterranean forest represented by cork oak and holm oak trees occupies more than 37.8 per cent of the area in the majority of the agricultural systems, with the exception of the PC, IS, MFS and RS agricultural systems. The mediterranean forest has an important role in the natural equilibrium of the agricultural ecosystems. Its fruits are an important source of livestock feed during autumn, and the dispersion of the trees allows farmers to cultivate the land under and between mediterranean forest. The cork taken from the cork oak is an important source of farm revenue, although it not considered for the purposes of these study. The area occupied by the other types of forest trees is only significant for the MFS and MF agricultural systems with 27.0

and 20.8 percent of the area respectively. The most representative species are eucalyptus and pine trees.

Four agricultural systems were selected for subsequent analysis. The agricultural systems selected were: intensive (IS) , semi-intensive (SIS), extensive (ES) and poor land (PLS). These four agricultural systems account for 62.7 per cent of the total area of the region, 77.2 percent of the cropped and 48.5 percent of permanent crop area and are believed to account for a significant percentage of the region's agricultural output.

4.2 - DATA

The data used to characterize the four agricultural systems selected, the growth of some farm variables evaluated in this chapter, the measurement of individual levels of technical efficiency undertaken in chapter V, and the farms selected to simulate the development of the farming systems under CAP framework, were based on individual farm account records collected by the Ministry of Agriculture since 1981. When work on this thesis began, the only RICA data set available for Alentejo was for the year 1988. Thus it was the 1988 data which was used to determine the basic characteristics of the farming systems selected. The first task was to identify each 1988 farm with each farming system. Since the farming system delimitations do not coincide with the county identification of the RICA farms, this mapping of RICA farms to farming systems was undertaken with the help of the county RICA technicians. For Alentejo, there were 335 farms in the 1988 RICA data set, of which 217 were classified into the farming systems analyzed. The total number of farms in Alentejo in 1988 was estimated to be 47,049. The distribution of the total sample of 217 farms by the four agricultural systems selected and by the area classes defined and used in chapter III, is shown in Table 4.2.

Table 4.2 - Sample Distribution of Farms Analyzed by the Ministry by Agricultural System Selected and Area Class (1988)

Agricultural	All observations		Small Farms		Medium Farms		Large Farms	
Systems	Number	%	Number	%	Number	%	Number	%
Intensive System(IS)	41	18.9	20	32.3	13	14.1	8	12.7
Semi Intensive System (SIS)	70	32.3	21	33.8	26	28.3	23	36.5
Extensive System (ES)	56	25.8	10	16.2	29	31.5	17	26.9
Poor Lands System (PLS)	50	23	11	17.7	24	26.1	15	23.8
Total	217	100	62	100	92	100	63	100

It was this sample of farms that in Chapter VI was used to select 9 farms to simulate farm development under the conditions of the CAP reform. Later, in the research work the RICA data for 1983-1991 become available, allowing us to build a panel of data by farming system. The number of farms belonging to the farming systems selected for the data set 1983-1987 was too small to build a balanced panel, and this data set was abandoned. A balanced panel for the period 1987-1991 was built and used to identify the recent changes in Alentejo farming systems, to analyze the growth of some farm variables and to evaluate individual levels of technical efficiency. This work is reported in sections 4.4 and 4.5 and chapter 5 respectively.

Table 4.3 - Sample Distribution of the Panel Data for 1987-1991 by Agricultural System

Item	Agricultural Systems			
	Intensive	Semi-Intensive	Extensive	Poor Land
Number of Farms	19	26	28	27

4.3 - CHARACTERISTICS OF THE FARMING SYSTEMS SELECTED

The information contained in Sobral and Marado (1987) and in the data of the 1988 RICA sample was used to characterize each one of the farming system selected. The basic characteristics of each one of the farming systems based on Sobral and Marado are described below and then a more formal characterization is undertaken using the data of the RICA sample. The IS and SIS farming systems, due to their better soil capacities, show more intensive production characteristics, while the ES and PLS due to some soil limitations show extensive production characteristics.

4.3.1 - Intensive Agricultural System (IS)

This system is composed of three agro-ecological zones and occupies an area which represents only 5.1 per cent of the total area of the region. Two of the agro-ecological zones are characterized by intensive dryland production systems while the third agro-ecological zone is characterized by a mixture of dryland and irrigated production systems due to the existence of the irrigated perimeters of Caia and Odivelas. These irrigated perimeters have a potential irrigated area of 14,700 hectares, which correspond to around 25 per cent of the total irrigated area of the Alentejo region.

The soils are the best found in the region and in Portugal. They belong to the land capacity classes A and B which have the highest capacity for agricultural production. Landscape is characterized by slight slopes, in some areas plains and in others slightly undulating. Production systems are characterized by intensive arable crops (72.2 per cent of total area). Wheat is the most important cereal that makes part of the rotations. The typical rotation in the dryland area is:

Year 1	Year 2	Year 3
Fallow*Sunflower or Chick Peas	Wheat	Wheat or Barley

while in the irrigated areas the most important rotations are:

Year 1	Year 2
Tomatoes or Corn or Continuous Rice	Wheat or Oats

Livestock activities are complementary to the cereal rotation and are dominated by extensive sheep activities. The forage produced by the rotations is utilized mainly for livestock feed. The importance of the livestock activities grows with farm size. The remaining area is occupied by forest (13.3 per cent) and permanent crops (15 per cent). The most important permanent crops are olive trees (12.7 percent) and vineyards (2.2 per cent).

4.3.2 - Semi Intensive Agricultural System (SIS)

This agricultural system occupies four agro-ecological zones and is characterized by semi intensive production systems based on cereals and livestock activities. The area occupied represents 21.4 per cent of the total area of the region. Soils are not as good as the those observed in the intensive agricultural system, and the majority belong to the land use capacity B, C and D.

The landscape is a rolling plateaux characterized by slopes that vary between 3 and 10 per cent. Permanent crops represent 10.5 per cent of the total area, mainly occupied by olive trees (9.3 per cent). The forestry area which occupies 48.4 per cent of the total area is mainly composed of mediterranean species (46.9 per cent of the total area). Under and between mediterranean trees farmers are able to grow rotations or natural pastures. Natural pastures are a substantial source of livestock feed. A typical rotation for this agricultural system is

Year 1	Year 2	Year 3	Year 4 -5
Fallow*Sunflower or Chick Peas	Wheat	Barley, Oats or Forage	Natural Pasture (1 or 2 Years)

Livestock is an important activity and uses the temporary forages and natural pastures produced by the rotations as a main feeding source.

4.3.3 - Extensive Agricultural System (ES)

This agricultural system is composed of three agro-ecological zones which represent 14.5 per cent of the total area of the region. Soils are thin and poor, belonging mainly to the land capacity class D and E. The landscape is an undulating plateau with slopes that vary from 6 - 15 per cent, which gives rise in certain regions to erosion problems. Land use is characterized by a low representation of permanent crops (7.6 percent) mainly occupied by olive trees (7.5 percent). The forestry area accounts for 40.9 per cent of the total area and is mainly occupied by mediterranean species. The rotations are longer than in the previous agricultural systems and are characterized by an increase of the period dedicated to natural pastures. A typical rotation is:

Year 1	Year 2	Year 3	Year 4-8
Fallow	Wheat or Oats	Oats or Forage	Natural Pasture (2-5 Years)

Livestock activities have an important role in the economy of this agricultural system and are represented by beef, sheep, goats and swine.

4.3.4 - Poor Land Agricultural System (PLS)

This agricultural system represents 21.7 per cent of the total area of the region and is characterized by thin and poor soils and a very dry climate. The majority of the soils belong to the land capacity class E. The landscape is highly undulating with slopes which vary between 16 and 25 per cent, giving rise to serious erosion problems.

Permanent crops occupy a low percentage of the area (4.7 per cent), while the mediterranean forest covers 37.8 per cent of the total area. The production systems are based on long dryland cereal rotations, and the typical rotation is characterized by:

Year 1	Year 2	Year 3	Year 4 - 8
Fallow	Oats or Wheat	Forage	Natural Pasture

4.3.5 - Additional Characteristics of the Farming Systems

The indicators contained in Tables 4.4 and 4.5 by farming system and farm size, derived from the 1988 farm sample described in section 4.2, complements the previous description of the farming systems. Regarding land structure, the farms belonging to more intensive farming systems have a lower average farm size and with an higher proportion of owned land than the more extensive farming systems. With respect to land occupation, irrigated activities have an important role in production structure of the intensive system (3.7 percent of total agricultural area) and principally small farms (one fourth of the area is irrigated), while for the other farming systems its role is marginal. Due to soil potential and rotational characteristics of each farming system, the intensity of land use is greater for the more intensive farming systems (IS and SIS) and as expected this intensity decreases as farm size increases since for larger farms fallow and natural pastures occupy a significant proportion of the land, while for smaller farms intensive production activities such as horticulture and permanent crops have an important role.

For all farming systems cereals occupy the majority of area cropped and this percentage increases with farm size. Oilseeds are represented in rotational characteristics of the IS, and also have some presence in the rotations of the SIS and PLS farming systems. Forage activities are relatively more important for the ES, PLS and SIS farming systems, while permanent crops have a higher representation on the more intensive farming systems. As a result of a higher area in forage activities, livestock density is greater for the ES, SIS and PLS farming systems, decreasing with farm size. The composition of the livestock herd is dominated by sheep activities for all farming systems. This domination is greater for the PLS and IS farming systems and, with exception of the IS farming system, the weight of sheep activities increases with farm size. Cattle activities are comparatively more important in the SIS and ES farming systems while other livestock activities are present in the ES and PLS farming systems.

In average terms, family labour represents less than 50 percent of total labour, with the ES and PLS farming systems showing a higher proportion of family labour than the IS and SIS. The proportion of family labour decreases with farm size representing more than 70 per cent for small farms and less than 30 per cent for large farms. Labour use per hectare is similar for the IS and SIS which show higher labour use than the more extensive farming systems (ES and PLS). The more intensive farming systems use higher levels of operating capital, with decreasing levels by farm size, and this is consistent with the fact that the more intensive production activities of smaller farms require more capital, and that as farm size increases there is a more efficient use of lumpy inputs such as machinery, equipment and buildings.

Table 4.4 - Selected Farm Indicators by Farming System for 1988

Item	Units	IS	SIS	ES	PLS
Average Area	Hectares	142.1	174.0	227.1	198.3
Owned Land/Total Land	%	62.2	47.7	32.6	39.8
Irrigated Land/Total Land	%	3.7	0.5	1.3	1.0
Average Irrigated Land	Hectares	5.3	0.9	2.9	2.0
Cultivated Land/Total Land	%	60.7	46.0	28.0	40.4
Area Cereals/Area Cultivated	%	70.8	57.9	54.8	62.9
Area Oilseeds/Area Cultivated	%	15.3	7.6	1.3	4.5
Area Forages/Area Cultivated	%	1.2	14.8	24.9	18.0
Total Labour/Total Land	LSU/Hectare[a]	0.022	0.022	0.014	0.015
Family Labour/Total Labour	%	36.1	36.2	44.8	44.4
Average Labour per Farm	LSU[a]	3.1	3.8	3.2	2.9
Operating Capital/Total Land	1000Esc./Ha.	120.3	82.0	66.3	71.9
Machinery and Equipment/Total Land	1000Esc./Ha.	44.0	29.8	22.8	26.7
Sheep/Total Livestock	%	63.3	52.9	47.1	75.0
Cattle/Total Livestock	%	35.1	40.4	38.2	15.3
Other Livestock/Total Livestock	%	1.6	6.7	14.7	9.8
Average Livestock per Farm	LU[b]	27.9	46.3	60.3	51.1
Livestock Units/Total Land	LU/Hectare[b]	0.196	0.266	0.266	0.258
Intermediate Costs/Total Land	1000Esc./Ha.	33.8	24.1	11.1	17.3
Machinery Costs/Total Land	1000Esc./Ha.	9.2	7.1	3.4	4.8
Livestock Costs/Livestock Units	1000Escudos/LU[b]	7.6	16.3	10.8	21.3
Crop Costs/Total Area	1000Esc./Ha.	20.7	11.3	4.0	6.2
Crop Product/Total Product	%	80.8	66.1	34.9	52.4
Livestock Product/Total Product	%	11.0	26.0	49.5	34.6
Direct Subsidies/Total Product	%	8.2	7.9	15.6	13.1
Crop Product/Total Area	1000Esc./Ha.	53.9	33.7	9.0	18.9
Livestock Product/LU	1000Escudos/LU[b]	37.4	49.9	48.0	48.5
Direct Subsidies/Total Land	1000Esc./Ha.	5.5	4.0	4.0	4.7
Total Product/Total Labour	1000Esc./LSU[a]	3035.5	2315.5	1803.1	2463.6
Total Product/Total Area	1000Esc./Ha.	66.7	51.0	25.8	36.2
Value Added/Total Land	1000Esc./Ha.	32.9	26.9	14.6	18.9
Average Net Income	1000 Escudos	1511.2	1674.2	1055.1	1493.5
Net Income/Total Land	1000Esc./Ha.	10.6	9.6	4.6	7.5

[a] LSU - Labour Standard Unit

[b] LU - Livestock Unit

Table 4.5 - Selected Farm Indicators by Farming System and Farm Size for 1988

Item	Units	IS-S	IS-M	IS-L	SIS-S	SIS-M	SIS-L	ES-S	ES-M	ES-L	PLS-S	PLS-M	PLS-L
Average Area	Hectares	25.8	114.5	478.0	22.2	105.7	390.0	25.4	143.1	489.1	25.9	123.0	445.0
Owned Land/Total Land	%	25.5	44.2	74.2	59.1	54.9	44.9	27.7	22.4	37.8	26.4	50.3	35.6
Irrigated Land/Total Land	%	25.0	1.2	1.8	3.2	0.4	0.4	4.3	0.2	1.7	0.0	1.6	0.8
Average Irrigated Land	Hectares	6.4	1.4	8.8	0.7	0.4	1.7	1.1	0.3	8.3	0.0	2.0	3.4
Cultivated Land/Total Land	%	92.9	66.5	54.1	67.9	50.6	43.5	58.9	37.7	22.3	63.1	47.2	36.4
Area Cereals/Cultivated Land	%	56.7	70.5	74.2	29.1	48.0	63.7	22.4	55.1	57.1	54.8	61.7	64.2
Area Oilseeds/Cultivated Land	%	16.0	12.9	16.3	2.3	6.3	8.5	4.7	0.0	2.2	5.6	4.2	4.5
Area Forages/Cultivated Land	%	2.1	1.1	1.0	18.3	24.3	11.1	43.0	21.3	26.4	10.6	14.5	20.5
Total Labour/Total Land	LSU/Hectare	0.062	0.017	0.018	0.092	0.024	0.018	0.085	0.015	0.012	0.070	0.021	0.009
Family Labour/Total Labour	%	75.4	47.2	14.2	71.1	50.5	20.8	75.0	63.8	25.5	70.7	50.0	30.5
Average Labour per Farm	LSU	1.6	2.0	8.8	2.1	2.6	6.9	2.2	2.2	5.7	1.8	2.6	4.2
Operating Capital/Total Land	1000Esc./Ha.	209.5	114.3	110.6	224.6	106.3	67.1	223.2	77.2	56.1	192.8	94.9	56.6
Machinery and Equipment/Total Land	1000Esc./Ha.	68.5	43.9	40.8	86.3	37.2	24.6	70.8	29.3	18.0	72.8	32.9	22.0
Sheep/Total Livestock	%	87.7	69.4	56.3	24.7	56.2	55.0	16.5	33.8	56.0	13.8	65.7	85.5
Cattle/Total Livestock	%	9.4	27.9	42.6	64.5	39.3	37.7	58.8	51.9	29.9	84.7	18.6	8.2
Other Livestock/Total Livestock	%	2.9	2.7	1.0	10.8	4.6	7.3	24.6	14.3	14.1	1.5	15.7	6.3
Average Livestock per Farm	LU	8.2	16.9	94.9	12.8	39.8	84.2	15.2	37.2	126.3	8.9	41.7	97.1
Livestock Units/Total Land	LU/Hectare	0.317	0.147	0.199	0.576	0.377	0.216	0.598	0.260	0.258	0.345	0.339	0.218

S - Small Farms (0-50 Hectares), M - Medium Farms (51-200 Hectares) and L - Large Farms (> 201 Hectares)

Table 4.5 - Selected Farm Indicators by Farming System and Farm Size for 1988 (Cont.)

Item	Units	IS-S	IS-M	IS-L	SIS-S	SIS-M	SIS-L	ES-S	ES-M	ES-L	PLS-S	PLS-M	PLS-L
Intermediate Costs/Total Land	1000Esc./Ha.	78.3	35.4	27.2	63.6	23.9	22.1	61.6	12.8	8.8	61.5	25.0	11.9
Machinery Costs/Total Land	1000Esc./Ha.	26.8	10.7	6.3	14.7	7.6	6.6	10.9	4.2	2.8	13.5	5.8	3.9
Livestock Costs/Livestock Units	1000Esc./LU	6.7	9.1	7.3	55.5	15.4	11.4	64.6	9.7	7.5	80.4	34.1	8.5
Crop Costs/Total Area	1000Esc./Ha.	44.6	21.5	17.1	12.4	8.5	12.2	9.7	5.4	3.2	18.6	6.4	5.5
Crop Product/Total Product	%	85.1	83.2	78.1	47.0	51.6	73.6	28.4	40.6	31.7	42.0	49.8	56.2
Livestock Product/Total Product	%	8.9	11.2	11.7	46.6	37.3	19.4	62.3	48.7	48.0	49.6	38.7	28.7
Direct Subsidies/Total Product	%	6.0	5.6	10.2	6.3	11.1	7.1	9.3	10.7	20.3	8.4	11.5	15.1
Crop Product/Total Area	1000Esc./Ha.	129.6	52.0	44.4	55.5	27.3	34.6	31.7	12.5	6.5	41.6	25.5	15.1
Livestock Product/LU	1000Esc./LU	42.7	47.4	33.4	95.5	52.5	42.1	116.5	57.8	38.3	142.6	58.4	35.3
Direct Subsidies/Total Land	1000Esc./Ha.	9.1	3.5	5.8	7.4	5.9	3.3	10.4	3.3	4.2	8.4	5.9	4.1
Total Product/Total Labour	1000Es/LSU	2457.2	3591.0	3094.1	1275.4	2190.8	2649.7	1312.1	2005.1	1779.1	1414.9	2425.2	2831.8
Total Product/Total Area	1000Esc./Ha.	152.2	62.4	56.9	118.0	53.0	47.0	111.6	30.9	20.6	99.1	51.1	26.8
Value Added/Total Land	1000Esc./Ha.	73.9	27.0	29.7	54.4	29.1	24.8	50.0	18.1	11.8	37.5	26.2	14.9
Average Net Income	1000 Esc.	948.4	813.3	4052.6	330.0	1147.8	3496.7	481.4	941.5	1586.2	258.3	1305.6	2699.9
Net Income/Total Land	1000Esc./Ha.	36.8	7.1	8.5	14.9	10.9	9.0	19.0	6.6	3.2	10.0	10.6	6.1

S - Small Farms (0-50 Hectares), M - Medium Farms (51-200 Hectares) and L - Large Farms (> 201 Hectares)

In overall terms, the use of intermediate input use is more intense for the IS farming system, while the ES farming system show lower input use per hectare. By groups of variable inputs, the PLS and SIS farming systems have a higher use of livestock inputs, while the IS and SIS farming systems show higher machinery and crop input use. The production structure is dominated by crop product for the IS, SIS and PLS farming systems, while for the ES livestock product is dominant. Land and labour productivity as well net income per hectare are greater for the more intensive farming systems (the IS and SIS) with decreasing levels by farm size. Crop product per hectare is higher for the more intensive farming systems, while livestock product per livestock units is similar for the SIS, PLS and ES and higher than the value observed for the IS farming system. Regarding capital and input profitability, the IS and PLS farming systems show higher profitability levels than the SIS and ES farming systems.

4.4 - RECENT CHANGES IN ALENTEJAN FARMING SYSTEMS

Following the description of the main characteristics of the four farming systems chosen, the objective of this section is to give a brief overview of the changes that have occurred in the production and economic structure of these farming systems between 1987 and 1991. This includes the first stage of the transition period. To do so, the data panel mentioned in section 4.2 was used to derive the Figures presented in Appendix I that show the evolution of the principal indicators selected and used in this section and to evaluate the annual growth rates of some farm indicators presented in Table 4.6.

Regarding land structure, the average farm size of the four farming system was maintained fairly constant, although a tendency for slight increases in the average farm size appears to be present. The land dedicated to irrigated activities has been increasing, especially for the more intensive farming systems (IS and SIS). With respect to land use, the cultivated as well as cereal land increased in average terms, although variations between years has been observed. The area of oilseeds and forages and pastures increased for all farming systems, and these results are similar to those identified in section 3.2.1 using regional aggregated data.

Since 1987 the average labour per farm and by farming system has shown a tendency to decrease and this decrease is essentially due to reductions in hired labour, although a slight decrease in family labour use was also observed. Regarding livestock, the average number of livestock units per farm and by farming system have been increasing especially for the IS and PLS farming systems, while the SIS farming system showed a tendency for stagnation. These increases resulted in positive changes in the stocking rate per hectare. The herd composition between sheep and cattle activities has been maintained fairly constant over time for the IS, PLS and ES, while for the SIS the importance of sheep has been decreasing. During the period analyzed, the levels of capital per hectare have been increasing, at a higher rate for the more intensive farming systems (IS and SIS).

Table 4.6 - Average Annual Growth Rates for some Indicators by Farming System (1987-1991)

Item	ES	IS	PLS	SIS
Average Area	0.77	0.93	0.34	-0.66
Total Labour	-2.96	-3.58	-0.32	-5.35
Livestock Herd	1.73	4.65	4.16	-0.11
Machinery and Equipment Capital	3.14	4.90	2.95	5.93
Total Product	-0.16	1.22	-1.45	-2.67

The consumption of variable inputs expressed in real terms per hectare, increased slightly for all farming systems, while changes in the consumption of fixed inputs per hectare were less evident, with the exception of the PLS farming system in which an increase was observed. The composition of the product among the different farming systems is similar for the PLS and SIS in which crop product accounts for around half of the total product, while for the IS and ES farming systems crop and livestock products are dominant, respectively. The contribution of livestock and principally crop product to total product has been decreasing, while an increase in the level of direct subsidies which reached percentages greater than 20 per cent for the ES, PLS and IS systems in 1991 was observed. Crop and livestock real product have been decreasing and this decrease was not compensated by the increase in the amount of subsidies received by farmers which lead to a decrease in total product for SIS, PLS and ES farming systems. With the exception for the IS farming system, the decrease in total product led to a decrease in real value added, while real net income decreased for all farms.

In this section changes in the production and economic structure of the ES, IS, PLS and SIS Alentejan farming systems were analyzed based on a panel of RICA farms for the period 1987-1991 and the following general conclusions can be made: 1) positive changes in the irrigated area principally for the IS and SIS, and in the area cropped as well as in the area of cereals, oilseeds and forages was observed, 2) negative changes in labour use, principally hired labour were observed, 3) the size of the livestock herd has been increasing, principally the number of sheep, 4) in overall terms the use of intermediate inputs per hectare increased for all farming systems, 5) with the exception of the IS farming system, total product have been decreasing, while the contribution to total product of subsidies has been increasing substantially, and 6) the profitability of the Alentejan farming systems has been decreasing, especially for the ES, PLS and SIS. These changes confirm with the conclusions drawn in section 2.4.3 and chapter III in aggregate terms for Portugal and Alentejo respectively.

4.5 - FARM GROWTH, FARM SIZE AND FARMING SYSTEM

The objective of this section is to analyze the growth of some farm variables responsible for farm size such as product, labour, capital and livestock, in order to make some inferences about the general process of growth of Alentejan farms, testing the hypothesis that growth or decline rates are specific to individual farms and farming systems and that growth rates are independent of the farm size.

In general, the study of farm firm growth has departed from Gibrat's Law of proportionate effect that states that the proportional change in firm size is independent of its absolute size. This suggests that firms show constant returns to size meaning that larger firms grow as fast as smaller firms (Clark, Fulton and Brown, 1992). Gibrat's Law also suggests three economic implications: 1) there is no optimum size of firms, 2) there is no relation between the rate of growth of a firm in subsequent and preceding periods and 3) there is an increase in industry concentration as time passes (Haworth, 1992).

Haworth (1992) tested some of the hypotheses arising from Gibrat's Law such as, that firms in different size categories have the same average proportionate growth rate, firms in different size categories have the same dispersion of proportionate growth rates about the mean, distribution of proportionate growth rates is lognormal and relative dispersion of firm sizes increases over time, and concluded that there was considerable evidence to question the hypothesis that the process of farm firm growth could be explained by the Gibrat's Law of proportionate effect and to assume that differences in growth rates are not due to random forces but to the presence of consistent individual growth rates. Deviations from Gibrat's law were also observed in other studies about individual firm growth such as those by Shapiro, Bollman and Ehrensaft (1987), Hall (1987), and Evans (1987), while Clark, Fulton and Brown (1992) using regional aggregate data for Canadian agriculture did not find strong evidence to reject the Gibrat's Law.

4.5.1 - Methodology

The model used to measure, test and compare the growth of some farm variables over time was similar to the one used by Upton and Haworth (1987), which hypothesized that the growth of a farm firm variable is exponential and incorporates year, farm and group effects.

The model is expressed in the following form:

$$Y_i(t) = \alpha_t \beta_i \gamma_j e^{(\delta_i T + \eta_j T)} U_{it}$$

where:

$Y_i(t)$ = variable being analyzed
α_t = year effect
β_j = farm effect
γ_j = farming system effect
δ_i = component of growth rate specific to farm
η_j = component of growth rate specific to farming system
T = time trend,

and t represents the year, i the farm and j the farming system indexes.

This formulation allows one to identify in a cross-section time series data set those effects that are considered important in the evolution of a farm firm variable, such as the ones that are year, farm and or farming system. This is to test if the evolution of a variable is significantly dependent on the year, the farm or farming system and if its growth rate is also farm specific and or farming system specific. The year effect is intended to capture the differences among years due to weather, inflation and other random factors specific to individual years. The farm effect is expected to introduce a farm individual effect for the variable in consideration which measures the relative magnitude of the farm for the variable being analyzed. The farming system effect is expected to capture the variation observed for each farm as a result of observations belonging to a specific farming system. Once the farming system effect is embodied in the farm effect the combination of the farm and farming systems effect is a measure of the relative size of the farms.

The cross effects of farm and or farming system with time allows us to test if the growth rate is group and or farm specific. Because the year effect was taken into account, it implies that the average growth rate is not constant over time, and mean size in a particular year is the mean size in the base year times the year effect for that year. The model considers the error term as multiplicative, thus assuming that the error term varies proportionally to the size of the variable in consideration and has a normal distribution with mean zero and constant variance.

The model above can be written in its logged form and becomes equal to

$$\mathbf{\log Y_i (t) = \log \alpha_t + \log \beta_i + \log \gamma_j + (\delta_i + \eta_j) T + \log U_{it}}, \qquad (4.1)$$

which was solved using dummy variables to represent different t years, j farming systems and i farms. This is an analysis of covariance model that allows us to test the effect of the different independent variables included in the evolution of a specific variable over time. The variables used in the analysis were similar to the ones used by Haworth (1992) and Shapiro, Bollman and Ehrensaft (1987). They were total product and capital (machinery and equipment) measured in thousands of escudos, total labour measured in labour standard units, and cattle and sheep quantities measured in livestock standard units.

In order to test Gibrat's law, that farm growth rates are unrelated to farm size, the individual farm size and growth rates measures estimated through equation 4.1 were correlated.

4.5.2 - Results

The results obtained from fitting the above equation to capital, labour, product and livestock variables allowed us to test to what extent the rate of growth was farm and or farming system specific and if there were significant differences among farm firm sizes. With respect to total product and capital, the results presented in Table 4.7 of the analysis of covariance, show that during the period 1987 - 1991 the rate of growth of the total product and capital was farming system and farm specific and that the contribution of the individual farm component to the growth rate was much higher than the contribution of the farming system component measured by the sum of squares. The same conclusion was reached for the size component of the equation in which the farm and the farming system effect were both significant at 5 per cent level, and the variance explained by the farm effect was much higher than the one explained by the farming system effect.

Table 4.7 - Results of Analysis of Covariance for Total Product and Capital by Different Effects

Source of Variation	Total Product				Capital			
	Sum of Squares	D.F.[a]	Variance Ratio (F)	Signif. Level	Sum of Squares	D.F.[a]	Variance Ratio (F)	Signif. Level
Total	442.9	459			1441.4	459		
Between Years	7.5	4	25.8	(0.001)	15.9	4	43.4	(0.001)
Between Farming Systems	11.9	3	55.1	(0.001)	127.9	3	465.7	(0.001)
Between Farm	390.1	88	61.1	(0.001)	1234.4	88	153.2	(0.001)
Between Farming Systems Growth Rates	1.1	3	5.1	(0.002)	2.8	3	10.2	(0.001)
Between Farm Growth Rates	12.4	88	1.94	(0.001)	35.4	88	4.4	(0.001)
Residual Error	19.7	272			24.9	272		
R Square	0.96				0.98			

[a] - Degrees of Freedom

Table 4.8 - Results of Analysis of Covariance for Labour and Livestock by Different Effects

Source of Variation	Labour				Livestock			
	Sum of Squares	D.F.[a]	Variance Ratio (F)	Signif. Level	Sum of Squares	D.F.[a]	Variance Ratio (F)	Signif. Level
Total	188.6	459			1464.5	459		
Between Years	1.8	4	10.2	(0.001)	2.8	4	11.1	(0.001)
Between Farming Systems	10.8	3	77.9	(0.001)	212.3	3	1112.2	(0.001)
Between Farm	154.9	88	38.1	(0.001)	1196.9	88	213.7	(0.001)
Between Farming Systems Growth Rates	0.4	3	3.1	(0.027)	3.7	3	19.6	(0.001)
Between Farm Growth Rates	8.0	88	2.0	(0.001)	31.6	88	5.6	(0.001)
Residual Error	12.6	272			17.3	272		
R Square	0.93				0.98			

[a] - Degrees of Freedom

Regarding total labour and livestock, the results presented in Table 4.8 are similar to the ones observed for total product and capital. The farm and the farming system components of the growth rate and size were significant at 5 per cent level with much of the variation observed being due to the farm component. Additional runs made only for hired labour, sheep and cattle indicated that the farming system component of the growth rate was not significant for hired labour and cattle, while for sheep the results were similar to the ones observed above.

The results showed that for all variables analyzed there were considerable differences in mean farm sizes and these differences vary across farming systems and inside each farming system across farms. This means that farm size is dependent on a farm belonging to a more intensive or extensive farming system and on other specific farm factors. Farm firms grow at different growth rates, which means that each farm has it own individual growth or decline rate. With the exception of hired labour and cattle in which growth rates are only farm specific, the growth rates vary across farming systems, and inside each farming system among different farms. The year effect is significant at the 5 per cent level for all variables, which implies that mean farm size and average growth rate has been varying over the years.

With the objective of discovering any relationship between the measures of growth and size obtained from the variables studied, a correlation analysis was performed over specific farm size, and growth parameters which had been obtained from the analysis of the covariance model. These parameters will also be used in the next chapter to find if there is a relationship between size and growth, and efficiency. The results presented in Table 4.9 show that there is a positive correlation between the different measures of size, meaning that the size of output is highly dependent on capital, labour and livestock size and also labour with livestock size, while size of capital is less dependent on labour and livestock sizes.

Table 4.9 - Correlations Between Measures of Size and Measures of Growth

Measures of Size	Measures of Size				Measures of Growth			
	Product	Capital	Labour	Livestock	Product	Capital	Labour	Livestock
Product								
Capital	0.55 [a]							
Labour	0.47 [a]	0.25 [a]						
Livestock	0.51 [a]	0.21 [a]	0.49 [a]					
Measures of Growth								
Product	-0.21 [a]	-0.13	0.18	0.16				
Capital	-0.09	-0.24 [a]	0.09	-0.07	0.28 [a]			
Labour	0.03	0.09	-0.60 [a]	-0.07	-0.11	-0.19 [a]		
Livestock	0.19 [a]	0.01	0.16	-0.13	0.23 [a]	0.24 [a]	-0.05	

[a] - significant at 5 % level

Regarding the correlation between the different measures of growth, one can conclude that the growth rate of output is positively correlated with the growth rate of capital and livestock, and the growth rate of capital is inversely correlated with the growth rate of labour and positively correlated with the growth rate of livestock. The cross correlations between measures of size and growth allow us to conclude that in general there is a weak association between size and growth measures. The exceptions are total product, capital and labour which are negatively correlated with their corresponding size and growth measures, meaning that, as farm size increases, the growth rate decreases, and total product size is positively correlated with livestock rate of growth. The cross correlations between size and growth for product, labour and capital which are negative and significant allows us to reject Gibrat's law of proportionate effect.

The results obtained are similar to those of Upton and Haworth (1987) in measuring farm firm growth in a sample of British farmers. The variables that they used as proxies for farm size measures were gross output, labour force, land area and machinery value. If farms show different individual growth rates for the different variables that measure farm size, then there is a set of factors associated with each farm that explain the existence of farm individual growth rates. These factors will be directly related to the production capabilities of farm and farmer as well as other subjective factors that may influence a farmer's decision towards growth. Upton and Haworth (1987) selected a set of variables that could be directly responsible for the different growth rates that their sample of British farmers exhibit, such as managerial ability, propensity to invest, intended expansion of farm, number of dependents, off-farm income and attitude towards risk. The list of farm specific factors can be increased to include years of education, professional training, age, availability of technical assistance, years of experience and etc. They showed through correlation analysis that the different growth rates were partly a result of differences in management ability.

It is widely accepted that all the factors mentioned above will have a relative importance in farmers' attitude towards farm growth, while external factors such as agricultural policy through its structural and price components will have a significant role in determining the magnitude and the path of farm firm growth rate. The period of analysis was coincident with the application of the EC structural policy, while no significant changes occurred in the price policy. Farmers who took advantage of the favourable conditions of the structural policy and expanded their production capabilities are expected to have had higher growth rates for the different measures of farm size. After 1992, with the full application of the price policy, it is expected that significant changes will occur in the magnitude and path of farm firm growth, particularly in farms belonging to farming systems with natural endowment limitations such as the ES and PLS.

Considering that the number of years of our sample was relatively small and that additional data on farm and farmer characteristics were not available, no further analysis was pursued, with the objective of extending the understanding of the process of farm firm growth.

4.6 - SUMMARY

Among the ten farming systems that characterize Alentejan agriculture, four farming systems were selected, the IS, SIS, ES and PLS. The IS and SIS farming systems occupy the better soils of the region and are characterized by a more intensive agriculture than the ES and PLS farming systems which are located in areas with significant limitations for agriculture. The IS and PLS farming systems show a production pattern in which crop activities are dominant in total product, while for the SIS farming system crop and livestock activities have similar contributions for total product and for the ES farming system livestock activities are dominant in total product. The characteristics of each farming system vary with farm size, with smaller farms showing a higher production intensity than larger farms.

During the period 1987-1991, the most important changes observed in the farming systems were an increase in the irrigated and cultivated area, a decrease in labour use principally hired labour, an increase in the size of the livestock herd, a decrease in total agricultural product and a decline in the profitability of the farming systems.

The analysis of growth of total product, labour, capital and livestock variables for the same period, allow us to conclude that: 1) the growth component of those variables was farm and farming system specific 2) the size component of those variables was positively correlated between them, and 3) with exception for livestock, the size component and the growth component of the variables analyzed was negatively and significantly correlated leading to a rejection of Gibrat's Law and meaning that growth rates decrease with farm size or small farms grow faster than larger farms.

In the next chapter the objective was to to look at the capacity of farmers to transform the inputs employed in production to generate their agricultural output. Individual levels of technical efficiency for IS, SIS, PLS and ES Alentejan farming systems were evaluated using the same panel data set for 1987-1991.

CHAPTER V - TECHNICAL EFFICIENCY AND PRODUCTION CHARACTERISTICS OF ALENTEJAN FARMING SYSTEMS

The objective of this chapter is to evaluate technical efficiency of the farms belonging to the four Alentejan farming systems selected in the last chapter, using panel data for the period 1987-1991. The methodologies used are a parametric and a nonparametric approach, and a comparison between the results of both methodologies is made. The individual levels of technical efficiency evaluated were used to look for possible determinants of the differences observed in efficiency levels between farms.

5.1 - EFFICIENCY CONCEPT

The concept of technical efficiency, along with price or allocative efficiency, make part of the broader concept of economic efficiency. Technical efficiency is reported as the capacity that a specific producer has to obtain the greatest output from a given set of inputs, applying a defined technology. The greatest output attainable from a given set of inputs is called a production frontier. Technical inefficiency is a result of an equiproportionate overutilization of all inputs. Of two farmers who use the same level of inputs and the same technology, the more efficient farmer is the one able to produce the larger output. Allocative or price efficiency is defined as the choice of the optimum mix of inputs under given prices. It assumes profit maximization, and marginal revenue product for all factors should equal marginal costs. Under this concept a firm that does not maximize profits is price inefficient. Allocative inefficiency is the result of input utilization in the wrong proportions, given input prices. This means that a farm is operating outside its least cost expansion path. However, it is possible to compare two price inefficient firms, facing the same output and input prices, and the one that has the higher profits is the more efficient (Lau and Yotopoulos, 1971). A firm is said to be economically efficient if it satisfies the conditions of technical and price efficiency.

Price efficiency depends upon the decisions taken inside the firms, and its analysis is limited by the extent to which the assumptions of profit maximization and competitive markets are verified in the real world. The evaluation of price efficiency is limited by the fact that firms face a world of imperfect knowledge and non-instantaneous equilibrium, farmers' decisions are made inside and outside the set of rational assumptions of economic theory, and data availability and statistical estimation are not in accordance with theoretical needs.

Technical efficiency is mostly related to geographical, environmental and management differences among farmers. The non-managerial determinants of technical efficiency are physical factors such as soil characteristics and climate, social and political factors such as demography and government intervention, and random factors (Timmer, 1970). The same author states that if environmental and geographical differences are taken into account, the final cause of technical efficiency is due to different farm management strategies.

One of the first authors to conceptualize a clear distinction between technical and allocative efficiency was Farrell. The ideas underlying Farrell's approach are illustrated in Figure 5.1. An efficient unit isoquant (EUI) was constructed for a group of firms that use inputs X_1 and X_2, meaning that all firms considered produce the same level of output. Firms that use the input bundles on the frontier, such as C, D, E, F and G, constitute the technically efficient set of firms. The firms within the frontier, such as H and J are technically inefficient. They use more of at least one of the factors of production to produce the unit level of output than do firms located on the frontier. The measure of technical efficiency for firm H is given by the ratio OE/OH. Assuming that input prices are known, the isocost line AB represents the minimum cost of producing one unit of output. Allocative efficiency for firm H is measured by the ratio OI/OE and its overall or economic efficiency is given by OI/OH = OE/OH × OI/OE. Firms located at point D show the highest level of economic efficiency, since they are both allocative and technically efficient.

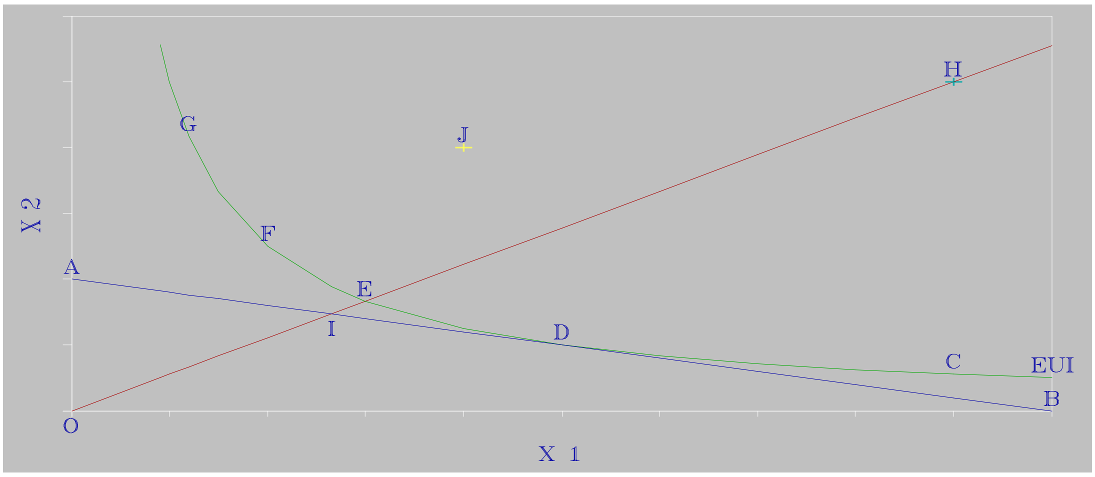


Figure 5.1 - Farrell's Efficiency Measures

The measure of technical efficiency can be further decomposed into three components: pure technical, scale and congestion efficiency. To do so, it is necessary to relax the assumptions of strong disposability of inputs and constant returns to scale that were implicitly assumed in the above definition. Strong disposability means that output does not decrease for an increase in any input, while weak disposability means that output does not decrease for a proportional increase in all inputs, allowing the existence of cases in which an increase in a particular input will force production downward. Figure 5.2 shows an isoquant map for firm H where the isoquant ABC'D' represents the reference technology for farm H assuming variable returns to scale and weak disposability of inputs which corresponds to the best practice frontier and the least restrictive technology. The isoquant ABCD is the reference technology assuming variable returns to scale and strong disposability of inputs, while the isoquant EFG is the reference technology assuming constant returns to scale and strong disposability of inputs, thus admitting that the firm H is operating on the long-run optimal scale and corresponds to the most restrictive technology (EFG is coincident with the reference isoquant EUI defined in Figure 5.1).

Similar to the above definition, technical efficiency of firm H is defined as the ratio OF/OH and this measure can be decomposed into its three mutually exclusive sources of efficiency. Pure technical efficiency is measured relatively to the least restrictive technology (ABC'D') and is the ratio OC'/OH. If the firm H was pure technical efficient it would operate at C', on the backward-bending segment of isoquant ABC'D', meaning that it was possible to increase output by reducing the congesting input X2. The improvement in input use from C' to C, the closest non-congested technology, is a measure of congesting efficiency and is equal to OC/OC'. If the firm H was operating at point C it would be pure and congestion efficient, but would not be operating on the long-run optimal scale (EFG). The firm H scale improvement from C to F is a measure of scale efficiency which is defined by the ratio OF/OC (Färe, Grosskopt and Pasurka, 1989).

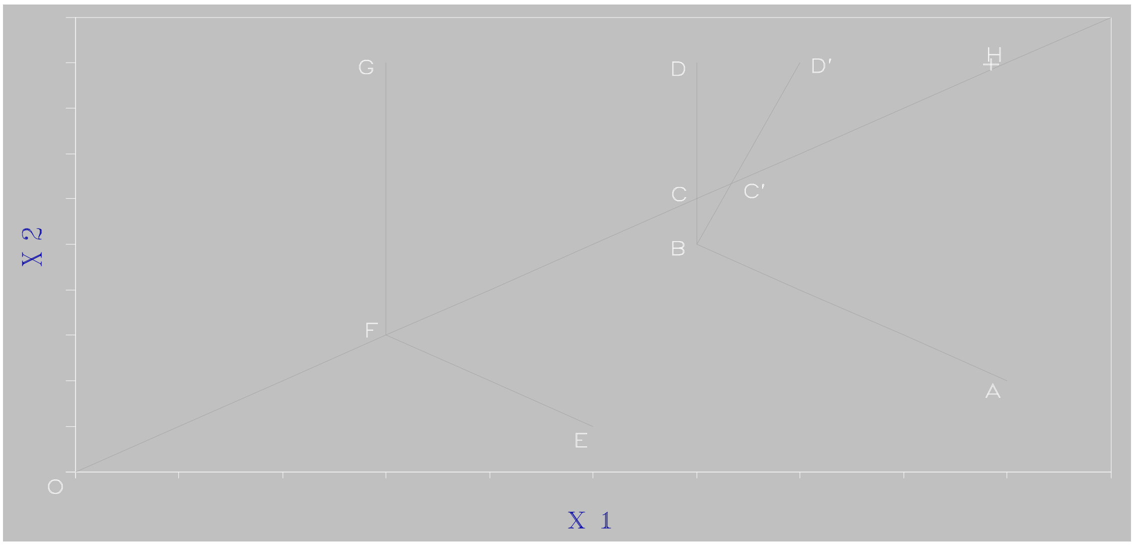


Figure 5.2 - Decomposition of Technical Efficiency

There is some controversy about the nature of technical and allocative efficiency, its measurement and existence. Leibenstein (1966) argues that empirical evidence shows that most of the observed inefficiency is due to X-inefficiency, and observed allocative inefficiency has a small magnitude. He states that the significant factors determining X-efficiency are intra-plant motivational efficiency, external motivational efficiency and nonmarket input inefficiency. On the other side, Stigler (1976) argues that all perceived inefficiency is allocative. He also argues that all perceived inefficiency is due to a failure of the researcher to measure all relevant inputs and to specify correctly the rational behaviour of the producers.

To evaluate economic efficiency, technical and allocative efficiency must be estimated. To estimate allocative efficiency it is necessary to have information, not only on input and output quantities, but also on prices, while technical efficiency only requires information on input and output quantities. In this study, only technical efficiency was evaluated, because information on input and output prices was only available in terms of price indexes for the agricultural systems sampled.

5.2 - MEASUREMENT OF TECHNICAL EFFICIENCY

The methodologies that have been utilized to evaluate technical efficiency at farm level can be divided into three groups: 1) the use of efficiency indicators based on farm accounts, 2) the parametric approach, and 3) the nonparametric approach.

Efficiency indicators based on farm accounts usually evaluate the historical performance of farms and allow for a comparative analysis with similar farms. The historical analysis permits a plotting of a farm's evolution during a certain time period, while the comparative analysis allows us to rank farms within a set of farms with similar attributes. The use of efficiency indicators has been subject to some criticism such as: 1) efficiency indicators use average products based on arithmetic means instead of marginal products, 2) accounting problems in valuing inputs and outputs, 3) the incapacity of these indicators to give sufficient information in order to correct errors committed in the farming system, 4) the comparative analysis is only valid for farmers of the same type and dimension, and 5) the comparison of inter-farm efficiency differences is only possible when farms have the same production function and face the same prices (Yotopoulos and Lau, 1973).

The parametric approach evaluates technical efficiency through the estimation of a production frontier by statistical methods. The difference between the observed and the frontier output is a measure of farms' technical efficiency. The use of production frontiers has some of the limitations referred to above, but they are able to identify the maximum possible level of output, given a bundle of inputs. If the information available for the set of farms being evaluated is only a time period which corresponds to a single cross-section, the methods available to evaluate technical efficiency, based on the estimation of a production frontier, can be divided in two groups: 1) deterministic frontiers and 2) stochastic frontiers (Førsund, Lovell and Schmidt, 1980). If the information available is made for several years, which corresponds to a panel of the data, technical efficiency can be estimated in a more consistent way than using cross-section methods. The estimation methods available are an adaptation of the panel data estimation procedures to the frontier case and are: 1) within estimator, 2) generalized least squares, and 3) maximum likelihood methods (Schmidt and Sickles, 1984). The best estimation method depends on the properties of the data and on the assumptions that the researcher is willing to make.

The nonparametric approach, also referred to in the literature as data envelopment analysis (DEA models), was first developed by Farrell and is based on the construction of a free disposal convex hull of observed input-output ratios, using linear programming techniques. The convex hull is based on a subset of the sample observations with the rest of the sample observations lying above it. Later, Färe, Grosskopf and Lovell (1985) extended the nonparametric approach developed by Farrell, through the relaxation of the technology considered to include scale and strong and weak disposability properties as well as considering the evaluation of efficiency based on inputs, outputs or input-output (graph) measures.

The nonparametric approach has the advantage of not imposing any functional form on the data, and being easy to generalize the single output to single input, to multiple outputs and multiple inputs evaluation of technical efficiency. It is appealing for the study of efficiency in those situations in which it is impossible to visualize a functional form and non-commensurate inputs and outputs are present, and has been largely used to study the efficiency of operations of non-profit organizations. The disadvantages are the susceptibility of the frontier to extreme observations and measurement error, and the non existence of statistical properties of the estimated measures of efficiency. Technical efficiency estimated by the nonparametric methods tend to show higher efficiency levels than estimated from parametric methods because nonparametric methods build a piecewise linear frontier and parametric methods a smooth frontier (Neff, Garcia and Nelson, 1994).

5.3 - PARAMETRIC APPROACH

The parametric approach to studying technical efficiency comprises two basic approaches, depending on the dimensions of the data available. If the time dimension is not available, cross-section methods have to be used. If the time dimension is available, panel data methods may be used, taking all the advantages that panel data are able to offer.

5.3.1 - Cross-Section Methods

Cross-section methods have been largely used to estimate technical efficiency, first using a deterministic approach to characterize the production frontier, assuming or not a particular distribution for the one-sided error term that defines technical efficiency, and second using a stochastic approach after the work by Aigner, Lovell and Schmidt (1977), which specified a stochastic frontier.

5.3.1.1 - DETERMINISTIC FRONTIERS

Parametric frontiers were developed in order to overcome some of the limitations imposed by Farrell's measure of technical efficiency. The development of this approach was based on the specification of a functional form for the production function, the requirement that all observations should be on or beneath the frontier and the relaxation of the constant returns to scale assumption of the Farrell method. The deterministic frontier can be written as

$$y_j = f(x_j;\beta)\exp(-u_j) \quad j = 1,2,\ldots,J \quad 2$$

which is equal to 5.1

$$\ln y_j = \ln[\, f(x_j;\beta)\,] - u_j \quad 4$$

for the Cobb-Douglas production function. The y_j is the possible production level for the j sample producer, f (x_j; β) is a suitable functional form of a vector x_j of N inputs and a vector of unknown parameters β, u_j is a one-sided random variable associated with firm specific factors that contribute to a specific producer not reaching the maximum level of production, and J represents the number of firms or producers in the cross-section sample. The one-sided error term u_j associated with technical efficiency forces $y_j \leq f(x_j; \beta)$, which means that the observed production is bounded above by f (x_j; β).

This model was first developed by Aigner and Chu (1968) who suggested that the parameter vector could be estimated using either linear or quadratic programming techniques. The objective function was to minimize the sum of the absolute values of residuals or the sum of squared residuals values, and can be expressed by the following programming problem

$$\min \sum_{j=1}^{J} [y_j - (\hat{\beta}_0 x_0 + \hat{\beta}_1 x_j 1 + ,..., + \hat{\beta}_{jn} x_n)] \quad 5$$

$$\textit{subject to} \quad 6$$

$$\hat{\beta}_0 x_0 + \hat{\beta}_1 x_j 1 + ,..., + \hat{\beta}_n x_{jn} \geq y_j \quad j = 1,2,...,J \;. \quad 7$$

The advantage of this technique was the ability to characterize frontier technology in a mathematical form and to relax the constant returns to scale of Farrell's imposition. The disadvantages are the imposition of the number of farms that are technically efficient, the fact that the frontier is extremely sensitive to outliers because it is based on a sample subset, and that the parameter estimates produced do not have statistical properties because no assumptions were made about the regressors or the disturbance.

Following a suggestion by Aigner and Chu (1968) that some output observations could lie above the estimated frontier, Timmer (1970) developed what was called the probabilistic frontier using linear programming techniques. The author assumed that the production frontier was of Cobb-Douglas type, expressed in equation 5.1, which could be estimated by a minimization of the linear sum of residuals, assuming that all u_j are non negative. Timmer (1970) showed that this estimation was equivalent to solving the following linear programming model

$$\min \hat{\beta}_0 x_0 + \hat{\beta}_1 \bar{x}_1 + ,..., + \hat{\beta}_n \bar{x}_n \quad 8$$

$$\textit{subject to} \quad 9$$

$$\hat{\beta}_0 x_0 + \hat{\beta}_1 x_j 1 + ,..., + \hat{\beta}_n x_{jn} \geq y_j \quad j = 1,2,...,J \;, \quad 10$$

wherex $_n$ is the mean of the sum of x_{jn}, and x_0 is the constant term. Timmer's frontier was called probabilistic, because some specific proportion of the observations was allowed to lie above the frontier to take outliers into account, although this feature lacked any statistical or economic rationale (Batesse, 1992). Later, Schmidt (1976) proved that the Aigner and Chu (1968), and Timmer (1970) frontiers were equivalent to maximum likelihood frontiers, with errors showing an exponential and half-normal distribution respectively. In both models, the constraint permits that estimated output must equal or be greater than observed output and the producers that satisfy the equality are 100 percent efficient, while for the others the ratio between observed (y_j) and estimated output (y_j) is a measure of technical efficiency.

The deterministic parametric frontier can be estimated statistically, if some assumptions are made about the regressors and the disturbance. Assuming that u_j are independent and identically distributed and x_n are exogenous, the distribution of u_j can be specified. In this situation, maximum likelihood technique can be used to estimate the frontier parameters. Several distributions were assumed for u_j, such as the two parameter beta (Afriat, 1972), gamma (Richmond, 1974), exponential and half-normal (Schmidt, 1976), and a gamma distribution (Green, 1980) . There are no a priori arguments to use any particular distribution, because maximum likelihood estimators depend on the assumed distribution. The maximum likelihood technique violates one of the regularity conditions invoked to prove the general theorem that maximum likelihood estimates are consistent and asymptotically efficient, namely that the range of the random variable should not depend on the parameters (Schmidt, 1985). An alternative method of estimation, called corrected ordinary least squares (COLS), was proposed by Richmond (1974). This method is based on the fact that ordinary least squares are best linear unbiased estimates except for the constant term, and Green (1980) showed that the correction of the constant term, by shifting the frontier until no residual is positive, provides a consistent estimator of β_0 , given that u_j are independent and identically distributed.

5.3.1.2 - STOCHASTIC FRONTIERS

Stochastic frontiers were developed in order to overcome the fact that in deterministic frontiers all variation in farm performance is attributed to technical efficiency. However, in the real world, a farm's performance is affected by two sets of factors, one set entirely outside its control and the other set under its control. The set of factors outside farm control such as luck, weather conditions, machine performance, topography, input supply, and errors of observations and measurement do not contribute to inefficiency, while the set of factors under a farm's control, such as the will and effort of the producer and his employees, are the ones that cause farm inefficiency.

The arguments described above lie behind the stochastic frontier model developed by Aigner, Lovell and Schmidt (1977), and Meeusen and Broeck (1977). The basic idea behind their model is that the error term is composed of two parts: 1) a symmetric component which allows random variation across farms and captures the effects of measurement errors and random shocks outside a farm's control, and 2) a one-sided component error which captures the effects of inefficiency relative to the stochastic frontier.

The stochastic frontier model may be written as

$$Y_j = f(X_j; \beta)\exp^{(v_j - u_j)} \quad j = 1,2,...,J \; 11$$

which is equal to

$$\ln Y_j = \ln[f(X_j;\beta)] + v_j - u_j \quad u_j \geq 0 \; 12$$

for the Cobb-Douglas production frontier, where the error term v_j assumes a symmetric distribution to capture the random effects of measurement errors and exogenous shocks, while the error term u_j assumes a one-sided distribution and measures technical inefficiency, and technical inefficiency is measured by the ratio

$$\frac{Y_j}{[f(x_j;\beta)+v_j]} \quad j = 1,,2,...,J \; .13$$

Assuming specific probability distributions for v_j and u_j, that v_j and u_j are independent, and that x_n is exogenous, the production frontier can be estimated either by the method of maximum likelihood or by corrected ordinary least squares. The estimated parameters are consistent and asymptotically efficient. The distributions assumed for the one-sided error term u_j have been half-normal (Aigner, Lovell and Schmidt, 1977), truncated normal (Stevenson 1980), exponential (Meeusen and Van Broeck, 1977), and gamma (Green, 1990). There is a difference between the distribution proposed by Aigner, Lovell and Schmidt (1977) and Stevenson (1980). The former assumed that the mode of the error term u was equal to zero, while Stevenson (1980) assumed that the mode was different from zero. The reasons underlying the Stevenson formulation were that the factors related to managerial efficiency such as the degree of educational training, intelligence and persuasiveness do not decrease monotonically for increasing levels of inefficiency.

Maximum likelihood frontier estimates are based on the maximization of the log likelihood function, subject to the assumption that the disturbances have a specified distribution, while corrected least squares estimates a corrected β_0 from the higher moments of the error term estimated by ordinary least squares. Assuming that the symmetric component v_j has a normal distribution $(0, \sigma_v^2)$ and the one sided disturbance is derived from a normal distribution $(0, \sigma_u^2)$ truncated above zero, the error density function ($\varepsilon = v - u$) is

$$f(\_) = \frac{2}{\sigma}\Phi\left(\frac{\varepsilon}{\sigma}\right)\left[1 - \phi\left(\varepsilon\ \lambda\ \sigma^{-1}\right)\right] \quad -\infty \leq \varepsilon \leq +\infty \; 14$$

where $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\lambda = \sigma_u/\sigma_v$, and Φ and φ are the standard normal density and distribution functions respectively (Aigner, Lovell and Schmidt, 1977). The mean and error variance of ε are equal to

$$E(\varepsilon) = E(u) = -\frac{\sqrt{2}}{\sqrt{\pi}}\sigma_u \; 15$$

$$V(\varepsilon) = V(u) + V(v) = \left(\pi - \frac{2}{\pi}\right)\sigma_u^2 + \sigma_v^2 \; 16$$

and the log-likelihood function for a sample of J observations can be written as

$$\ln \_(Y \mid \beta, \lambda, \sigma^{\dagger}) = J \ln \frac{\sqrt{2}}{\sqrt{\pi}} + J \ln \sigma^{-1} + \sum_{j=1}^{J} \ln\left[1 - \phi\left(\varepsilon_j \lambda \sigma^{-1}\right)\right] - \frac{1}{2\sigma\dagger}\sum_{j=1}^{J}\varepsilon_j^2 \; 17$$

Using the alternative procedure to estimate the production frontier, corrected ordinary least squares, only the intercept needs to be corrected by the mean value of u_j. In this case, the constant term is corrected by the derivation of the parameters of u_j from its higher-order central moments, based on ordinary least squares residuals. The consistent estimator of β_0 is

$$\beta_0 = \hat{\beta}_{0_0} - \sigma_u \sqrt{\frac{2}{\pi}} \; 18$$

and σ_u^2 and σ_v^2 can be consistently estimated using the ordinary least square residuals e_j

$$\sigma_u^2 = \left[\frac{\sqrt{\pi}}{2}\left(\frac{\pi}{\pi - 4}\right)\left(\frac{\sum_{j=1}^{N} e_j^3}{N}\right)\right]^{\frac{2}{3}}$$

$$\sigma_v^2 = \left(\frac{\sum_{j=1}^{N} e_j^2}{N} - \frac{\pi - 2}{\pi} \sigma_u^2 \right) \quad 20$$

where e_j^2 and e_j^3 are the second and third central moments of residuals.

The mean of the error is a measure of average technical efficiency for the sample of observations being studied. Individual levels of technical efficiency are derived for both cases by Jondrow et al. (1982) and equal to the mean of the conditional distribution of u given ε

$$E(u|\varepsilon) = \sigma_* \left[\frac{\Phi(\varepsilon\lambda/\sigma)}{1-\phi(\varepsilon\lambda/\sigma)} - \left(\frac{\varepsilon\lambda}{\sigma} \right) \right] \quad 21$$

where $\sigma_*^2 = \sigma_u^2\sigma_v^2/\sigma^2$.

The deterministic parametric frontier estimated by Aigner and Chu (1968) or by Timmer (1970) programming approaches, estimates a best practice frontier because of their non-statistical nature, that is without assuming any particular distribution for the one-sided error, and yielding 100 percent efficient observations. The deterministic statistical and the stochastic approach estimate an absolute frontier; that is, an explicit distribution is assumed for the one-sided error, and the observed frontier production values are less than the corresponding frontier values (Førsund, Lovell and Schmidt, 1980, and Batesse, 1992).

5.3.2 - Panel Data Methods

Panel data has general advantages over cross-section data such as: panel data increases the degrees of freedom and reduces collinearity among the explanatory variables, increases the number of economic questions that can be analyzed, and allows the study of the dynamics of the individuals (Hsiao, 1986). Regarding the study of technical efficiency, the specific advantages are that the use of panel data avoids some of the problems of cross-section estimation of efficiency which are discussed below, and can incorporate variations in efficiency through time (Pitt and Lee, 1981).

Schmidt and Sickles (1984) state that the single cross-section stochastic frontier models have three major difficulties: 1) problems related to consistency of the level of technical efficiency estimated for each firm, because the error term contains statistical noise as well as technical inefficiency, 2) the separation of technical efficiency from statistical noise demands assumptions about the distribution of technical inefficiency and it is not clear how robust are the results regarding those assumptions, and 3) technical inefficiency may be or not independent of the regressors. A panel data of J observations on T time periods allows the avoidance of the three major limitations stated above for cross-section, because inefficiency can be consistently estimated as $T \rightarrow \infty$, strong distributional assumptions are avoidable as well as the uncorrelatedness between technical inefficiency and the regressors.

Considering a single equation production function of the following form

$$y_{jt} = f(x_{jt}; \beta) \exp^{(v_{jt} - u_j)} \quad j = 1,\ldots,J, \; t = 1,\ldots,T \; 22$$

which is equal to 5.2

$$\ln y_{jt} = \ln [\, f(x_{jt}; \beta) \,] + v_{jt} - u_j, 24$$

for the Cobb-Douglas production function, where j represents firms or producers, t time periods, x_{jt} is a vector of N inputs, Y_{jt} is output for a given firm, and v_{jt} are independent of x_{jt} assuming that producers maximize expected profits (Zellner, Kmenta and Dreze, 1966). The above model fits the panel data literature framework with a firm effect u_j and no time effect. The u_j are the firm effects that represent technical efficiency and consequently $u_j \geq 0$.

The principal methods available to estimate the above equation and technical efficiency with panel data are the within estimator, generalized least squares and maximum likelihood techniques. Each of these methods embodies a set of assumptions regarding the firm effects and the regressors, and the properties of the estimators will depend on these assumptions as well as on the size of the sample in its two dimensions J and T.

5.3.2.1 - WITHIN ESTIMATOR

The within estimator, also called the dummy variable least squares estimator, treats the individual effects u_j as fixed, and can be estimated using dummy variables or the within transformation. In the first case, a separate intercept for each firm is estimated and this is done by adding J dummy variables, one for each firm, or alternatively, by keeping the constant term and adding J-1 dummies. The within transformation consists of expressing all data in terms of the deviations from each firm's mean and then applying ordinary least squares on the transformed data. In this case the firm intercepts can be recovered as the means of the residuals by firm. The advantage of the dummy variable is that it allows us to obtain standard errors for all parameters of the model and consequently for the firm effects u_j. However, to avoid the dummy variable trap, the number of dummy variables has to be equal to the number of farms minus one, to eliminate perfect collinearity and singularity of the matix of regressors (Judge et al., 1985).

The main advantage of the within estimator is that the consistency of the estimated parameters does not depend on the uncorrelatedness of the regressors and the individual effects and on the distribution of the effects, because it treats them as fixed. The consistency of the estimated parameters β requires either J or T $\rightarrow \infty$, while consistency of firm individual parameters u_j, require T $\rightarrow \infty$. The disadvantage of the within estimator is that regressors that are invariant over time cannot be included in the model, though they vary across firms. To relax this constraint, assumptions about the uncorrelatedness of the regressors and firm effects and about the distribution of the effects have to be made, using generalized least squares or maximum likelihood estimators (Schmidt and Sickles, 1984).

The estimatedu $_j$ are firm specific measures of technical efficiency. The effects can be normalized, assuming $u_j \geq 0$ for the frontier case, and were defined by Schmidt and Sickles (1984) as

$$u_j = \max(\hat{u}_j) - \hat{u}_j \qquad 5.3$$

For the most efficient firm, $u_j = 0$, and relative measures of technical efficiency are given by e^{-uj}.

5.3.2.2 - GENERALIZED LEAST SQUARES

Generalized least squares treats the individual effects u_j as random and uncorrelated with the regressors, and this corresponds to the variance components model of the panel data literature. Consistent estimation of the regressors, assuming the realistic case in which the covariance matrix is unknown, requires J $\rightarrow \infty$. However, if the individual effects are correlated with the regressors, the estimates of the regressors are biased and inconsistent even if the covariance matrix is known, excepting when J and T $\rightarrow \infty$, in which within and generalized least squares converge (Seale, 1990). Mundlak (1978) showed that if the effects and the regressors are correlated, generalized least squares are similar to the 'within estimator', whether the effects are random or fixed. Only when the effects are random and uncorrelated with the regressors and the covariance matrix is known, is generalized least squares more efficient than the 'within estimator'. The advantage of the generalized least squares is the possibility of including regressors that are invariant over time but vary between individuals or groups of individuals.

The individual firm random effects u_j can be estimated from the residuals as

$$\hat{u}_j = \frac{1}{T}\sum_{t=1}^{T}\varepsilon_{jt} \qquad 5.4$$

$$\hat{u}_j = \frac{\hat{\sigma}_u^2 \left(\sum_{t=1}^{T}\varepsilon_{jt} \right)}{T\,\hat{\sigma}_u^2 + \hat{\sigma}_v^2} \qquad 5.5$$

where the first formula was proposed by Schmidt and Sickles (1984), the second by Judge et al. (1985), and equation 5.2 normalizes the random effects considering that $u_j \geq 0$ for the frontier case.

5.3.2.3 - MAXIMUM LIKELIHOOD

To estimate the panel frontier model by maximum likelihood techniques, distributional assumptions must be specified for u_j and v_{jt}. Generally, v_{jt} is assumed to be normal and independent of u_j, while u_j is assumed to be half-normal, although other distributions can be considered such as truncated normal, gamma and exponential, but with additional computational costs. For a half-normal distribution of u_j the log-likelihood function was first derived by Pitt and Lee (1981) and is equal to

$$\ln L = J \ln 2 - \frac{JT}{2} \ln 2\pi - \frac{J(T-1)}{2} \ln \sigma_v^2 - \frac{J}{2} \ln \left(\sigma_v^2 + T\sigma_u^2 \right)$$

$$- \frac{T}{2\sigma_v^2} \sum_{j=1}^{J} \left(\frac{y_{j'} Y_j}{T} \right) \qquad 5.6$$
$$+ \frac{T^2 \sigma_u^2}{2\sigma_v^2 \left(\sigma_v^2 + T\sigma_u^2 \right)} \sum_{j=1}^{J} \left(\overline{y}_j - \overline{x}_j \beta \right)^2$$

$$+ \sum_{J=1}^{J} \ln \left[1 - \phi \left(\frac{T\sigma_u}{\sigma_v \left(\sigma_v^2 + T\sigma_u^2 \right)^{\frac{1}{2}}} \right) \right],$$

where φ is the standard normal distribution, y_j and x_j are output and input matrices, and$\overline{y}_j$ and$\overline{x}_j$ are the sample means of y and x for the j unit. The levels of technical efficiency u_j can be estimated either by equations 5.3 to 5.5 (Seale, 1990) or by the method proposed by Batesse and Coelli (1988), based on the conditional expectation of u_j given the maximum likelihood errors, and expressed by the following formula

$$TE_i = E(\exp(-u_j) \mid E_j = e_j) = \left(\frac{1 - \phi[\sigma - (u_j / \sigma)]}{1 - \phi(-u_j / \sigma)} \right) \exp(-u_j + \frac{1}{2\sigma^2}). \qquad 5.7$$

Similar to generalized least squares, maximum likelihood methods are more efficient than within only when individual effects are uncorrelated with the regressors and have the advantage of allowing time invariant regressors.

All the methods described above considered that technical efficiency is time invariant; however, depending on the data available, that assumption may prove to be unrealistic for many potential applications (Cornwell, Schmidt and Sickles, 1990). In the next section we look at different forms of relaxing this assumption.

5.3.3 - Time Varying Technical Efficiency

The models referred to above to estimate technical efficiency in the context of a panel of data assumed that technical efficiency does not vary over time. Several authors such as Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990), Batesse and Coelli (1992), and Lee and Schmidt (1993) proposed different forms of relaxing that assumption and of obtaining estimates of time-varying levels of technical efficiency.

Cornwell, Schmidt and Sickles (1990) relaxed the assumption of time invariant technical efficiency by replacing the firm effects u_j by a quadratic function of time with parameters that vary over firms, expressed by the following equation

$$u_{jt} = \theta_j 1 + \theta_j 2 \ t + \theta_j 3 \ t^2 . \qquad 5.8$$

In this specification, the fact that output levels vary over firms and time allows also for productivity growth to vary over firms and time. To estimate this model the authors proposed either the within estimator or generalized least squares corrected for the u_{jt} expressed in equation 5.8. The time varying levels of technical efficiency u_{jt} are obtained regressing the residuals (y_{jt} -x_{jt} β), which are an estimate of (v_{jt}-u_j), on the quadratic function of time expressed in equation 5.8. The levels of technical efficiency are derived in a fashion similar to the one described in equations 5.3 and 5.4.

A more flexible model was established by Kumbhakar (1990), in which it was assumed that the non-negative firm effects u_{jt} were the product of the time-invariant firm effects u_j and a deterministic function of time $\gamma(t)$, which was assumed to be equal to

$$\gamma(t) = [\ 1 + \exp(\ bt + ct^2\ )\ ]^{-1}$$

where b and c are parameters that allow $\gamma(t)$ to vary between 0 and 1 and to be monotone-decreasing (or increasing) or convex (or concave). The production frontier associated with the error structure described has to be estimated consistently with maximum likelihood techniques.

Batesse and Coelli (1992) proposed a rigid parameterization of technical efficiency in which time varying technical efficiency u_{jt}, is the product of time invariant firm effects u_j and a function of time $\gamma(t)$. The u_j shows a non-negative truncated normal distribution while $\gamma(t)$ is equal to

$$\gamma(t) = \exp[-\eta(t - T)]$$

where η is a scalar. This parameterization is rigid because technical efficiency must increase at a decreasing rate ($\eta > 0$), remain constant ($\eta = 0$), or decrease at an increasing rate ($\eta < 0$), and the method used is maximum likelihood.

The model developed by Lee and Schmidt (1993) assumed a flexible form for technical efficiency, in which $u_{jt} = \theta_t \delta_j$, where θ_t are the parameters to be estimated, and θ_t can have several components. This model is nonlinear and can be estimated by the minimization of a criterion function, assuming either fixed or random individual effects.

Time varying technical efficiency is an appealing assumption when a sufficient number of time periods for the data being analyzed is available. However, with the exception of the last methodology, the additional assumptions made to describe the variation of technical efficiency over time as well as the complexity of the estimation procedures necessary to consider time varying technical efficiency, constrains to a certain extent the advantage of having time varying technical efficiency.

5.4 - NONPARAMETRIC APPROACH

The non-parametric approach to measure efficiency departs from the definition of Farrell (1957) of efficiency which was extended later by Färe, Grosskopf and Lovell (1985 and 1994). This approach of measuring efficiency is based on the definition of a piecewise technology and the efficiency measures of individual producers are evaluated relative to the best practice frontier constructed as a piecewise linear envelopment of the data generated by the set of all producers that belong to a reference group. This is a radial measure of efficiency because it is evaluated with respect to the best practice frontier. However, if efficiency is evaluated against the efficient subset of observations, the efficiency measure is non-radial and is called the Russel measure of efficiency (Schmidt, 1978).

To measure efficiency using the nonparametric approach a definition of the technology that transforms input quantities into output quantities has to be made. The technology can be defined in three different forms: input, output and input-output (graph) correspondences. These different correspondences model the same technology but emphasize different aspects of it. The input correspondence models all input vectors that yield at least an output vector, thus modelling input substitution. The output correspondence models all output vectors that are obtainable from an input vector modelling output substitution. The graph correspondence models all feasible input-output vectors representing input and output substitution as well as input-output transformations. If prices are available, then additional characterizations of the technology can be made regarding revenue and cost. Additional aspects of the technology can be taken into account such as the scale of operations, diversification of activities and disposability of input and outputs. Depending on the data available, a given representation of the technology can be chosen to measure efficiency (Färe, Grosskopf and Lovell, 1994).

Considering the input correspondence that considers output as given, the piecewise linear representation of a given technology for a reference group of J producers, M outputs (Y) and N inputs (X), assuming constant returns to scale, disposability of inputs and nonnegative amounts of inputs and outputs, can be defined as

$$y_m \leq \sum_{j=1}^{J} z_j \, y_{jm}, \quad m = 1,2,\ldots,M \quad 37$$

$$\sum_{j=1}^{J} z_j \, x_{nj} \leq x_n, \quad n = 1,2,\ldots,N \quad 38$$

where z_j are intensity variables that denote the intensity levels at which the input and output values for each individual producer might be conducted, through the shrinkage or expansion of the individual observed values of each producer, with the objective of constructing unobserved but feasible observations, thus facilitating the construction of the segments of the piecewise linear boundary of the technology.

Based on the above technology in which output is given, productive efficiency measures evaluate for each individual producer where its input vector x is located in the input set. This approach is referred to as input based (Färe, Grosskopf and Lovell, 1994) since inputs are the choice variables and efficiency is measured as the maximum feasible shrinkage of an observed input vector. If only input and output quantities are available, then productive efficiency measurement is limited to technical efficiency measures. Assuming constant returns to scale and strong disposability of inputs, an overall technical efficiency measure can be calculated for producer j as the solution of the following linear programming problem

$$OTE_j(C,S) = \min \lambda \ 39$$
$$subject\ to\ 40$$
$$y_{jm} \le \sum_{j=1}^{J} z_j\, y_{jm}\,, \quad m = 1,2,..,M \qquad 5.9$$

$$\sum_{j=1}^{J} z_j\, x_{jn} \le \lambda\, x_{jn} \quad n = 1,2,...,N\ ,42$$
$$z_j \ge 0 \quad j = 1,2,...,J\ ,43$$

where (C, S) represent constant returns to scale and strong disposability of inputs, and λ measures the largest feasible contraction of the input set of producer j being evaluated. In order to evaluate pure technical, scale, and congestion efficiency as well as to determine if a specific producer exhibits constant, increasing or decreasing returns to scale, it is necessary to relax the assumptions of constant returns to scale and strong disposability of inputs.

Considering that the technology satisfies nonincreasing returns to scale and strong disposability of inputs, then evaluation of this measure of technical efficiency will be made by the following linear programming problem

$$TE_j(N,S) = \min \lambda \ 44$$
$$subject\ to\ 45$$
$$y_{jm} \le \sum_{j=1}^{J} z_j\, y_{jm}\,, \quad m = 1,2,..,M\ , \qquad 5.10$$

$$\sum_{j=1}^{J} z_j\, x_{jn} \le \lambda\, x_{jn}\,, \quad n = 1,2,...,N\ ,47$$
$$\sum_{j=1}^{J} z_j \le 1,48$$
$$z_j \ge 0\,, \quad j = 1,2,...,J\ ,49$$

a relaxation of the scale properties to consider variable returns to scale leads to the following linear programming problem

$TE_j(V,S) = \min \lambda$ 50

subject to 51

$$y_{jm} \leq \sum_{j=1}^{J} z_j \, y_{jm} \, , \quad m = 1,2,..,M \, , \qquad 5.11$$

$$\sum_{j=1}^{J} z_j \, x_{jn} \leq \lambda \, x_{jn} \, , \quad n = 1,2,...,N \, , 53$$

$$\sum_{j=1}^{J} z_j = 1, 54$$

$$z_j \geq 0 \, , \quad j = 1,2,...,J \, , 55$$

while the relaxation of strong input disposability to weak input disposability associated with variable returns to scale allows us to define a measure of pure technical efficiency as the solution of the following nonlinear programming problem

$PTE_j(V,W) = \min \lambda$ 56

subject to 57

$$y_{jm} \leq \sum_{j=1}^{J} z_j \, y_{jm} \, , \quad m = 1,2,..,M \, , \qquad 5.12$$

$$\sum_{j=1}^{J} z_j \, x_{jn} = \sigma \lambda \, x_{jn} \, , \quad n = 1,2,...,N \, , 59$$

$$\sum_{j=1}^{J} z_j = 1, 60$$

$$0 < \sigma < 1 \, , 61$$

$$z_j \geq 0 \, , \quad j = 1,2,...,J \, , 62$$

which can be converted into a linear programming problem by taking $\sigma=1$, without changing the optimal values of λ and z (Färe, Grosskopf and Lovell, 1994). Based on the above technical efficiency measures, scale efficiency is defined as the ratio between overall technical efficiency and variable returns to scale technical efficiency

$SE_j = OTE_j (C, S) / TE_j(V, S)$

and congestion efficiency as the ratio between variable returns to scale technical efficiency and pure technical efficiency

$CE_j = TE_j\ (V, S) / PTE_j(V, W)$.

A producer is scale efficient if $OTE_j(C, S)=TE_j(V, S)$ or if it is equally efficient in terms of overall technical efficiency and variable returns to scale technical efficiency. If a producer is scale inefficient ($SE_j < 1$), the source of scale inefficiency is due to increasing returns to scale when OTE_j (C, S) = TE_j (N, S) and due to decreasing returns to scale when $OTE_j(C, S) < TE_j$ (N, S). If a producer is congestion inefficient, it is possible to evaluate the input or subset of inputs that determine congestion inefficiency. To do so, it is necessary to evaluate technical efficiency with a technology that satisfies variable returns to scale and consider the decomposition of the input vector x into two subvectors $x^{\alpha} = (1, 2, ..., N^{\alpha})$ with strong disposability and $x^{\alpha+1} = (N^{\alpha+1}, ..., N)$ with weak disposability, which corresponds to the evaluation of the following nonlinear programming problem

$$TE_j(V, S^{\alpha}) = \min \lambda \ 63$$
$$subject\ to\ 64$$
$$y_{jm} \leq \sum_{j=1}^{J} z_j\, y_{jm}\ ,\quad m = 1,2,..,M\ ,65$$
$$\sum_{j=1}^{J} z_j\, x_{jn} \leq \lambda\, x_{jn}\ ,\quad n = 1,2,...,N^{\alpha}\ , \qquad 5.13$$
$$\sum_{j=1}^{J} z_j\, x_{jn} = \sigma\, \lambda\, x_{jn}\ ,\quad n = N^{\alpha+1},...,N, 67$$
$$\sum_{j=1}^{J} z_j = 1, 68$$
$$0 < \sigma < 1\ , 69$$
$$z_j \geq 0\ ,\quad j = 1,2,...,J\ , 70$$

and if $TE_j(V, S) = TE_j(V, S^{\alpha})$, the subvector $x^{\alpha+1}$ obstructs production.

The definition of overall technical efficiency made above and as demonstrated by Färe, Grosskopf and Lovell (1994), can be decomposed in the following three components

$OTE_j = PTE_j\ .\ SE_j\ .\ CE_j$,

a measure of pure technical efficiency, a measure of scale efficiency and a measure of congestion efficiency. A producer is efficient (OTE_j=1), if all three measures are equal to unity.

The nonradial Russel measure of technical efficiency evaluates efficiency regarding the efficient subset of observations and this is done allowing for non-proportional reductions in each input vector of a given producer, permitting the input vector to shrink to the efficient subset. This measure can be evaluated by a linear programming approach similar to the ones defined above, but allowing for a specific λ for each input and modifying the objective function to be the average value of the sum of λ_n evaluated for each producer. Assuming constant returns to scale, the Russel measure of technical efficiency can be expressed by the following linear programming problem

$$RTE_j(C) = \frac{1}{N} \min \sum_{n=1}^{N} \lambda_n \quad 71$$

$$\textit{subject to} \quad 72$$

$$y_{jm} \leq \sum_{j=1}^{J} z_j \, y_{jm}, \quad m = 1,2,..,M \;, 73$$

$$\sum_{j=1}^{J} z_j \, x_{jn} = \lambda_n \, x_{jn}, \quad n = 1,2,...,N \;, 74$$

$$z_j \geq 0, \quad j = 1,2,...,J. \quad 75$$

Since the Russel measure is evaluated relative to the efficient subset, it yields the same result when measured relative to a technology satisfying weak or strong disposability of inputs, thus without need for a measure of congestion efficiency, while the variable returns to scale and nonincreasing returns to scale measures, can be derived imposing similar restrictions on the z_j as for the radial measures.

The advantages of the nonparametric approach to measure technical efficiency are the non-imposition of a functional form to the technology being evaluated, and the measures of technical efficiency evaluated are independent of the units used to define the inputs and outputs. The disadvantages are measurement error and variable specification. The nonparametric approach does not take into consideration an error term, and if measurement error occurs the construction of the frontier will be affected, and this error is more serious when the measurement error occurs in an efficient firm that lies on the frontier. Another disadvantage is the fact that the technical efficiency measures do not have any statistical support (Schmidt, 1985).

5.5 - DATA AND METHODOLOGY

The panel data for the period 1987-1991 described in Chapter IV was utilized to evaluate technical efficiency of Alentejan farming systems. Technical efficiency levels were evaluated using a parametric and a nonparametric approach. For both approaches the variables used to estimate and measure technical efficiency were

OUT represents crop, livestock and other output;
LAN represents the rent of land;
LAB represents total labour;
MAC represents all machinery costs;
CLC represents all crop and livestock costs.

General overhead costs which account for around 4.9 percent of total cost were impossible to impute to each one of the inputs defined above and were excluded from the analysis. Output and input quantities were obtained by deflating the revenue and cost values by respectively, the EC's agricultural output and input price indices for Portugal. Each of the variables defined above (output or inputs) was the result of aggregating several items using a weighted index. The weights were the shares of each item in the value product for product items or in each input costs for cost items. Table 5.1 shows a summary of the data on the different variables considered, while in Table 1 of appendix II the output and input data for each farm by farming system and year is shown.

For the parametric approach a Cobb-Douglas functional form was chosen similar to equation 5.1 and defined by the following expression

$$\log(OUT_{jt}) = \beta_0 + \beta_1 \log(LAN_{jt}) + \beta_2 \log(LAB_{jt}) + \beta_3 \log(MAC_{jt}) + \beta_4 \log(CLC_{jt}) - u_j + v_{jt},$$

where v_{jt} is a random variable assumed to be independent and identically distributed $N(0, \sigma_v^2)$, and u_j have the properties described in 5.3.2 depending on the estimation technique used. For each estimation procedure individual levels of technical efficiency were derived using equations 5.4 for within, 5.2 and 5.4 for generalized least squares and 5.6 for maximum likelihood estimator. The Hausman-Taylor test was used to choose among the three estimation alternatives available the best model in accordance with the data characteristics (Hausman, 1978 and Hausman and Taylor, 1981).

Table 5.1 - Summary Statistics for the Variables Used in the Parametric and Nonparametric Frontier (Average 1987-1991 for 100 Farms)

Variable	Sample Mean	Sample Standard Deviation	Minimum Value	Maximum Value
Output	4188	4466	184	40481
Land	196	221	3	1354
Labour	7855	7444	792	109440
Machinery	607	648	10	11371
Crop and Livestock	1048	1163	17	4850

With respect to the non-parametric approach, individual overall, pure, scale and congestion radial technical efficiency measures were evaluated for the aggregated data comprising the five years considered. To derive these measures of efficiency the linear programming problems expressed in equations 5.8 to 5.11 were solved for each farm, meaning that the efficiency measures evaluated are input based.

Five years of data were available, which is a relatively short period to consider changes in technical efficiency over time, and consequently it was assumed for both approaches that technical efficiency was time invariant.

5.6 - RESULTS

This sections starts with the results of the parametric and nonparametric approach, and this is followed by the presentation of the comparison between both methodologies and ends with the relationship between efficiency and farm characteristics.

5.6.1 - Parametric Approach

The results for the Cobb-Douglas production frontier estimated are presented in Table 5.2. The estimated coefficients show some variation depending on the estimation procedure, although the results obtained by the generalized least squares and maximum likelihood techniques are very similar. The inputs with higher production elasticities are labour, and crop and livestock, inputs for the within estimation procedure and machinery, and crop and livestock, inputs for generalized least squares and maximum likelihood techniques. Returns to scale are close to 0.92, thus in the decreasing returns to scale range, and a test performed to verify if the sum of production elasticities was equal to one, showed that it was not significantly different from unity, meaning that constant returns to scale is a reasonable assumption for the sample of farms considered. The estimation method that explains more of the variation in the output (88 per cent) is the within, while generalized least squares explains the minimum (84 per cent).

Table 5.2 - Parametric Estimates of the Production Function Frontier (1987-1991)

Parameter	Ordinary Least Squares	Within	Generalized Least Squares	Maximum Likelihood
Constant	2.126		1.805	2.367
	(0.325)		(0.400)	(0.377)
Land	0.062	0.182	0.129	0.116
	(0.031)	(0.063)	(0.040)	(0.038)
Labour	0.079	0.278	0.179	0.190
	(0.043)	(0.062)	(0.050)	(0.038)
Machinery	0.359	0.118	0.238	0.242
	(0.034)	(0.051)	(0.039)	(0.038)
Crop and Livestock	0.409	0.345	0.386	0.378
	(0.035)	(0.053)	(0.041)	(0.038)
σ_u^2			0.143	0.619[a]
σ_v^2	0.284	0.142	0.184	0.764[b]
R^2	0.70	0.88	0.84	0.84
Returns to Scale	0.909	0.923	0.932	0.926

standard errors in parenthesis
[a] this value is equal to $\sigma^2 = \sigma + \sigma$
[b] this value is equal to $\gamma = \sigma / \sigma^2$

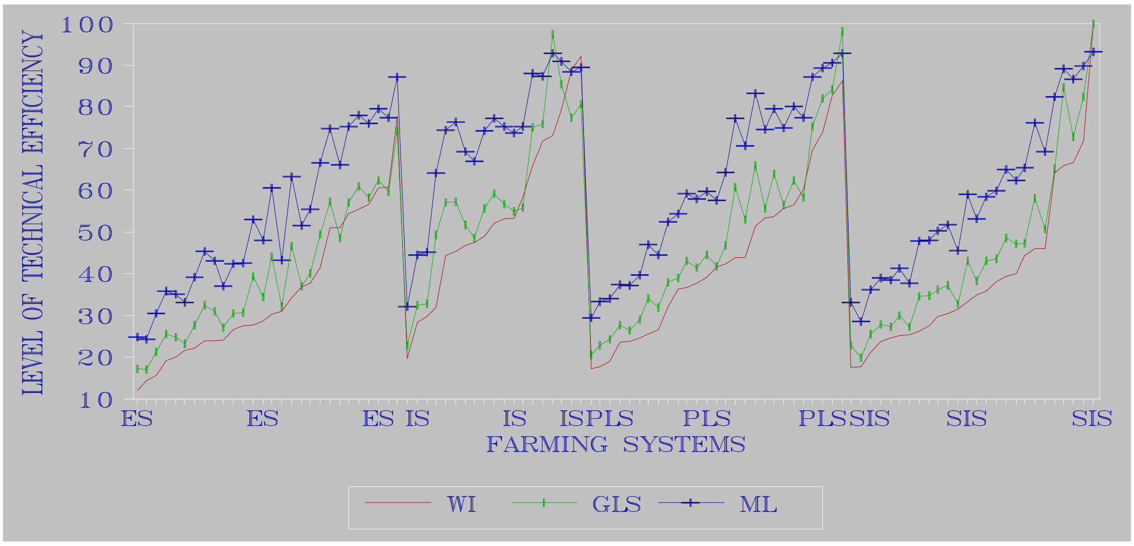


Figure 5.3 - Parametric Individual Levels of Technical Efficiency by Farming System

In Figure 5.3 and Table 2 of appendix II, individual levels of technical efficiency are shown for each farming system and estimation technique, by crescent order of the within results. Although individual ranking and the magnitude of the levels of technical efficiency are different for the three methods, one can conclude that the three estimation techniques show a close pattern regarding the individual levels of technical efficiency. This closeness is higher between the within and generalized least squares and between generalized least squares and maximum likelihood estimates of technical efficiency (Pearson correlation coefficients=rp=0.97), while rp=0.94 between within and maximum likelihood. However, analysing by farming system, the within estimates of technical efficiency for the IS system show a pattern that diverges slightly more from the generalized and maximum likelihood estimates (rp=0.90) than when the same estimates of technical efficiency are compared for the other farming systems (rp>0.94). The maximum likelihood technique shows comparatively higher values for technical efficiency than the generalized least squares and within estimator, while the within estimator shows the lower values. With respect to individual ranking of the farms, one can conclude from Table 2 of Appendix 2, that the ranking of the farms is almost equal between generalized least squares and maximum likelihood estimators (Spearman correlation coefficient rs=0.99) and slightly different between within and generalized and maximum likelihood estimators (rs=0.98).

The average values for technical efficiency by farming system and estimation technique shown in Figure 5.4 and Table 5.3 allow us to conclude that the IS and PLS farming systems have on average higher levels of technical efficiency than the SIS and ES farming systems, while the IS shows the highest and the ES the lowest average value of technical efficiency. The most efficient farms belong to the SIS and the least efficient farms to the ES farming systems. The differences observed in the levels of technical efficiency between farming systems were statistically tested. The analysis of variance and the nonparametric Kruskal-Wallis test were used to test the null hypothesis that technical efficiency is independent of the farming system. The analysis of variance test compares the within and among group variation of efficiency measures and the Kruskal-Wallis test is a one way analysis of variance based on ranks. The results of these two tests show that technical efficiency is not independent of the farming system.

Table 5.3 - Parametric Average, Maximum and Minimum Values of Technical Efficiency and Statistical Tests by Farming System

Farming System	Within			Generalized Least Squares			Maximum Likelihood		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
ES	35.2	77.8	12.1	39.6	74.2	17.1	53.2	87.2	24.2
IS	54.2	92.1	19.6	59.2	97.4	22.8	72.9	92.7	32.1
PLS	43.5	86.3	17.2	49.2	98.2	20.6	62.4	92.8	29.4
SIS	39.5	100.0	17.6	45.4	100.0	19.7	58.0	93.2	28.5
All	42.2			47.4			60.7		
Analysis of Variance (F)		4.01 (0.01)			4.21 (0.00)			4.47 (0.01)	
Kruskal-Wallis (χ^2)		11.2 (0.01)			10.9 (0.01)			11.2 (0.01)	

() Prob > F or χ^2.

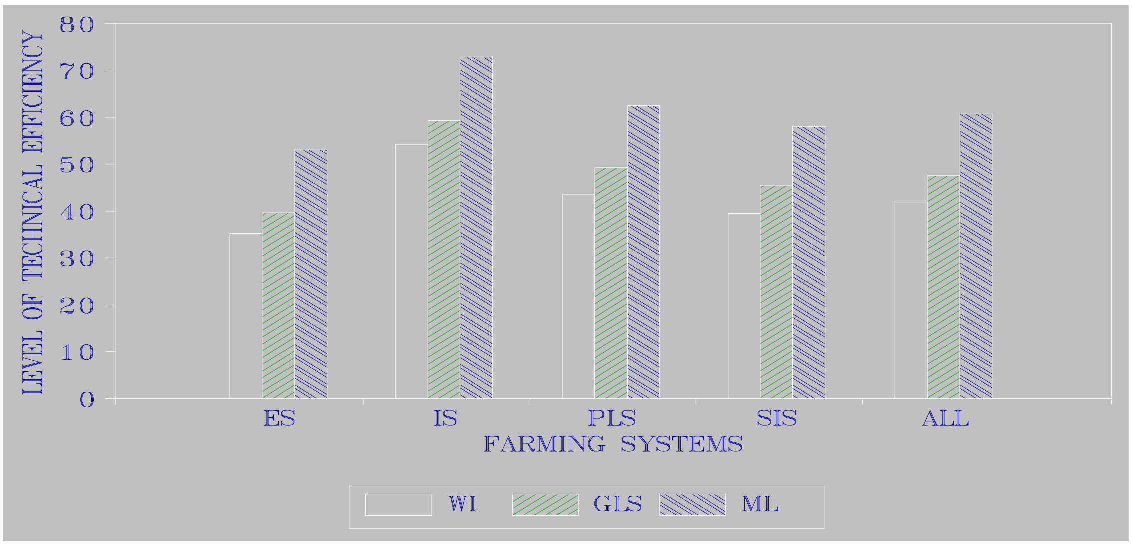


Figure 5.4 - Parametric Average Levels of Technical Efficiency by Farming System

Regarding the distribution of the individual levels of technical efficiency by classes of technical efficiency shown in Figure 5.5 and Table 5.4, the within and generalized least squares techniques show a skewed distribution pattern towards the lower efficiency classes, while the maximum likelihood technique shows an equilibrated distribution pattern similar to the normal. These distribution patterns are confirmed by the skewness statistic, which takes the values of 0.77, 0.66 and -0.03 for the within, generalized least squares and maximum likelihood estimators respectively. The variance observed in the three measures of technical efficiency was very similar as expressed by the values of the standard deviation between 19.6 and 19.8.

Table 5.4 - Parametric Distribution of Farms by Class Levels of Technical Efficiency

Classes of Efficiency	Within	GLS	ML
0-50	67	60	35
51-70	22	25	27
71-90	9	12	33
90-100	2	3	5
Skewness Statistic	0.77	0.66	-0.03

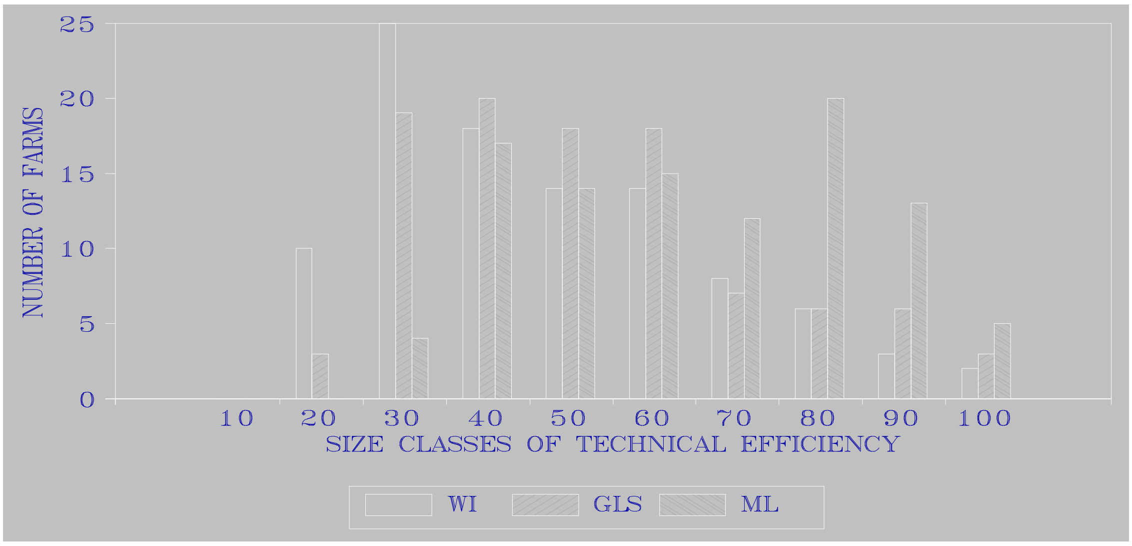


Figure 5.5 - Parametric Distribution of Farms by Class Levels of Efficiency

With the objective of selecting the best estimation procedure, Table 5.5 shows the results of the Hausman-Taylor test. The results show that ordinary least squares as well as the generalized least squares and maximum likelihood techniques were rejected when compared with the within. This means that individual effects are present, individual effects are correlated with the regressors, and individual effects are not random and with a distribution N(0,σ). Thus the best estimation technique is the within and individual levels of technical efficiency evaluated by the within estimator were chosen to be used later in the chapter.

Table 5.5 -Tests to Select the Best Estimation Procedure

Models	Null Hypothesis H_0	χ^2 - Statistic	$\chi^2_{0.95}$ - Value	Decision
OLS / Within[a]	$\beta_0,\beta = u_i,\beta$	5.92	1.00	Reject H_0
GLS/Within	Cor u_i / x_{in} = 0	24.22	9.49	Reject H_0
ML/Within	Cor u_i / x_{in} = 0 and u_i N(0,σ)	27.17	9.49	Reject H_0

[a] is an F test

The average values, ranking, distribution and best estimation technique obtained above for the three estimation techniques of technical efficiency are very similar with the ones obtained in the studies undertaken by: Seale (1990) for a sample of floor tile manufactures in Egypt; Cornwell, Schmidt and Sickles (1990) for a sample of US airlines; and Dawson, Lingard and Woodford (1991) for a sample of Philippines rice farmers. As shown above, the average values of technical efficiency for the within are lower than ML estimates of technical efficiency and this result is similar to the ones obtained in the Cornwell, Schmidt and Sickles, and Dawson, Lingard and Woodford studies, while in the Seale study there is not enough evidence.

The ranking of individual levels of technical efficiency for the three estimation techniques was very similar, as demonstrated by the high values of the correlation coefficients (rs > 0.97) and similar results were obtained by the three studies mentioned above, with Dawson, Lingard and Woodford reporting an rs = 0.95. The distribution of the levels of technical efficiency observed in our estimates were skewed for the within and close to the normal for the ML, and similar results were obtained in the Dawson, Lingard and Woodford study. With respect to the selection of the best estimation technique, the within estimator was preferred to the GLS and ML in our study and the same conclusion was reached in the Seale and the Cornwell, Schmidt and Sickles studies, while in the Dawson, Lingard and Woodford study the ML and within approaches were not tested. However, these last authors considered that the efficiency estimates of the stochastic model were more appealing, because farms had survived over time (1970-1984) which seemed to be incompatible with the low estimates of efficiency generated by the within model.

5.6.2 - Nonparametric Approach

In this section efficiency is evaluated for the sample of 100 farms considered, and each farm's efficiency was assessed relative to the performance of the other farms in the sample. Thus this method yields a best practice frontier, not an absolute frontier, in which some farms must be efficient, and if the sample is homogeneous, it will have relative high efficiency ratings.

The results of the levels of technical efficiency for the nonparametric approach are shown in Figure 5.6 and Table 3 of Appendix II for the four measures of efficiency evaluated, overall technical, pure technical, scale and congestion efficiency. The results are ranked by crescent order of overall technical efficiency and by farming system. The comparison of the different patterns displayed allows us to conclude that pure technical efficiency increases as overall technical efficiency increases, and that this relationship is stronger for the IS farming system rp=0.84). With respect to scale efficiency, there is not a clear pattern of comparison with overall technical efficiency as for pure technical efficiency. However, the average rp of 0.56 allows us to conclude that a positive association between them exists, and this association is stronger for IS (rp=0.76) and lower for the SIS (rp=0.40) farming systems. Congestion efficiency has a weak positive association with overall efficiency (rp=0.25) and a negative association with pure technical efficiency (rp=-0.21). The comparison between scale and pure technical efficiency, as well as congestion with scale efficiency, does not show any significant comparative pattern.

Figure 5.6 -Nonparametric Individual Levels of Efficiency by Farming System

The average values of the four measures of efficiency and the percentage of efficient farms by farming system are presented in Table 5.6 and Figure 5.7. With the exception of scale efficiency, the IS farming system shows the higher average values regarding overall, pure and congestion efficiency, 73.5, 89.6 and 96.3 per cent respectively, while the PLS farming system presents the highest average value for scale efficiency (86 per cent). However, the four farming systems show similar average values for scale and congestion efficiency, around 84 and 94 percent respectively, meaning that the main differences between the farming systems are observed with respect to overall and pure technical efficiency.

The average values observed for overall technical efficiency show that it would have been possible to reduce actual inputs by 42.8, 26.5, 37.3, and 47.7 per cent for the ES, IS, PLS and SIS farming systems respectively, whilst producing the observed output. The main sources of inefficiency are due to pure technical and scale efficiency. Pure technical efficiency contributes more to the inefficiency observed for the ES, PLS and SIS, while scale efficiency is more important for the IS system. The average values for congestion efficiency of around 94 percent show that its contribution to overall technical inefficiency is small.

The analysis of variance and the Kruskal-Wallis tests applied to the four measures of technical efficiency show that, for overall and pure technical efficiency, the null hypothesis of independence between technical efficiency and farming systems can only be rejected with a significance level of 10 per cent, meaning that those two measures of technical efficiency are not strongly dependent on the farming system. The same tests applied to scale and congestion efficiency allow us to conclude that these measures are independent of the farming system.

Table 5.6 - Nonparametric Average Levels of Efficiency, Percentage of Efficient Farms and Statistical Tests by Farming System

Farming System	Average Efficiency				Percentage of Efficient Farms			
	OTE	PTE	SCE	COE	OTE	PTE	SCE	COE
ES	57.2	75.7	81.5	93.0	7.1	39.3	7.1	46.4
IS	73.5	89.6	84.5	96.3	21.1	63.2	21.1	47.4
PLS	62.7	77.4	86.0	94.1	22.2	37.0	25.9	48.1
SIS	55.3	71.1	85.3	92.9	11.5	34.6	11.5	46.2
All	61.3	77.6	84.3	93.9	15.0	42.0	16.0	47.0
Analysis of Variance (F)	2.45 (0.06)	2.42 (0.07)	0.43 (0.72)	0.34 (0.79)				
Kruskal-Wallis (χ^2)	6.83 (0.07)	6.18 (0.10)	1.31 (0.72)	0.37 (0.94)				

() Prob > F or χ^2.

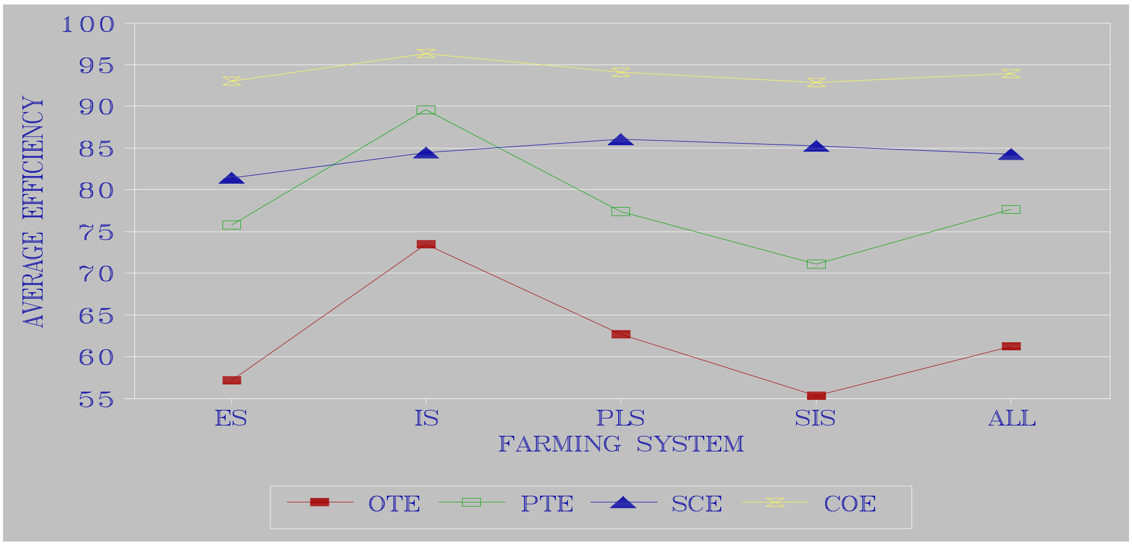


Figure 5.7 - Nonparametric Average Levels of Efficiency by Farming System

Regarding the percentage of efficient farms, the PLS and IS farming system shows the highest percentage and the ES and SIS systems show the lowest percentage of farms that are overall and scale efficient, the IS farming system shows the highest percentage of farms that are pure technically efficient (63 per cent), and almost fifty per cent of the farms are congestion efficient in all farming systems. Almost 50 per cent of the farms belonging to the four farming systems are congestion efficient and 86 per cent have an efficiency level greater than 90 percent, meaning that the majority of the farms are congestion efficient and thus inputs are not in excess to the point that output falls.

The distribution of the farms by classes of efficiency presented in Table 5.7 and Figure 5.8, shows that 41 percent of the farms have an overall technical efficiency below 50 percent. However, 49, 46 and 81 per cent of the farms have pure, scale and congestion efficiency levels above 90 per cent respectively. Thus overall efficiency is skewed towards the lower levels of efficiency, whereas pure technical, scale and congestion efficiency are skewed towards the higher levels of efficiency, as can be demonstrated by the skewness statistic of 0.22, -0.49, -1.05, -3.07. As expected the variation in the levels of efficiency expressed by the standard deviation decrease from 24.6 for OTE to 12.1 for COE.

Table 5.7 - Nonparametric Distribution of Farms by Class of Efficiency

Classes of efficiency	OTE	PTE	SCE	COE
0-50	41	18	3	2
51-70	19	22	12	5
71-90	22	11	39	12
90-100	18	49	46	81
Skewness Statistic	0.22	-0.49	-1.05	-3.07

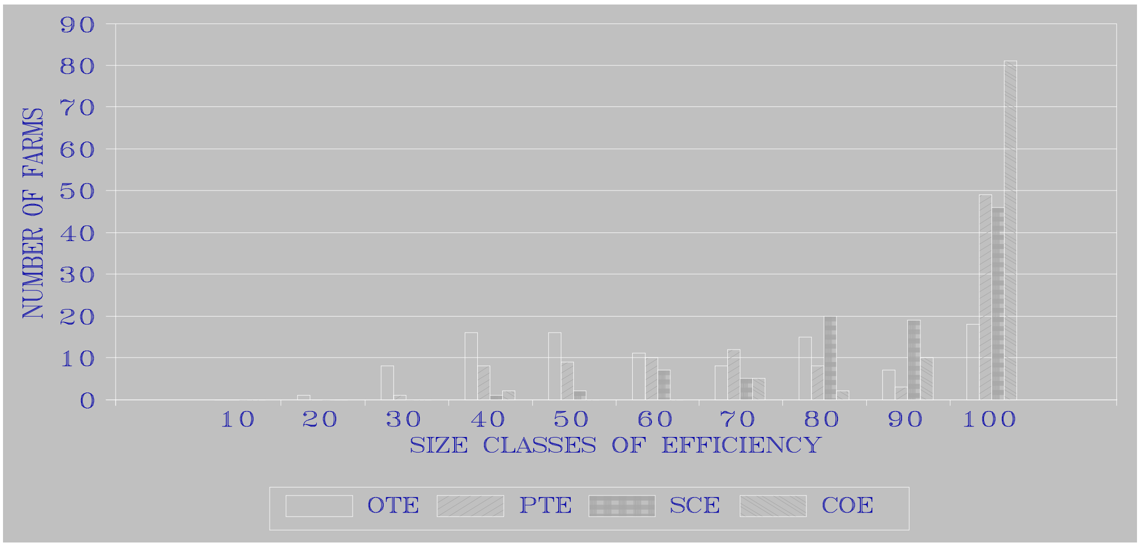


Figure 5.8 - Nonparametric Distribution of Farms by Class Levels of Efficiency

The average levels of technical efficiency (OTE=61.3) are much lower than the ones measured by Byrnes, Färe, Grosskopf and Kraft (1987) for a sample of Illinois grain farmers (OTE=95.8), Weersink, Turvey and Godah (1990) for a sample of Ontario dairy farms (OTE=91.8), and Neff, Garcia and Nelson (1994) for a sample of Illinois grain farms (0.92). Similar to our results, pure technical and scale inefficiency were the majority sources of overall technical inefficiency for the Weersink, Turvey and Godah study, while scale and congestion inefficiency were the major sources of inefficiency in the Byrnes, Färe, Grosskopf and Kraft study.

5.6.2.1 - Efficient Use of Individual Inputs

The overall technically inefficient farms (OTE<1), the ones that are not located on the frontier, have inputs, one or more, that are in excess, and act as a slack variable in the programming technique used to evaluate technical efficiency and it is possible to know those inputs that are in excess for each inefficient farm. The first part of Table 5.8 summarizes by farming system the percentage of farms with inputs that are in excess. Globally, land is the input that a higher percentage of inefficient farms have in excess (35 per cent), and crop and livestock inputs are the ones which a lower percentage of inefficient farms have in excess (3 percent). By farming system, the inputs in excess are more significant in the case of: land for the IS and PLS farming systems; labour for the ES and IS; machinery for the ES, IS and PLS; and crop and livestock for the IS farming system. These results show that in general the IS farming system shows a higher percentage of inefficient farms with an excess of inputs.

Table 5.8 - Percentage of inefficient Farms with Slack Inputs; and Average Shadow Price on Farms where there is Binding Inputs

Farming System	Slack Inputs (% of Total Farms)				Average Shadow Price of Inputs Constraints			
	Land	Labour	Machinery	Crop/Livestock	Land	Labour	Machinery	Crop/Livestock
ES	21.4	17.9	17.9	3.6	0.00255	0.00000	0.00075	0.00006
IS	63.2	10.5	15.8	10.5	0.00049	0.00000	0.00008	0.00074
PLS	37.0	3.7	14.8	0.0	0.00146	0.00000	0.00015	0.00027
SIS	26.9	0.0	7.7	0.0	0.00166	0.00000	0.00020	0.00010
ALL	35.0	8.0	14.0	3.0	0.00181	0.00000	0.00031	0.00024

When OTE was evaluated for all farms, some inputs were scarce and constraining production. For the constraining inputs, the shadow price of each input restriction is a relative measure of its scarcity and is defined as the increase in efficiency level that would be expected if an additional unit of input was available. The second part of the Table 5.8 shows by farming system the average shadow price for each input constraint for those farms in which the level of input was constraining production. On average, land is the input able to generate higher increases in the level of efficiency (0.00181 per unit of input), followed by machinery (0.00031) and by crop and livestock (0.0024). Although labour is a binding constraint for some farms, the results showed that its shadow price is very close to zero, meaning that an increase in its use will not result on a significant improvement in the level of efficiency. By farming system, the inputs able to generate larger increases in the levels of efficiency, if one more unit of it was available, were land for the ES, PLS, and SIS, crop and livestock inputs for the IS, and machinery for the ES farming system.

Regarding the farms that are overall technically efficient (OTE=1), they are located on the estimated frontier, but this does not mean that some inputs could not be slack for the efficient farms (Piesse, Sartoriuos, Thirtle and Zyl, 1994). However, with respect to the subset of efficient farms analyzed (15 per cent of total), all are fully efficient, meaning that none of the inputs is acting as a slack variable and this result is similar to the one obtained by Piesse, Sartorius, Thirtle and Zyl (1994) for a sample of South Africa farms in which they found that only one of their efficient farms was not fully efficient.

5.6.2.2 - SOURCES OF SCALE AND CONGESTION INEFFICIENCY

The nonparametric analysis allows us to assess the sources of scale inefficiency. If a firm is scale efficient, it exhibits constant returns to scale (CRS), and if it is scale inefficient the sources of inefficiency could be due to increasing (IRS) or decreasing (DRS) returns to scale. As Byrnes, Färe, GrossKopf and Kraft (1987) state, the scale inefficient farms are in the short run outside the point of constant returns to scale, but they can be at a profit-maximizing equilibrium and technically efficient regarding pure and congestion efficiency. Table 5.9 shows the percentage of farms in each group by farming system. The evidence presented in Table 5.9 suggests that the main source of scale inefficiency for all farming systems is due to increasing returns to scale (64 per cent), although the SIS farming system has around 31 per cent of the farms with decreasing returns to scale. This result is similar to that reported by Weersink, Turvey and Godah (1990) in which the authors found that most scale inefficiency was due to IRS, but different from that obtained by Byrnes, Färe, Grosskopf and Kraft (1987) in which most scale inefficiency was due to DRS.

As reported later in Table 5.11, scale efficiency increases with farm size either expressed in hectares or volume of sales. In order to relate the sources of scale efficiency with farm size, farms were classified by area and sales classes as shown in the second half of Table 5.9. The results show that for small and medium farms the main source of scale inefficiency is due to IRS. For larger farms the main source of scale inefficiency is most due to DRS when farms are classified by sales classes and due to IRS and DRS (almost the same proportion) when farms are classified by area classes. Among the farms showing DRS, the majority of them belong to the larger farm size classes, 71.4 and 90.5 per cent respectively for area and sales classes. To reach scale efficiency, the majority of the small and medium farms need to increase the size of their operations, while some of the larger farms have to increase, and others to reduce, their size of operations.

Table 5.9 - Returns to Scale by Farming System, Area and Sales Classes
(Percentage of Farms)

Item	IRS	CRS	DRS
By Farming System			
ES	75.0	7.1	17.9
IS	57.9	21.1	21.1
PLS	63.0	22.2	14.8
SIS	57.7	11.5	30.8
ALL	64.0	15.0	21.0
By Area Classes [a]			
Small	70.0	23.3	6.7
Medium	73.0	16.2	10.8
Large	48.5	6.1	45.5
By Sales Classes [a]			
Small	90.0	6.7	3.3
Medium	82.9	14.3	2.9
Large	22.9	22.9	54.3

[a] - classes defined in Table 5.11

As noted above, congestion inefficiency is not an important feature of the sample of farms analyzed. However, it is of interest to know the inputs that contribute to that inefficiency. This was done for each congestion inefficient farm, by solving the linear programming problem expressed in equation 5.12 four times, considering that each input shows weak disposability alone. Then the results obtained are compared with $TE_j(V,S)$ to evaluate the congestion inputs. Regarding the congestion inefficient farms analyzed, the results shown in Table 5.10 allow us to conclude that land is only congesting 26.9 percent of those farms, while for more than two thirds of those farms labour, machinery and crop and livestock inputs are in excess. By farming system, land shows a relatively low percentage for the IS, and labour for the SIS, farming systems. The combination of inputs that are in excess for the same farm are presented in the second part of Table 5.10. The most frequent congesting combination is labour, machinery and livestock for 44.2 per cent of the farms, followed by machinery and crop and livestock inputs for 17.3 per cent of the farms.

Table 5.10 - Percentage of Congestion Inefficient Farms by Congesting Inputs and More Frequent Combinations of Congested Inputs

Farming System	Congestion Inputs (% of Inefficient Farms)				Combination of Congested Inputs (% of Inefficient Farms)				
	Land	Labour	Machinery	Crop/Livestock	LMC[a]	MC[a]	TLC[a]	TMC[a]	Other
ES	35.7	78.6	78.6	92.9	50.0	14.3	14.3	7.1	14.7
IS	10.0	80.0	70.0	90.0	40.0	20.0	20.0	0.0	20.0
PLS	28.6	78.6	78.6	92.9	50.0	14.3	21.4	7.1	7.2
SIS	28.6	50.0	92.9	92.9	35.7	21.4	0.0	28.6	14.3
ALL	26.9	71.2	80.8	92.3	44.2	17.3	13.5	11.5	13.5

[a] T - Land, L - Labour, M - Machinery and C - Crop and Livestock.

5.6.3 - Comparison Between Parametric and Nonparametric Methods

A comparison of individual levels of technical efficiency of the within estimator (parametric method) with overall technical efficiency (nonparametric method) is undertaken in Figure 5.9, while the same comparison of the individual rankings of the farms is shown in Table 3 of Appendix II. This shows that in general the measured value of efficiency is higher for the nonparametric approach (average = 61.3 %) when compared with the parametric approach (within average = 42.2 %), but with a similar pattern regarding the relative value of technical efficiency and ranking of farms when measured by the rp=0.86 and rs=0.89 coefficients. Both measures of technical efficiency are closer for the PLS and SIS farming systems, where the rp coefficient is equal to 0.91 and 0.92 and the rs coefficient is equal to 0.94 and 0.92 respectively, and diverge slightly for the ES and IS farming systems, where the rp coefficient is 0.78 and 0.81 and the rs coefficient is 0.84 and 0.77 respectively. As shown before, the distribution of the within and OTE values are both skewed towards the lower levels of efficiency (skewness statistic equal to 0.77 and 0.22 respectively).

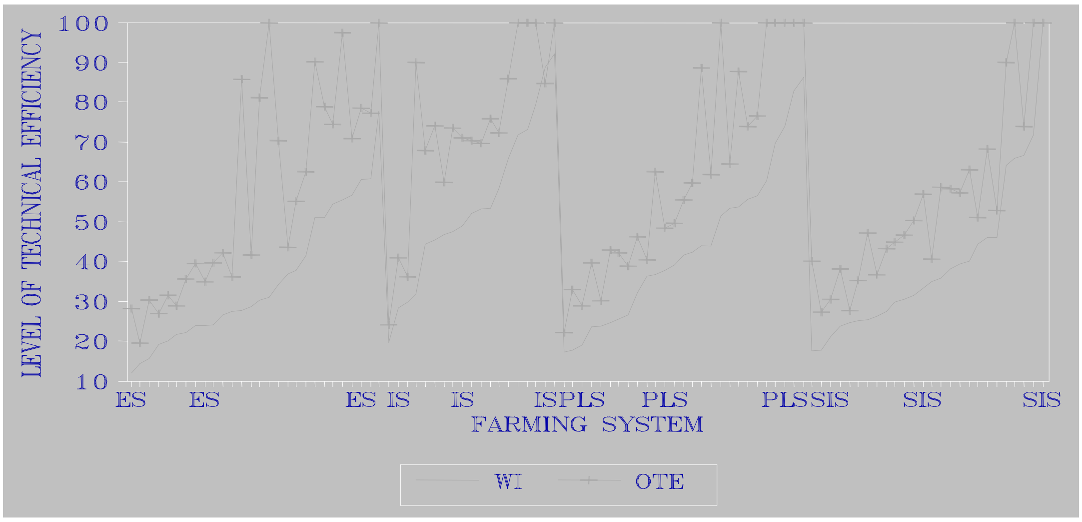


Figure 5.9 - Comparison of Individual Levels of Efficiency for Within and OTE

A comparison between within and the Timmer probabilistic model for a panel of data of British farmers was made by Dawson (1985). The author also concluded that the efficiency estimates from the parametric procedure (50.0 %) were lower than those from the nonparametric measures (96.0 %). However, he obtained a lower correlation coefficient between those measures (0.69) than in the present study, and the variance in efficiency was higher for the parametric case. Although it had higher spread of efficiency ratings, the author concluded that the preferred measure was the within estimator because it is not subject to the management bias that is inherent to the probabilistic model.

A comparison between parametric and nonparametric methods was also made by Neff, Garcia and Nelson (1994), but the authors used cross-section data for different years. The methods compared were two radial nonparametric (single output and multiple output), a deterministic and a stochastic parametric frontier. Similar to our findings, the authors also concluded that nonparametric methods tend to show higher average efficiency measures than the parametric methods and pointed out that a significant reason for this is that nonparametric analysis constructs a different frontier for each farm, which is piecewise linear and not smooth as in the parametric case. The correlation values between the two parametric (0.92) and the two nonparametric methods (0.97) were high, but the correlations between parametric and nonparametric methods ranged from 0.37 to 0.70. These correlation coefficient are similar to ours regarding the comparison of the parametric methods, but much lower for the comparison between parametric and nonparametric methods. However, when the authors discarded the observations with a difference of efficiency of 10 percent between parametric and nonparametric methods and with efficiency equal to one in the nonparametric methods, the correlation between parametric and nonparametric methods increased substantially from 0.49 to 0.72 and from 0.60 to 0.85.

A formal test to choose between the parametric and nonparametric methods of estimating efficiency has not been presented in the literature that has compared both approaches. Banker, Charnes, Cooper and Maindiratta (1988), using a simulation to compare parametric and nonparametric estimates of a translog frontier, found that the nonparametric model was almost perfect in classifying the observations that were technically and scale efficient and consequently that it was superior to the parametric method. This conclusion applied here would lead us to choose the nonparametric method used to measure OTE, PTE, SCE and COE. However, when some authors make comparisons between methods, they tend to prefer the ones that show a narrower range in the efficiency levels, which applied to our case would lead us to choose the parametric method within. As Neff, Garcia and Nelson (1994) point out, considerable care must be taken in using efficiency measures because the absolute level, distribution and relative ranking of farm efficiency are systematically influenced by the method employed. With the objective of relating farm characteristics with efficiency levels, we decided to use both approaches as a valid measure of efficiency in the next section.

5.6.4 - Technical Efficiency and Farm Characteristics

Most of the literature studying farm efficiency try to relate the measures of efficiency with farm characteristics such as: family size, age, entrepreneurial skills, experience, size, fragmentation, irrigation, ownership, use of modern inputs, distance from urban areas, extension, confidence in technology, off-farm work, credit and location. In general the relationship is expected to be positive for family size, education, credit, experience and extension, and negative for age and fragmentation, while regarding size the results obtained have varied from a negative relationship to a positive one as will be shown below.

The measures of technical efficiency evaluated in the last two sections allowed us to conclude that overall technical efficiency (within or OTE) is not independent of the farming system to which each farm belongs. The objectives of this section are: 1) to relate efficiency with the growth and size measures derived in the last section of the previous chapter where the process of farm growth was analyzed and with farm size expressed in area and volume of sales, and 2) to analyze the relationship between technical efficiency with other farm attributes, such as experience, land ownership, irrigation, labour characteristics, livestock and output specialization. To accomplish this last objective, farms were divided into groups and the analysis of variance and Kruskal-Wallis tests referred to above were used to verify the null hypothesis that technical efficiency and the attribute considered are independent.

5.6.4.1 - TECHNICAL EFFICIENCY, FARM GROWTH AND FARM SIZE

This section is divided into two parts: the first part relates efficiency with the farm growth and size measures derived in section 4.5, while the second part relates efficiency with two measures of size, the area and the volume of sales. To analyze the relationship between the process of farm growth and efficiency, a correlation analysis was performed between individual levels of technical efficiency and the individual growth rates and size measures derived in section 4.5 for total product, capital, labour and livestock. The correlation coefficients between efficiency and the growth rates were not significantly different from zero, meaning that there is a neutral relationship between the technical efficiency measures (within, OTE, PTE, SCE, COE) and the growth rates for total product, capital, labour and livestock.

Regarding the relationship between efficiency and the size measures derived in section 4.5 the following conclusions were derived: 1) a positive association was found between within, OTE and SCE efficiency measures and the size measure for total product (and this result will be confirmed below by the analysis of variance and Kruskal-Wallis statistical tests performed for other measures of size such as the volume of sales and area) meaning that efficiency increases with farm size, and 2) a negative association was observed between COE and the size measure of total labour, and between OTE and the size measure of total livestock.

A relationship between the levels of efficiency and growth rates was not found for the variables analyzed in section 4.5. However, for total product, when both size and growth measures are included as explanatory variables for efficiency, the results obtained were the following:

$$\underset{}{\text{Within}} = \underset{(18.96)}{52.592} + \underset{(2.063)}{22.390}\,\text{GRPB} + \underset{(4.883)}{8.541}\,\text{SIPB} \qquad R^2 = 0.1998$$

$$\text{OTE} = \underset{(17.62)}{66.757} + \underset{(0.700)}{10.377}\,\text{GRPB} + \underset{(1.895)}{4.528}\,\text{SIPB} \qquad R^2 = 0.0359,$$

where GRPB and SIPB are the measures of growth and size for total product derived in section 4.5. A positive and significant relationship between the within efficiency measure and the size and growth rate measures was found. This result in connection with the correlation analysis referred to above, allows us to conclude that only when the farms have the same size, are efficiency and the growth rate positively related; meaning that for the same size, the more efficient farms are the ones that have a greater growth rate.

To measure the relationship between technical efficiency and size, farm size was expressed both in terms of hectares and in the volume of sales, and farms were divided into three groups: small, medium and large. The results presented in Table 5.11 show that overall technical efficiency is dependent on farm size, either in terms of hectares or volume of sales, although for the size measure expressed in hectares and the within estimator the relationship is only significant at 0.15 per cent level. When the size is expressed in hectares, technical efficiency decreases with farm size for the OTE, PTE and COE measures and this relationship is significant. Scale efficiency, although increasing with farm size is not significant.

Regarding size expressed in volume of sales, all measures of efficiency increase as the volume of sales increase with the exception of COE. However, only the within, OTE and SCE measures are dependent on the volume of sales, meaning that farms have to increase their sales volume to improve their overall efficiency level and reach the optimal scale of operations. This result means that larger farms can on average produce more output than smaller farms from a given amount of input.

Table 5.11 - Statistical Tests of the Association between Efficiency Measures and Farm Size

Group	Size (Hectares)[a]					Size (Volume of Sales)[b]				
	Within	OTE	PTE	SCE	COE	Within	OTE	PTE	SCE	COE
Average Values										
1	44.9	70.6	87.1	81.6	97.8	31.1	54.7	78.9	71.5	96.1
2	45.0	64.6	79.8	83.8	95.4	41.8	59.2	72.1	87.9	92.7
3	36.5	49.1	66.6	87.1	88.6	52.1	68.9	82.0	91.5	93.3
Statistical Tests										
Analysis of Variance (F)	2.02	7.3	6.8	0.98	5.37	10.9	2.99	1.61	20.1	0.69
	(0.14)	(0.00)	(0.00)	(0.38)	(0.01)	(0.00)	(0.05)	(0.20)	(0.00)	(0.50)
Kruskal-Wallis (χ^2)	4.50	12.4	9.47	0.40	16.4	20.4	6.92	3.91	24.7	2.57
	(0.10)	(0.00)	(0.01)	(0.81)	(0.00)	(0.00)	(0.03)	(0.14)	(0.00)	(0.27)

[a] Group 1: < 50 Ha. Group 2 : 51 - 200 Ha. Group 3: >201 Ha..
[b] Group 1: Sales < 3600 Escudos Group 2: Sales 3601-7500 Escudos Group 3:Sales >7501 Escudos.
() Prob > F or χ^2.

The above results showed that overall technical efficiency is not neutral to size when size is expressed in hectares or volume of sales. When size is expressed in physical input units, small farms are more efficient than larger ones, and these results are similar to those obtained by Grabowski, Kraft, Pasurka and Aly (1990) for Southern Illinois grain farmers using cross-section data and a stochastic frontier, while the panel data study by Dawson (1985), the cross-section studies by Bravo-Ureta and Rieger (1991) for New England dairy farms using a stochastic frontier, and the nonparametric study by Weersink, Turvey and Godah (1990), showed a positive relationship.

When size is expressed through an output measure, efficiency increases with farm size, and similar results were obtained by Machado (1993) in a cross-section study of Portuguese farms from the Northeast and Central regions using a stochastic frontier, and Kalaitzandonakes, Wu and Ma (1992) for a sample of Missouri farms using parametric and nonparametric methods, while Grabowski, Kraft, Pasurka and Aly (1990) found a negative relationship. A set of other studies such as the nonparametric approach by Byrnes, Färe, Grosskopf and Kraft (1987), the Bravo-Ureta (1986) cross-section analysis of New England dairy farms using a probabilistic frontier, and the Kalirajan (1991) study of Indian farms and the Bravo-Ureta and Evenson (1994) peasant farmers study in Paraguay, both using cross-section data and a stochastic frontier, found that technical efficiency was neutral to size.

Some authors, such as Van de Broek (1988) for several Belgian manufacturing industries and Machado (1993), extended the analysis between efficiency and farm size and estimated a measure of size elasticity of efficiency. They related efficiency and value added through a power function and found a positive relationship. The estimated size elasticity of efficiency varied from

0.08 to 0.12 for Belgian industries and was equal to 0.016 for the Northeast and Central Portuguese farms studied by Machado. For the Alentejan farms considered in this study, a similar function was estimated between the within and OTE efficiency measures and value added. The results were equal to

$$\ln \text{Within} = \underset{(5.823)}{2.316} + \underset{(3.331)}{0.1651} \ln \text{Value Added} \quad R^2 = 0.102 \quad F=11.094 \qquad (5.14)$$

$$\ln \text{OTE} = \underset{(9.759)}{3.737} + \underset{(0.763)}{0.036} \ln \text{Value Added} \quad R^2 = 0.006 \quad F=0.582 \qquad (5.15),$$

where a positive and significant relationship was only found for the within measure. The corresponding size elasticity of efficiency is equal to 0.1651 which means that a one per cent increase in value added would increase efficiency by 0.17 per cent. This value is higher than the 0.016 reported by Machado for the Northeast and Central regions of Portugal.

With the objective of testing wether the size elasticity was different for each farming system, a set of specific dummies for the intercept and the slope were included in equation 5.14 and 5.15. A backward elimination of the non significant variables lead to the following models:

$$\ln \text{Within} = \underset{(5.85)}{2.211} + \underset{(3.60)}{0.169} \ln \text{Value Added} + \underset{(3.50)}{0.048} \text{ DISVA} \quad R^2 = 0.2026 \quad F=12.323 \quad (5.16)$$

$$\ln \text{OTE} = \underset{(9.65)}{3.625} + \underset{(2.49)}{0.271} \text{ DIS} + \underset{(0.94)}{0.044} \ln \text{Value Added} \quad R^2 = 0.0656 \quad F=3.419 \quad (5.17),$$

where DISVA is a slope dummy and DIS is an intercept dummy for the IS system. The result for the within measure shows that the size elasticity of efficiency for the intensive system is greater (0.22) than the size elasticity of the ES, PLS and SIS farming systems (0.17). A 1 per cent increase in the value added produced by the IS farming system leads to an improvement in efficiency 0.05 percentage points greater than the average value for the other farming systems.

For the OTE measure, the size elasticity of efficiency evaluated in 5.15 and 5.17 was not significant different from zero. In spite of the absence of a relationship, a model similar to 5.16 with intercept and slope dummies was also fitted to the three component measures of OTE, and the following results were obtained:

$$\ln PTE = \underset{(14.31)}{4.442} + \underset{(2.27)}{0.203} \, DIS - \underset{(-0.61)}{0.023} \ln \text{Value Added} \qquad R^2 = 0.0555 \quad F=2.850$$

$$\ln SCE = \underset{(20.63)}{3.626} + \underset{(4.51)}{0.098} \ln \text{Value Added} \qquad R^2 = 0.1715 \quad F=20.290$$

$$\ln COE = \underset{(31.22)}{4.794} - \underset{(-1.73)}{0.0331} \ln \text{Value Added} \qquad R^2 = 0.0298 \quad F=3.008,$$

where a positive association was found between scale efficiency and the size measure with a corresponding size elasticity of scale efficiency equal to 0.098 and constant across all farming systems, while for the PTE and COE measures only a weak negative association was found with the size measure which implies a low and negative size elasticity.

5.6.4.2 - Technical Efficiency and Other Farm Characteristics

The results about the relationship between technical efficiency and farmers' experience (measured by the farmer's age) show that the measures of technical efficiency are not independent of farmers' experience, with the exception of scale and congestion efficiency (Table 5.12). For all efficiency measures young farmers have higher efficiency levels than farmers older than 40 years of age. Among these, more experienced farmers show higher efficiency levels than less experienced farmers. Dependence between overall technical efficiency and farmers experience were also observed by Kalirajan (1981) in a cross-section study of Indian farms using a stochastic approach and Bravo-Ureta and Evenson (1994), while Bravo-Ureta and Rieger (1991), and Parikh and Shah (1994) in a cross-section study of Pakistan farms with a stochastic frontier, found a neutral relationship.

Regarding land ownership, technical efficiency measures are independent of land ownership type (Table 5.12), meaning that farms predominantly owned or rented show similar levels of efficiency, although the efficiency levels of predominantly owned farms are slightly higher than those of the predominantly rented farms. However, the analysis of variance test for scale efficiency is significant at 10 per cent, meaning that farms predominantly owned are closer to the optimal scale of operations. Considering overall technical efficiency, a neutral relationship was also obtained by Kalirajan (1981), while Weersink, Turvey and Godah (1990) found a positive relation, and Grabowski, Kraft, Pasurka and Aly (1990) found a negative relationship between ownership and technical efficiency.

Table 5.12 - Statistical Tests of the Association between Efficiency Measures and Farmer Experience and Land Ownership

Group	Experience[a]					Land Ownership[b]				
	Within	OTE	PTE	SCE	COE	Within	OTE	PTE	SCE	COE
Average Values										
1	49.8	71.1	85.0	87.0	95.3	44.1	63.5	76.0	87.9	95.4
2	33.3	50.4	68.7	82.4	92.4	41.0	59.9	78.5	81.9	93.0
3	43.1	61.9	78.7	83.7	93.9					
Statistical Tests										
Analysis of Variance (F)	5.79	5.78	3.8	0.74	0.41	0.57	0.47	0.27	3.55	0.84
	(0.00)	(0.00)	(0.03)	(0.48)	(0.66)	(0.45)	(0.49)	(0.60)	(0.06)	(0.36)
Kruskal-Wallis (χ^2)	10.5	10.2	6.70	5.10	0.70	0.96	0.51	0.14	1.85	0.14
	(0.01)	(0.01)	(0.04)	(0.07)	(0.70)	(0.33)	(0.47)	(0.70)	(0.17)	(0.71)

[a] Group 1: < 40 Years of age Group 2: 41 - 55 Years of Age Group 3: > 56 Years of Age.
[b] Group 1: Area Owned > 50% Area Total Group 2: Area Rented > 50 % Area Total
( ) Prob > F or χ^2

With respect to irrigation attributes (farms with some irrigation area compared with dryland farms) as well as family farms compared with farms in which most of the labour force is hired, the results shown in Table 5.13 allow us to conclude that irrigation and labour characteristics are independent of the technical efficiency measures considered. However, the analysis of variance for scale efficiency shows that technical efficiency is dependent on labour characteristics with a significance level of 15 per cent, which could indicate that farms with predominantly hired labour (larger farms) have a scale of operations closer to the optimum scale than the family farms (smaller farms). A complementary analysis was undertaken relating overall technical efficiency with the size of the labour force, and the results showed that there a negative association between those variables; while a positive association was found between capital and technical efficiency.

Table 5.13 - Statistical Tests of the Association between Efficiency Measures and Irrigation and Labour

Group	Irrigation[a]					Labour[b]				
	Within	OTE	PTE	SCE	COE	Within	OTE	PTE	SCE	COE
Average Values										
1	41.3	60.1	73.8	85.1	95.1	42.8	64.7	80.5	81.8	96.8
2	43.1	62.4	81.3	83.4	92.7	41.2	56.2	73.4	87.7	89.7
Statistical Tests										
Analysis of Variance (F)	0.21	0.22	2.49	0.27	0.92	0.18	3.00	2.22	3.38	8.84
	(0.65)	(0.64)	(0.12)	(0.60)	(0.34)	(0.68)	(0.08)	(0.14)	(0.06)	(0.00)
Kruskal-Wallis (χ^2)	1.17	0.44	1.85	0.35	0.03	0.19	2.53	1.38	2.41	11.42
	(0.27)	(0.50)	(0.18)	(0.55)	(0.85)	(0.67)	(0.11)	(0.24)	(0.12)	(0.00)

[a] Group 1: Farms with Irrigation Area Group 2: Dryland Farms.
[b] Group 1: Family Labour > 50% Total Labour Group 2: Hired Labour > 50%Total Labour.
() Prob > F or χ^2

The results presented in Table 5.14, regarding the composition of the herd, show that technical efficiency is not independent of herd composition, with the exception of scale efficiency, and that for all measures of efficiency cattle farms are more efficient than sheep farms. With respect to the composition of agricultural product, the results show that technical efficiency is dependent on farm specialization. Specialized farms are more efficient than diversified farms and among specialized farms, crop farms are more efficient than livestock farms.

Table 5.14 - Statistical Tests of the Association between Efficiency Measures, and Livestock and Agricultural Product

Group	Livestock[a]					Product[b]				
	Within	OTE	PTE	SCE	COE	Within	OTE	PTE	SCE	COE
Average Values										
1	37.2	53.1	70.4	84.6	91.0	52.8	71.4	86.3	87.7	94.8
2	46.8	68.7	84.2	83.9	96.6	34.1	58.3	75.5	79.4	95.8
3						23.6	34.4	53.4	82.9	87.3
Statistical Tests										
Analysis of Variance (F)	6.11	11.1	8.98	0.06	5.45	25.8	19.2	15.2	2.98	2.99
	(0.01)	(0.00)	(0.00)	(0.81)	(0.02)	(0.00)	(0.00)	(0.00)	(0.05)	(0.05)
Kruskal-Wallis (χ^2)	6.31	10.1	8.18	0.05	13.4	40.7	31.0	21.6	4.92	4.88
	(0.01)	(0.00)	(0.00)	(082)	(0.00)	(0.00)	(0.00)	(0.00)	(0.08)	(0.08)

[a] Group 1: Sheep Units > 50% Total Livestock Units Group 2: Cattle Units > 50% of Total Livestock Units.
[b] Group 1: Crop Product > 60% Total Group 2: Livestock Product > 60% Total Group 3: Diversified Farms.
() Prob > F or χ^2

5.7 - SUMMARY

In this chapter individual levels of technical efficiency were evaluated for panel data (1987-1991) for farms of the four Alentejan farming systems selected, using a parametric and a nonparametric approach. The technical efficiency levels measured using a production function approach should be considered bearing in mind the assumptions and limitations that are embodied in the empirical applications undertaken. One standard assumption is that farmers always maximize expected profits (Zellner, Kmenta e Dreze, 1966), which allows us to estimate the Cobb-Douglas production function by a single equation and does not violate the condition that the regressors are uncorrelated with the error term. However, sometimes it is difficult to correctly perceive what is being maximized or to account for all constraints in the maximization process (Førsund, Lovell and Schmidt, 1980). Other limitations that may result in biased estimators of the production relationship are usually observed such as: 1) errors in the measurement and aggregation of variables and 2) the omission of variables. Errors in the measurement and aggregation of capital, land and labour can occur when differences in quality and age are not considered.

Some variables such as management and risk are difficult to measure and they are omitted in most studies, but this leads to bias in the estimates of returns to scale and an overestimation of the parameters associated with those inputs which are correlated with the omitted variables (Griliches, 1957). If risk is not incorporated in the production relationship, then the estimates of efficiency may not be credible (Kumbhakar, 1993). With respect to management, the availability of panel data allowed the incorporation of a management variable as proposed by Mundlak (1961) and Hoch (1962), and applied by Dawson and Lingard (1982), Dawson and Lingard (1991) and Dawson, Lingard and Woodford (1991). If it is assumed that management remains equally effective over time, then the management variable for each firm can be represented by firm specific dummy variables in the production model. This results in a covariance model that is equal to the panel within estimator presented in section 5.3.2.1, in which the dummy variables represented the different levels of efficiency. In this circumstance the levels of efficiency evaluated can also be viewed as a measure of individual levels of farmer's management.

Besides the measurement errors and omission of variables, the nonparametric approach has its own limitations, such as the absence of statistical properties for the variables measured and the susceptibility of the frontier to extreme observations. These limitations, if present in the data, would lead to biased estimates of the measures of technical efficiency.

Regarding the parametric approach, a Cobb-Douglas production frontier was estimated using the within, generalized and maximum likelihood estimators. The comparison between the individual levels of technical efficiency obtained for the three estimators shows that individual levels of technical efficiency were different in absolute value, but highly correlated and involved a similar ranking of farms. Considering the assumptions embodied in each estimator, the Hausman-Taylor test allows us to conclude that the within estimator was the one that best describes the data. The results of an analysis of variance and a Kruskal-Wallis test, showed that the levels of technical efficiency are not independent of the farming system. On average the IS farming system shows the highest value of technical efficiency while the ES farming system the lowest.

The nonparametric approach allowed us to estimate overall technical efficiency, as well as its components pure, scale and congestion efficiency. The results show that most of the inefficiency observed is due to pure and scale technical inefficiency, since the values observed for congestion efficiency are very close to unity. The analysis of variance and the Kruskal-Wallis test lead to a result similar to that obtained for the parametric approach, in which technical efficiency is not independent of the farming system. However, this conclusion could only be extended to pure technical efficiency, since for scale and congestion efficiency there is independence between efficiency and farming systems. On average the IS farming system shows the higher, and the SIS the lower, levels of efficiency, which is slightly different from the parametric results.

For the farms that were overall technically inefficient, the inputs that were more in excess were land and machinery, while for those farms in which inputs were constraining production, land showed the higher shadow price. Around 15 per cent of the farms analyzed have the optimal scale of production while 75 per cent are scale inefficient. On average, most of the scale inefficiency observed was due to farms being located in the increasing returns to scale range (64 per cent). This percentage increases to around 70 and 83 per cent for small and medium farms when area and sales are the size measures respectively. For larger farms 45.5 percent of the scale inefficiency is due to DRS, and the majority (>71 per cent) of the farms showing DRS, belong to the larger farm size classes as measured by area. Although congestion inefficiency did not have a significant role in overall technical inefficiency, the most important congesting inputs were machinery, labour, and crop and livestock.

The comparison between the parametric and the nonparametric results shows that the results were very similar in absolute value and ranking of the farms for the total sample of farms. This closeness is greater for the PLS and SIS farming systems and diverges slightly for the IS and ES farming systems. Both methods were used to relate efficiency with farm characteristics due to the absence of a formal test to choose between the parametric and nonparametric methods. In general, the results showed that the relationship between within and OTE measures and farm characteristics was in the majority of the cases in the same direction.

Technical efficiency was related to the measures of farm growth and size derived in section 4.5, and to the following farm characteristics: size (hectares and volume of sales), farmer's experience, land ownership, irrigation area, type of labour use, composition of livestock herd and output specialization (crop, livestock and diversified farms). The tests performed allowed us to conclude that: 1) efficiency was independent of the rates of growth of total product, capital, labour and livestock, but for total product and when farms have the same size, the more efficient farms are the ones that have a greater growth rate, 2) technical efficiency was not independent of farm size, farm experience, livestock type and farm specialization and 3) technical efficiency was independent of land ownership, irrigation area and type of labour use.

Regarding size, efficiency decreases as farm size increases in hectares and efficiency increases as the volume of sales increases. The results for the volume of sales are similar to the ones obtained by Machado (1993) for Portuguese farms in a different region and using cross-section data. A measure of the size elasticity of efficiency in relation to the value added of 0.17 per cent was obtained and is greater for the IS farming system (+ 0,05 percentage points). These values are higher than the 0.016 reported by Machado (1993). Further estimates of size elasticity of efficiency were also obtained for the SCE (0.098), PTE (-0.023) and COE (-0.33 per cent) efficiency measures.

With respect to other farm characteristics, younger farmers show higher levels of efficiency than older farmers, cattle farms are more efficient than sheep farms and specialized farms are more efficient than diversified farms. Between the specialized farms crop production is more efficient than livestock production.

In overall terms, the average values of technical efficiency obtained (61.3 % for the nonparametric and 42.2 % for the within estimator) for the Alentejo are different from the ones obtained by Machado (1993) for a cross-section study of Northeast and Central regions of Portugal (60.3 and 44.6 % for the nonparametric and 80.0 and 87.9 % for the stochastic frontier), although the results are not directly comparable because of differences in the data, and years considered. The average values of the within results are closer to the ones obtained by Dawson and Lingard (1991) and Dawson, Lingard and Woodford (1991) of 54.1 and 58.6 respectively, using the same methodology but for different farm types.

Our results indicate that there is scope to improve the levels of production given the resource base and modern inputs that are used in the production process. As noted above, there is an identification of the efficiency measure with the management input, and probably an improvement in the production process would be dependent upon an improvement in the management practices of farmers leading to increases in output produced. This conclusion is confirmed by the unfavourable characteristics of Alentejan farmers in terms of age, education and professional training described before. A proportion of the levels of inefficiency observed in the four farming systems studied may also be a reflection of the instability observed in land ownership during the last decade, due to the irregular development of the process of agrarian reform.

When OTE is decomposed into its three measures of efficiency, the results show that average pure technical efficiency is around 78 per cent with a substantial proportion of the farms being located on the frontier (42 percent of the farms are efficient). This means that regarding PTE Alentejan farmers are relatively close to the production frontier. This value is similar to the stochastic efficiency measures obtained by Machado (1993), which led that author to conclude that no significant gains in productivity could be made with the current production techniques, and that the crucial objective of agricultural policy must be to expand the frontier or by for example promoting the adoption of more modern technologies.

With respect to the scale component of the OTE, the average value of 84.3 for SCE and the small number of scale efficient farms (16%), allows us to conclude that improvements in the scale of operations might be necessary in the future, principally regarding land and land improvements, labour, machinery and equipment. Congestion inefficiency is not an important problem for Alentejan farms (an average efficiency value of 94 per cent, and 47 per cent of farms efficient), although improvements can be made by the inefficient farms with respect to labour, machinery and equipment, and crop and livestock inputs.

CHAPTER VI - THE FUTURE DEVELOPMENT OF ALENTEJAN AGRICULTURAL SYSTEMS

The objective of this Chapter is to build a model using a mathematical programming approach, in order to study the development of the four farming systems of the Alentejan region selected in Chapter IV. The model incorporates actual production processes, and alternative activities and technologies and serves to simulate the impact on farm income and farm growth of different policy instruments available during the nineties and derived from the 1992 CAP reform. First, an overview of previous models developed with similar objectives, as well as a review of previous studies about Alentejo farming systems, is made; second, a description of the empirical model to be implemented to analyze farm development along with the selection of the farms for each farming system is defined; and third, the verification and the results of the models developed are presented. In the last section, technical efficiency levels were evaluated for the nine farms studied and scenarios considered using a nonparametric approach.

6.1 - MODEL SELECTION

To conceptualize and build a mathematical programming model with the objective of studying production response to changes in various aspects of the physical, financial and socio-economic environment, several aspects need to be taken in account, such as: 1) conceptualization of the production framework, 2) the decision making process, 3) the farm adjustment process over time, 4) changes in the planning environment, and 5) uncertainty.

The production framework has been conceptualized in mathematical programming approaches through the definition of a matrix of input-output coefficients. This matrix incorporates the relationship between different activities and inputs needed to achieve predefined production levels. A linear relationship is assumed for input consumption, and input availability is limited and dependent on farm capacities. Developments in mathematical modelling and agricultural production research relaxed the deterministic nature of the input-output matrix, allowing for stochastic input-output relationships, and the incorporation of the biological structure of agricultural production.

The decision making process is a complex and sequential procedure, mainly dependent on the relationships between activities, and on farmers' goals. The relationship between activities has been modelled through the establishment and manipulation of restrictions to represent the sequential nature of the production process. The farmers' goals have been used to define the objective function to be optimized. The optimization of a single measure of profitability, supposed to measure farmer goals, has been the most widely utilized objective function. However, this approach is limited by the fact that farmers usually pursue not only one, but several goals at the same time. The development of goal programming, allowing the incorporation of several goals in the objective function, permitted the approximation of farm models with reality. Depending on the objectives of the study, some of the profitability measures used to represent farmers' goals were: present profit, present returns to land and management, present consumption, terminal net worth, present cash flow and internal rate of return (Cocks and Carter, 1968).

Farm adjustment over time is a complex and difficult task of farm modelling activity, because it involves building a model with the capability of predicting future farm performances, based on assumptions and predictions about future events in a changing and uncertain world. It involves the process of farm development, considering that technological change and new enterprises, as well as the set of other internal and external factors affecting agricultural production, will be changing over time. Modelling farm growth requires the definition of behavioural variables such as the rate of adoption of new technologies and enterprises, and the conceptualization of the framework of farm production capacities. Behavioural variables are generally defined based on past observed trends, while the development of production capacities is modelled based on investment theory and a careful handling of money capital flows.

The stochastic nature of agricultural production leads to income variability from one year to another, due to unpredicted variations in prices, yields and resource availability. The risk resulting from unpredicted variations in these factors can be incorporated in farm modelling through risk programming techniques. Some of these techniques, such as E-V frontier, mean absolute total deviation (MOTAD), maximin criterion and focus-loss model are based on expected utility and game theory.

Different kinds of mathematical programming models have been used to incorporate and analyze the aspects previously discussed. The models utilized can be divided into four basic groups: comparative static supply adjustment models, multiperiod linear programming models, recursive programming, and simulation models (Irwin, 1968). These four groups have been used to study a large range of situations at farm, regional, and national level and are generally built based on farm types defined for the region or regions in consideration.

Comparative static supply models are the most common mathematical programming approach to farm modelling. The production process is included in a matrix which captures the various combinations of annual and durable inputs. A basic solution is obtained for an average year, and simulations can be performed on predicted variables at different time periods. Then, a comparison between the optimal solution in different time periods can be made. These models allow us to analyze the process of farm development, comparing two or more isolated time periods. However, it ignores the intermediate steps of the adjustment process that usually take place during a certain period of time. The adjustment process usually involves farm growth, adoption of new technologies, and changes in the decision making process. Comparative static models also exclude the understanding of liabilities and net worth in explaining the generation of funds from internal sources and the process of borrowing funds to expand the farm business.

Multiperiod linear programming models incorporate the planning question of the farm over time. The production process is modelled for several years, and the different years are connected by transfer activities. These activities transfer resources such as cash balances and inventories from one year to another. Investment decisions can be modelled as alternative activities and their profitability evaluated. The final objective is to optimize farm results over the planning horizon considered. Several aspects need to be taken into account in a multiperiod programming model such as definition of the objective function, length of the planning horizon, estimation of the discount rate and definition of initial and final conditions.

With respect to the objective function to be maximized, the choice is between the criteria that give preference to present (maximization of disposable income) or future consumption (maximization of terminal net worth). The present consumption criterion is limited by the arbitrariness of choosing a discount rate for the computations of present value, and the non guarantee of the existence of a planning horizon, while the future consumption criterion guarantees the existence of a planning horizon, but assumes a linear consumption function (Boussard, 1971). The length of the planning horizon should be large enough to produce stable solutions for the initial periods when modifications in the planning horizon are introduced. An alternative way used to reduce the length of the model and the size of the matrix is to define a set of terminal conditions. Multiperiod models allow us to incorporate and manipulate variables such as family consumption, fixed obligations, labour supply, price cycles, enlargement of activities, improvements of technical efficiency over time and changes in the level of capital stocks. The main objective of the studies using this approach was to analyze the process of farm growth based on investment decisions, growth rate and terminal size.

Rigidity of the objective function to be maximized is pointed out as one of the limitations of the multiperiod approach, because it is difficult to interpret the real meaning of the net present value of net returns or final net worth over a large plan horizon in an uncertain and changing world. The results of the modelling exercise could also be dependent on the discount rate chosen. However, when the evaluation of alternative investments is the main objective, this methodological approach appears to be a good choice among alternative farm planning techniques.

Recursive programming is a sequential optimizing technique, embodying a functional relationship between any given period and preceding periods. This time lag relationship allows us to analyze dynamic factors responsible for the farm adjustment process over time. Some of these factors are: 1) environmental changes such as advances in technology, changes in output-input price ratios, price stability schemes, tax rates and credit conditions, and 2) the effect of external factors on farmer expectations such as a rising standard of living for non-farm activities. Recursive programming is based on the construction of a sequence of annual linear programming models. Each annual model is solved with slight alterations, and based on the optimum solution obtained from the previous year. Flexibility constraints are used to represent the changes of some key variables over time, through the utilization of upper and lower bounds in resource availability. These upper and lower bounds are defined in a recursive way, that is taking into consideration the optimum solution of previous years. It has been used to study the farm growth process when changes in physical, financial, and socio-economic environments are expected to occur.

Simulation models are built to handle farm behaviour over time. These models are used in those situations in which the decision process is extremely complex and analytical approaches are difficult to develop. It handles situations with multiple goals, indivisibilities, sequential decisions within the planning period using different criteria, non-linear functions, and concepts of organizational, managerial and behavioural theories (Irwin, 1968). Empirical applications have been made to study a wide range of situations, such as the impact of managerial ability and capital structure on farm growth, the impact of business organization on farm organization and expansion, the assessment of the effect of agricultural policies and other external factors on farm growth, and the evaluation of alternative management strategies under changes in environmental and economic conditions. An important feature of some of the simulation models developed was the incorporation of the complex structure of the biological relationships that determine agricultural production. Generally, simulation models do not guarantee the existence of an absolute optimum because analytic optimization procedures are not used explicitly.

Among the four approaches described above, multiperiod and recursive programming appear to be the ones that would be better adapted to the study of the development of Alentejo farms over time, if it is recognized that 1) changes in the planning environment, such as agricultural policy and technological change, and external factors, usually affect farm production with a time lag, 2) uncertainty and limited knowledge produce gradual and not sudden shifts from current farm organization 3) investments and return to fixed costs will play an influential role in the long-term survival of Alentejo farms, and 4) external funds will have an increasing relevance in expanding the production opportunities of the farms selected. A brief description of both methodologies is made in the following two sections.

6.1.1 - Recursive Programming

The recursive programming application to agricultural production analysis was developed by Day (1963a). Since then, it has been used to model agricultural production activity at farm (Heidhues, 1966 and Kingma, 1978), regional (Day, 1963a; Heidhues, 1966 and Ahn and Singh, 1978) and national level (Schaller, 1968). The objectives of the majority of these studies were to analyze the adjustment process over time due to changes in the planning environment and external factors.

Recursive programming assumes that the adjustment process to new conditions occurs with a time lag. The most important causes that pose barriers to instantaneous farm adjustment are quasi-fixed factors and uncertainty. Quasi-fixed factors are an objective barrier because disinvestments usually produce a loss of asset value and require a change in production activities, while uncertainty raises a subjective resistance to sudden shifts in the production process. Both adjustment barriers can be incorporated into a programming model by allowing for investment and disinvestment activities and behavioral constraints respectively. Behavioral constraints allow limited changes in the level of activities in each year to permit farmers to gradually adjust to new economic conditions.

A recursive programming model is a sequence of one period models based on endogenous and exogenous information and can be written as:

$$\pi^*(t) = \max < z(t), x(t) > \qquad t = 1,2,...,T$$

$$\text{subject to} \qquad (6.1)$$

$$A(t)\, x(t) \leq b(t) \quad \text{and}$$

$$x(t) \geq 0,$$

where

$\pi^*(t)$ is the value of the objective function in period t under the optimal plan $x^*(t)$,

z(t) is the n dimensional vector of coefficients of the objective function $z_j(t)$ for j=1,...,n

x(t) is the n dimensional vector of the level of activities for period t, $x_j(t)$ for j=1,...,n,

A(t) is the $m \times n$ matrix of coefficients representing the technical and institutional structure of production, and

b(t) is the m dimensional vector of capacities of fixed and quasi-fixed factors, and numerical values of behavioral constraints b_i (t) for i=1,...,m.

The endogenous information for any period t is obtained from the optimum solution of past periods, for those variables that are a consequence of past decisions. This is represented by the dependence of the elements of the vector b(t) on the optimum plan of the preceding year x^* (t-1) and the capacity vector b(t-1). The exogenous information is represented by a vector v(t) that allows for external interferences. It recognizes the fact that external factors may influence farm development and growth.

Endogenous and exogenous information can be summarized as

$$b(t) = A(t-1)\,\Lambda\, x^*(t-1) + \Gamma\, b(-1) + v(t) \qquad (6.2)$$

The n × n diagonal matrix Λ transfers the amount of resources added or subtracted by the optimum solution of the previous year, while the diagonal m × m matrix Γ transfers all or part of the resources available in period t-1 (Heidhues, 1966).

The first explicit approach to the use of recursive programming applied to agricultural response analysis was developed by Day (1963a). The author evaluated regional production response under the condition that individual producers maximize their expected profits when adjusting to current economic conditions and expectations. Flexibility constraints were used to allow for limited changes in the level of production activities for any year. Investment activities allowed the author 1) to expand production capacity for the same technological stage, and 2) to abandon old capacities and introduce new capacities for new technological stages.

The recursive model developed by Heidhues (1966) was intended to evaluate the effects of alternative EEC price policies on a group of German farms. The individual-farm models developed considered two dynamic factors in the farm adjustment process: advances in technologies and price variations, and the effect of a raising in non-farm standard of living on farmers' income expectations. The objective function maximized the total value of assets and the ability of a farm to accumulate investment capital subject to a consumption function and other requirements. However, the author states that farmers' goals based on total value of assets is hard to specify because of the difficulties posed by valuation of durable assets and some situations do not require the maintenance of, or an increase in the total value of assets. This situation occurs when there is a tendency for specialization in a small number of enterprises, while a change from labour-intensive production structures to more capital intensive ones requires funds to be available for investment.

To handle farmers' adjustments over time, the author introduced behavioral constraints in the part dealing with money capital, which included internal and external funds. The internal flow of capital was handled with the following liquidity and investment constraints:

Liquidity:

Hired Labour + Fixed ≤ Production + Interest + Transfer from
Expense Obligation Return Income Investment Capital

Investment:

Investment + Transfer to = Disinvestment + Borrowing + Bank + Surplus Liquidity
Commitment Liquidity Account of Period t-1
Account

while the external flow of capital was handled with the following equations:

Total Debt:

Borrowing ≤ Previous Year + Loans Paid off in + Previous Period
Debt Limit Previous Period New Borrowing

Rate of Borrowing:

Borrowing = (Rate of Debt)*(Previous Limit) + Previous - Previous Period
Rate Repayment New Borrowing

Repayment:

Repayment = Fraction of Last + Fraction of Repayment Due
Period Borrowing Due from Commitment of earlier Periods

Investment and disinvestment opportunities were modelled with a modified approach to the theory of asset fixity to account for the lack of knowledge at the time the decisions were made. Investment decisions were based on current expectations of annual income and cost. The capacity constraint of fixed assets took the following form:

Resource Value = Amount Available at Beginning - Depreciation + Amount Added to Solution
at Time t of Previous Period of Previous Period

+ Endogenous adjustments

where obsolescence can be introduced through the exogenous adjustments.

A simplified version of the Heidhues matrix of coefficients is presented in Table 6.1 and is composed of five types of activities and restrictions. This basic recursive structure has been used by other authors with slight alterations to accomplish other objectives.

Table 6.1- Matrix of Coefficients of Heidhues Individual Farm Model

	Production	Labour Hiring	Investment and Disinvestment	Fixed Obligations	Borrowing and Repayment
Land Crop Rotations Feed Supply Livestock Labour	A_{11}	A_{12}	0	0	0
Technical Equipment Farm Buildings	A_{21}	0	A_{22}	0	0
Private Consumption Fixed Charges	0	0	0	A_{34}	0
Liquidity Investment	A_{41}	A_{42}	A_{43}	A_{44}	A_{45}
Debt Limit Rate of Borrowing Repayment of Loans and Interest	0	0	0	0	A_{55}

Source: Heidhues (1966)

Ahn and Singh (1978) used a recursive programming approach to project regional development under alternative policy assumptions about price supports and credits. The objective function to be maximized in each year was the anticipated net profit. Recursive constraints were established for farm power and working capital, while production activities were bound in each year by flexibility constraints to account for adaptive safety-first behaviour. Adoption of new technologies was also bound by behavioral constraints to reflect farmers' resistance to use modern technology. With the purpose of policy simulation, output and input prices were projected using a linear time trend.

Kingma (1978) developed a recursive stochastic model of growth for Australian farms. The model incorporated savings, investment, and elements of risk, in which parameters for any time period depended on decisions taken in previous time periods. Stochastic coefficients for wheat yields, pasture growth, and prices were derived and introduced in the model. This model assumed that farmers have limited knowledge of the future, that they regard the next year's production plan as a deviation from the current farm organization, and that marginal profits from increases in investment should equal marginal cost of capital. The matrix of coefficients was similar to the one developed by Heidhues (1966), except for the inclusion of taxation. The objective function to be maximized in each year was cash surplus.

6.1.2 - Multiperiod Programming

Multiperiod linear programming models can be described as a set of one year static models linked together mainly by four types of transfer activities: 1) activities which link the production relationships of period t with period t+1, 2) activities which transfer the real investment (machinery, buildings and equipment, etc.) from period t to period t+1, 3) activities which transfer the money capital from period t to period t+1, and 4) activities which transfer the obligations which arise from credit in period t to period t+1.

A multiperiod programming model maximizes the income at the end of the period under consideration and can be written as:

$$\pi^{*}(t) = \max < \sum_{t=1}^{T} \qquad (6.3)$$

where

$\pi^{*}(t)$ is the value of the objective function at the end of period T under the optimum plan $x^{*}(t)$, for t=1,2,...,T,

z(t) is the n dimensional vector of coefficients of the objective function $z_j(t)$ for j=1,...,n and t=1,2,...,T,

x(t) is the n dimensional vector of the level of activities for period t, $x_j(t)$ for j=1,...,n and t=1,2,...,T,

A(t) is the $m \times n$ matrix of coefficients representing the technical and institutional structure of production, for t=1,2,...,T, and

b(t) is the m dimensional vector of capacities of constraints $b_i(t)$ for i=1,...,m and t=1,2,...T.

In a multiperiod model the objective function could take several forms, depending on the assumptions that are accepted. The maximization of the net present value of future profits is the assumption of the Hicksian model in its simple form for farmers' objectives (Cocks, 1966). If it is assumed that 1) profit generated each year could be either consumed or invested, and 2) profit makes no contribution to the value of the long-term objective until it is consumed and net investments are not consumed until the planning horizon is reached, then this assumptions leads to the modified Hicksian goal of maximization of the present value of current consumption and terminal net worth expressed in the following equation

$$\text{Max} \sum_{j=1}^{n} d_j C_j + d_n \sum_{j=1}^{n} NW \qquad (6.4)$$

where C is consumption, d is the rate of discount and NW is terminal net worth.

When this modified Hicksian goal incorporates utility considerations about farmers' decision making processes, either in consumption (basic and additional consumption) or between consumption and investment, then two situations can occur: 1) assuming a basic consumption activity that will always have a high utility and consequently will be always forced into the model through a constraint, then the objective function remains the modified Hicksian goal and, 2) assuming also the basic consumption activity and that the rate of personal discount for extra marginal consumption (luxury) equals the off-farm lending rate, which means that the farmer is indifferent to the choice between consumption and investment and if the farmer is indifferent he always invests, then in the modified Hicksian goal luxury consumption is eliminated and it is reduced to the maximization of the present value of accumulated net investments. In this last situation the discount factor applied is common to all courses of action and the long term goal is reduced to the maximization of the accumulated value of net assets.

Cocks and Carter (1968) discussed seven alternative objective functions that can be considered long-term micro goals relating to the cash at each stage as well as the value of terminal assets. Such goals were present value of future consumption, present value of future profits (considering that profits are withdrawn at the end of each period or profits are reinvested), internal rate of return, present value of future cash flows and terminal net worth.

The rate of discount to reduce future income flows to present values depends on the objective and the assumptions in the study being conducted. Choices have to be made between nominal or real discount rates, depending on the price assumptions used in the model to specify the different annual flows, and between private or social discount rates, depending on the objectives of the study. The multiperiod objective functions that need the use of a discount rate exhibit the disadvantage that discount rates are calculated at aggregated and not at farm level, and do not express the preferences between present and future consumption but only the tensions that exist in the financial markets at a certain moment in time (Boussard, 1971).

The duration of the planning horizon considered is an essential aspect when building multiperiod models due to possible size matrix problems. The basic rule was defined by Modigliani (1956) which states that the planning horizon should be large enough to allow stable solutions for the initial periods when modifications in the planning horizon are introduced. An alternative way of overcoming the need to use a large planning horizon is to define a set of terminal conditions that consider the tangibility of the resources, the useful life of which extends beyond the planning horizon considered.

The first programming model dealing with the question of planning over time was developed by Swanson (1955). Since then, more detailed and complex models have been developed, among others by Loftsgard and Heady (1959), Dean and Benedictis (1964), Boehlje and White (1969) and Norton, Easter and Roe (1980). The early models by Swanson, Loftsgard and Heady, and Dean and Benedictis were developed with the objective of getting optimum farm plans and did not consider the contribution of external capital markets to the process of farm growth. In these early models, the objective function considered was the maximization of the present value of net returns over the plan horizon considered, subject to consumption requirements by the farm family. The first two models considered annual fixed consumption expenditures, while in the model developed by Dean and Benedictis annual consumption was a function of income from the previous year.

The later models developed by Boehlje and White and Easter, Norton and Roe were more complex, because the contribution of external funds for the process of farm development was considered. These models were composed of four types of sub-matrices: 1) a production matrix which corresponds to the conventional mono-periodic matrix of input-output coefficients to describe the relationship among productive activities, 2) an investment matrix that enables the conversion of accumulated financial assets to durable assets, 3) a credit matrix which allows for short and long term borrowing activities, and 4) an income matrix that permits a division of the income generated between consumption and investment. The objective function considered was based on the farmers' long-term goals such as the final net worth and the present value of disposable income. The model developed by Norton, Easter and Roe incorporated the risk aspects of farm production using a MOTAD formulation.

6.2 - Previous Studies About Alentejan Farming Systems

Several studies have been conducted to analyze the impact of the application of the Common Agricultural Policy to the Alentejan farming systems. Most of the studies evaluated the change of the return to land and management during the transition period due to the application of the common price policy, with some of them also considering the introduction of improved technologies and new activities. The methodological approach followed by the different authors can be divided into two groups: 1) budgeting techniques 2) mathematical programming techniques with and without risk considerations. Linear programming was the dominant mathematical programming technique used at farm and regional level, while budgeting techniques using whole farm budgets was the methodology used in activity level studies. With the exception for the recent study undertaken by Carvalho (1994) evaluating the impact of the 1992 CAP reform, the other studies referred to below used the price projections based on the initial agreements for the transition period (1986-1995).

Two studies (Percheiro, 1986 and Canha, 1988) analyzed 4 farms belonging to the farming system MSPL and MS, located in the Alentejo coastal area and not considered in this study. Percheiro (1986) evaluated the optimum enterprise combination in two farm types on the irrigated perimeter of Mira, situated in the southern part of the Alentejo region. This irrigated perimeter, with an irrigated area of 12,000 hectares, is characterized by the majority of its agricultural area being used for maize (40 per cent), pasture (20 per cent) and forage (20 per cent) production. These activities had the main purpose of feeding milk cows. The author used linear programming to model two farm types which were specialized in milk production. The objective was to simulate the impact of projected prices for milk, maize and feedstuffs, during the period 1985 - 1998, in the optimum enterprise combination. The results showed a 50 percent decrease in farm profitability during the period considered. In spite of output price decreases, milk production remained competitive with other irrigated crops such as tomatoes for processing, rice and maize for grain. However, most of the livestock feed should be produced on the farm.

Canha (1988) estimated the effects on farm income of projected Portuguese output prices in two farms of the Santiago do Cacém county. The author selected two farms, one characterized by traditional activities of the Alentejo region based on dryland cereal rotations and livestock production, and another based on fruit crops and irrigated activities. Linear programming models were built to measure the effect of projected output prices. The conclusions reached indicated that farm income would decrease significantly (63 %) in the farm type based on dryland activities, while a smaller decrease (25 %) of farm income was observed in the other farm type. Output mix was characterized by an increase in pasture-forage activities for livestock production. Lamb was comparatively more profitable than beef, and the income generated by tomatoes for processing and fruit crops stabilize farm income in the long run.

With respect to the previous studies about the four farming systems considered in this thesis, they have been conducted at activity, regional and farm level. One of the first to evaluate the impact of the CAP on the most important Alentejo activities was undertaken by Fox (1987). The author studied the impact of the future output price policy on the following activities: wheat, sunflower, rice, tomatoes, lamb and beef. The methodological approach followed by the author and referred to in chapter II, was whole farm activity budgets in which private profitability (receipts minus input and factor costs) and social profitability (using social prices) was evaluated. The assumptions underlying the study were: output prices will decrease according to the transition rules, private and social wage rates will increase 1.5 percent per year in real terms, real cost of capital will remain constant, real social costs of tradable inputs will stay constant, and real private costs of tradable inputs were adjusted for the 1984 removal of subsidies on fertilizer and mixed feed.

Table 6.2 shows private and social profit for the different activities studied at the beginning of the accession and second stage, and at the end of the transition period. The results indicate that irrigated activities, such as rice, tomatoes for processing, and sunflower show positive private and social profitability; this means that these activities will not have major problems in adjusting to the new economic conditions caused by the application of the CAP.

Wheat on good soils and lamb with high management will survive with a slight improvement in the technology used, in spite of their negative profitability in some years.

Wheat on poor soils, lamb with medium management, feedlot beef, and pasture fed beef will have problems in adjusting to the new economic conditions. Technical change, associated with new policies, will be needed to make those activities profitable in the future. The author advocates development of effective insurance schemes to decrease the high production risks in Alentejo dryland agriculture, and its negative consequences on the farmer's willingness to invest. Price risks can be controlled by the Portuguese government, while yield risk can only be controlled by the adoption of insurance schemes or an expansion of irrigation. The expansion of irrigation to new areas will probably be used for more profitable crops, rather than improving the profitability of livestock activities based on pasture feeding.

Table 6.2 - Private and Social Profitability for Alentejo Activities, 1986 - 1996
(Returns to Land and Management)

	1986			1991			1996		
	Profitability		Net Policy Effects[a]	Profitability		Net Policy Effects[a]	Profitability		Net Policy Effects[a]
Activities	Private	Social		Private	Social		Private	Social	
Wheat Good Soils[b]	7.76	-2.79	+10.55	3.84	3.71	+0.13	-0.49	-0.56	+0.07
Wheat Poor Soils[b]	1.51	-6.48	+7.99	-2.54	-3.20	+0.66	-7.03	-7.60	+0.57
Sunflower[b]	5.31	2.43	+7.74	4.40	3.77	+0.63	2.33	1.87	+0.46
Rice[b]	15.32	6.52	+8.80	12.16	11.70	+0.46	14.63	14.28	+0.35
Tomatoes[b]	3.08	1.25	+1.83	19.99	18.79	+1.20	14.16	13.64	+0.52
Lamb Medium Management[c]	29	-146	+175	-31	-202	+171	-71	-239	+168
Lamb HIgh Management[c]	49	-82	+131	-6	-136	+130	-41	-168	+127
Beef Feedlot[c]	-44	-139	+95	-59	-79	+20	-32	-52	+20
Beef Pasture[c]	-24	-154	+130	-41	-100	+59	-24	-82	+58

Source: Fox, 1987
[a] + equals a subsidy
[b] Escudos per kilogram of final product
[c] Escudos per kilogram of carcass weight

A further development of the Fox study was undertaken by Avillez et al. (1988). The objectives were to analyze the effects of two scenarios of price on the profitability of the main irrigated activities of the Alentejo. One output price scenario assumed price changes in the Community similar to the trend observed in the last years, and the other supposed a substantial decrease in the prices during the first three years and afterwards prices would follow the pace of inflation. The main conclusions were that the competitiveness of fresh and processed fruit and vegetables will increase in the irrigated areas of the Alentejo, and the area for tomatoes for processing will have an auspicious future, although the expansion of tomato area will be limited by Portugal's production quota. An increase in the tomato growing area, if accepted, will produce a reduction in the production aid and consequently in the minimum realised producer price. Rice and maize will have a decrease in their profitability, but it is believed that small improvements in their technology will enable them to increase their competitiveness. Irrigated sunflower and sugar beet could have a significant role in future Alentejo irrigation systems. The authors pointed out that the positive profitability of the irrigation agricultural systems, when compared with the dryland agricultural systems, will be an incentive to improve and expand the irrigated areas in the future. To reduce the chance that the cost of improving and expanding the irrigated areas is greater than its economic benefits, the authors suggested that such investments should be evaluated considering their private and social returns, their impact on income distribution, and their impact on the environment and natural resources (including the rural landscape and habitat).

Marques (1988) developed a regional model of Alentejo dryland agriculture with the objective of studying the economic implications of Portuguese entrance into the EEC for Alentejo producers. The author measured the adjustments in resource allocations, output mix and returns, and simulated the introduction of new production technologies and activities. The methodological approach followed was to build a regional model, based on sequential discrete stochastic linear programming models for three farm types of the region. Risk was introduced by stochastic input-output coefficients which captured forage and pasture yield variability. Technical change was introduced through ley-farming rotations and improved livestock production. Three output price scenarios were used, each one reflecting different assumptions about the future output price policy. The first scenario considered the continuation of current CAP trends, the second scenario assumed larger reductions in support for agriculture, and the last scenario presumed total trade liberalization. The results confirmed those obtained by Fox (1987) in which a substantial reduction in farm income was foreseen. The reductions in farm income were greater for the scenarios that assumed larger decreases in CAP support prices. Regarding output mix, there was a decrease in crop activities and an increase in the pasture crops and livestock activities. This output mix change was reinforced when the ley-farming rotations and improved livestock activities were introduced into the model. Returns to land and labour, measured as the shadow price of their constraints, show a sharp decrease. The results also showed that fixed costs will have in the future an important role in determining the profitability of each activity and of the farm as a whole, meaning that the production structure of Alentejo farms and their corresponding capital costs could determine future farm survival.

Several studies were conducted at farm level, such as the ones by Pinheiro and Carvalho (1986), Silva (1988), Rego (1989), Cunha (1989) and Serrão (1990) for farms located in the Évora and Viana do Alentejo counties. In general, it was not possible to identify the farms used for these farm level studies with the farming systems selected in this thesis, because the boundaries of farming systems do not have an exact correspondence with the county divisions which were used by the authors to identify farm location. Pinheiro and Carvalho (1986) used linear programming to study the impact of the adoption of future Community prices on the level of farm income and optimum enterprise mix on a farm type of the Alentejo region. The results confirmed that the price policy followed before the entrance of Portugal into the EEC, favoured cereals to the detriment of livestock. The price policy adopted for outputs and inputs (e.g., feedstuff subsidies), meant that livestock production based on feedstuffs was more profitable than livestock production based on pasture and forage produced on the farm. With the application of Community prices, livestock activities will compete with cereals, because the rotations adopted will have a higher component of pasture and forage. Among livestock activities, sheep show higher profitability than beef. Among the irrigated activities, tomatoes for processing and rice are the most profitable activities. The authors argue that the research priorities in the Alentejo should be oriented to find the best dryland and irrigated activities, as well as to solve some of the constraints of their adoption by Alentejo farmers.

Serrão (1990) estimated the effects on farm income of adopting the common price policy and new technologies on optimum enterprise combination for a farm type of the Évora region. The author used linear programming, and integrated in the model the stochastic nature of agricultural production and the sequential characteristics of the decision making process. The results showed a sharp decrease in farm income due to the adoption of price policy. The adoption of new technologies can partially offset the reduction in farm income. With respect to the optimum enterprise combination, a substitution of the traditional rotations of cereals in the poor and medium soils by longer rotations that include legumes was foreseen. The author recommended that agricultural research should directed towards new management systems for livestock herds and pastures to take into account the benefits of the growth cycle of pastures in Mediterranean weather, improved sheep breeding genetics, and the effect of legumes on increasing cereals' yields and reducing fertilization costs.

The studies done by Silva (1988), Rego (1989) and Cunha (1989) used linear programming in farms belonging to the Evora and Viana do Alentejo counties to evaluate the optimum enterprise combination, resulting from the adoption of the Community price policy until the end of the period of accession (1996) to capture the effects the changes on the output mix, resource use and farm income. The output price scenario used was characterized by an evolution of prices pessimistic in the short-term and an optimistic in the long-term and the results confirmed to a large extent the conclusions of previous studies in which a decrease in farm income was observed. Output mix is characterized by an increase in forage activities for livestock feed, in the substitution of crop activities, due to the relative output price changes. The irrigation activities such as maize and pasture are competitive, as well as wheat, when the correct technology is used. The protein crops are an alternative in the future due to their favourable prices. Regarding livestock activities, sheep and beef activities are profitable when based on pasture and forage produced on the farm due to lower production costs, while sheep is more profitable than beef. The traditional pig activity based on pasture feeding is also profitable in the long-term, if the risk of African swine fever is eradicated.

Although some of studies referred to above have used different methodologies and price assumptions, the conclusions reached are in general similar, with the exception of the negative private profitability of lamb and beef activities predicted by Fox (1987) which the other authors found to be positive in the future. The majority of the authors concluded that farm income is expected to decrease in real terms, due to future output price decreases. The adoption of new technologies and new activities, tested by some authors, can in some cases help to offset the negative impact of the application of the common price policy. Cereals are profitable when grown on adequate soils and using the correct technology, there is an increase in pastures and forage activities to support livestock production, sheep and goat production is comparatively more profitable than beef, and irrigation activities are profitable. The recommendations made by the different authors to increase farm income and to build viable economic farms in the future were: to improve the level of management which is in accordance with our findings about the need to improve the levels of technical efficiency evaluated in the previous chapter, to create an efficient production structure, to improve production techniques for the different activities, to improve the infrastructure support to agricultural activity, and to increase the number of irrigated areas.

In a recent study Carvalho (1994), using linear programming models with a risk discrete stochastic formulation, analyzed the impact of the 1992 CAP reform on three Alentejan farms in a comparative static framework. Two of the farms were located in the richer zone (IS, SIS) and one located in the poor zone (PLS), with areas between 200 and 500 hectares. The results showed that income would decrease putting at risk the future survival of two of the farms considered, livestock extensification would take place with beef replacing sheep and goat activities, and that an increase in the area of pastures and forage and a decrease in the area of cereals, oilseeds and protein crops is likely to occur.

6.3 - MODEL CHOICE

The studies referred to in the previous section analyzed the impact of the entrance of Portugal into the EC on the Alentejo agriculture, but the following aspects were not considered: 1) the role of financial funds either internal or external, investment and growth in the best strategy of farm development because a comparative static framework was used to compare price change scenarios, and as Marques (1988) pointed out fixed costs will have an important role in determining the profitability of Alentejan farms in the future, 2) with the exception of the recent study by Carvalho (1994), all the other studies did not take into consideration the 1992 CAP reform, 3) the majority of the studies were biased towards large farms (>200 hectares) and did not consider the small and medium farms that produce 39.9 per cent of Alentejo agricultural GDP or (50.7 per cent if forest activities are excluded) and represent 92.3 per cent of Alentejan farmers, and 4) the farm level studies were in the majority of the cases located on farms near Evora, with the exception of the farms studied by Percheiro (1986) and Canha (1988) which are located in the coastal area and not included in the farming systems selected, and two of the farms studied by Carvalho which are located in the Beja District (one belonging to the IS and another to the PLS farming system).

The above reasons lead us to consider important a study: 1) of the impact of the 1992 CAP reform 1) on four of the Alentejo farming systems selected that correspond to 61 per cent of Alentejo area and are located in the interior part of the region, permitting us to have a broader picture in terms of the development of Alentejan agriculture; 2) to analyze the development of small and medium sized farms because of their importance in terms of agricultural GDP and principally in terms of the number of farmers employed in agriculture; and 3) to consider a multi-year linear programming approach with the objective of capturing the role of funds flows in the process of farm development and growth.

Among the multi-year linear programming approaches, the choice between a recursive and a multiperiod model depends on the way the decision making process at farm level is conceptualized. To take full advantage of a pure recursive approach, the researcher should have a perfect knowledge of the decision-making process and the farmer's attitude towards farm growth in analysing the solution for a given year, to incorporate in next year model the farmers preferences about farm growth and development. However, knowledge about the decision-making process and attitude towards growth is not perfect because it is farming system and farmer specific, and complex as partially discussed in section 4.5.

A multiperiod approach always incorporates a recursive nature because the connection between periods always relates basic and non-basic variables among the different periods that constitute a multiperiod-model, but does not allow us to introduce modifications at the middle of the time horizon as a result of the optimum plans obtained from previous years and changes in farmers' decision making and attitudes towards growth. However, if the researcher knew all the farmer's alternatives in terms of the decision-making process and attitude towards growth, and was able to incorporate them in a multiperiod model, then the results obtained by a recursive and a multiperiod approach would not differ significantly.

As a result, multiperiod programming models lead to optimum decisions over the period considered with the objective of finding the optimum development path of the farm under consideration, while recursive programming models using a sequential optimizing technique to explain economic behaviour, do not attempt to devise optimal decision rules over the period considered, but to describe the actual path development in a sequential manner, year by year. In a multiperiod programming model the farmer is assumed to make a set of production decisions at the outset based on a view of the whole planning period, whereas in a recursive programming model the farmer is assumed to make a series of annual production decisions, each based on a view of the year ahead.

For our research, the specific knowledge in terms of behavioural variables and restrictions responsible for farm growth and the decision-making process was obtained from interviews made with a limited number of selected farmers. The information obtained from these interviews, although very important, did not justify the use of a recursive approach since it did not establish a set of rules able to be used as a coherent and rational procedure to select and analyze the best farm plan for each year and to decide the best course of action for next year. Also, it was unpractical from the viewpoint of this research to follow the ideal approach, which would have been to analyze with each farmer the results obtained for each year and then incorporate their options and decisions into the matrix for next year, repeating this exercise for all the years analyzed and farms considered. As a result of these limitations, a multiperiod approach was considered to be the most suitable methodology for studying the development of Alentejan farms during the period 1992-2000.

6.4 - EMPIRICAL MODEL

A multiperiod linear programming model was developed with the objective of analysing the development of the four Alentejo farming systems selected in Chapter IV. The multiperiod nature of the model embodies a recursive relationship between the previous periods and the following periods regarding resources and income generated. The model will capture the effects of changes in the planning environment such as the technological and agricultural policy settings. These changes will affect farmers' optimum levels of production, resource use and income, will be an important factor in defining the development strategies of Alentejo agriculture, and will determine in selecting which farmers will have a production structure with capabilities of staying in agriculture in the future.

A simplified matrix of the model to be implemented is presented in Table 6.3. A set of 11 constraints and 10 variables was defined with the objective of analysing the different aspects of the production process and evaluating the economic performance of farms. Since the model will be used to predict farm performance over a period of nine years (1992-2000), the structure of the matrix was developed in a flexible way. The flexibility will allow the modification of input-output coefficients and exogenous variables, and the simulation of those variables that are supposed to be determinants in farm performance. A production sector that

Table 6.3 - Simplified Matrix of Alentejo Farms Model

Type of Constraints	Activities										
	Production	Input Buying	Hiring/ Renting	Transfer	Owned Durable Inputs	Investment and Disinvestment	Selling	Policy	Capital Flow		
									Borrowing	Funds Flow	Farmer Expenditures
Land	A		A	A							
Labour	A		A								
Variable Inputs	A	A									
Durable Inputs	A		A		A	A					
Feed Supply	A			A							
Animal	A										
Supply Durable Resources		A			A	A					
Borrowing						A		A	A		
Policy	A			A				A			
Output	A						A				
Funds Flow	A	A	A		A	A	A	A	A	A	
Farm Expenditures										A	A

A- Input - Output Coefficient

comprises crop and livestock activities is the basic structure of the model. This sector will use resources from the input buying, hiring, renting, owned resources, and investment and disinvestment activities. Input buying activities are mainly composed of variable inputs, while hiring and renting activities are composed of machinery, labour and land activities. Owned resources, investment and disinvestment activities, supply durable inputs such as machinery, equipment, buildings and land improvements. The policy sector incorporates in the model some of the policy instruments available for the study period, such as production and investment subsidies and policy restrictions on farm activities derived from the application of the rules for the second stage of the transition period and the reform of the CAP. The money capital sector constituted by borrowing, annual funds flow and farmer expenditure sub-sectors, evaluates the financial performance of farm activity. Borrowing activities supply external funds to meet demands for farm investments and short term capital needs. The funds flow activities evaluate annual farmer performance, and the farmer expenditure activities measure income availability for the next period of farm activity.

The matrix represents farm economic opportunities for a given year. Some of the variables and resources are dependent on the optimum solution obtained from previous years. The optimum solution for each year is expected to represent the best farmer combination of resources and activities for that year, considering its production capabilities, the planning environment, and farmers' goals. The farmer goal assumed was the maximisation of the sum of net present value of additional (luxury) consumption and terminal net worth expressed in equation 6.4.

To disclose the relationships between the different sectors a more detailed analysis of each sector is outlined in the following sections. In Appendix III a mathematical formulation of the model is presented, while the budget activities and individual farm model matrices in SAS linear programming format can be obtained from the author. The models were solved using the SAS linear programming routine called OR.

6.4.1 - Production Sector

This sector is defined by the set of crop and livestock activities that determine the farmers' production opportunities and by the set of resources available to generate those activities. The set of crop and livestock activities is based on farmers' present activities, and on the availability of new and improved activities. Resource availability is based on actual farm production structure and input market supply. To match production requirements with supply the following constraint must be satisfied.

Resource ≤ Resource
Utilisation Availability

Input markets supply variable inputs such as seed, fertilizer, chemicals, gas and oil in unlimited quantities. Petrol and oil consumption were modelled as a function of the time required to perform the agricultural operations of the different activities as well as tractor power. Standard times for agricultural operations by tractor power were supplied by the Department of Agricultural Engineering of the Ministry of Agriculture, and petrol and oil consumption were a linear function of tractor power. Gas and oil consumption coefficients were 0.1 litres/H.P./hour and 0.003 litres/H.P./hour, respectively.

Durable resources such as land, machinery, equipment and buildings are supplied in limited quantities, either by resources owned at the end of the previous period, or by renting, hiring and investments. The supply of durable inputs such as machinery, buildings and equipment become available in each period satisfying the following equation

Machinery, Equipment and Buildings Availability	=	Durable Resources at the end of Previous Period	+	Hiring In	+	Hiring Out	+	Investment
		- Disinvestment - Obsolescence						

to meet the requirements of production activities. Land was divided into different soil groups in order to consider its capacity for producing the different crop activities. The farms selected showed three types of land ownership: owned, rented or both. For the last two cases a land-renting activity was incorporated into the model. To allow for farm size change, principally for those farms belonging to small and medium sized classes, land renting in and renting out were considered as alternative activities while activities to purchase and sell land were not considered because of the difficulties that arise in modelling those kind of activities. The availability of land for a given period satisfied the following equation

Land Availability = Land Owned + Renting in - Renting out

Labour requirements are met by family labour, permanent employees, and short-term hiring labour. Short-term hiring labour is usually used to cover specific labour requirements of some activities. Labour availability satisfies the following equality

Labour Availability = Family Labour + Permanent Labour + Seasonal Labour

For those farms with permanent labour exclusively used in livestock activities, such as shepherds, labour requirements for livestock activities were separated from the general labour constraints. For this situation labour supply to livestock activities was modelled as a general integer variable.

The demand for owned and hired resources such as machinery, equipment and labour is dependent on the period of the year. To take into account periods with a high demand, in which supply could be scarce, the demand for those resources was divided into periods. Four periods were considered for labour, machinery and equipment, which correspond principally to the specific demands for those resources by crop activities as shown in Table 6.4.

Table 6.4 - Periods Considered for Labour, Machinery and Equipment

Periods	Period of the Year	Operations
Period 1 (P1)	15 September to 15 December	Land Preparation and Seeding of Winter - Spring Crops
Period 2 (P2)	16 December to 31 of May	Middle Operations of Winter - Spring crops and Land Preparation, and Seeding of Spring - Summer Crops
Period 2 (P3)	1 June to 31 July	Harvest of Winter - Spring Crops, and Middle Operations of Spring - Summer Crops
Period 4 (P4)	1 August to 14 September	Harvest of Spring - Summer Crops

Alternative crop activities were specified based on new and improved crop activities made available by agricultural research conducted in the region. These alternative activities were incorporated in several crop rotations recommended for each agricultural system. Experimentation conducted in the region demonstrated that minimum tillage techniques are a technical alternative when compared with traditional tillage techniques (Bernardes, 1988) which led to the incorporation of alternative wheat activities based on minimum tillage techniques into the model.

Regarding wheat, a quadratic production response curve to nitrogen estimated by Carvalho and Azevedo (1990) was available for some soil types of the intensive, semi intensive and poor land agricultural systems. The wheat response curve that was used to model nitrogen as a decision variable for the selected farms belonging to those agricultural systems was

$$W = -2621 + 29.5R - 0.045R^2 - 0.057N^2 + 0.053NR,$$

where W is the wheat output level, R is the amount of rainfall between November and February and N the level of nitrogen.

The above quadratic response curve was approximated by linear segments (K1 to K4) as shown in Figure 6.1. Rotations that incorporate leguminous crops are able to biologically fix nitrogen and supply it to the next activity. The supply of nitrogen was modelled by allowing those activities to be a source of nitrogen. Nitrogen supply was modelled, based on the following equations which express the supply of nitrogen, the requirement of a minimum supply at planting and the selection of the optimum level of nitrogen and output (Duoly and Norton (1975) and Kingwell and Pannell (1987))

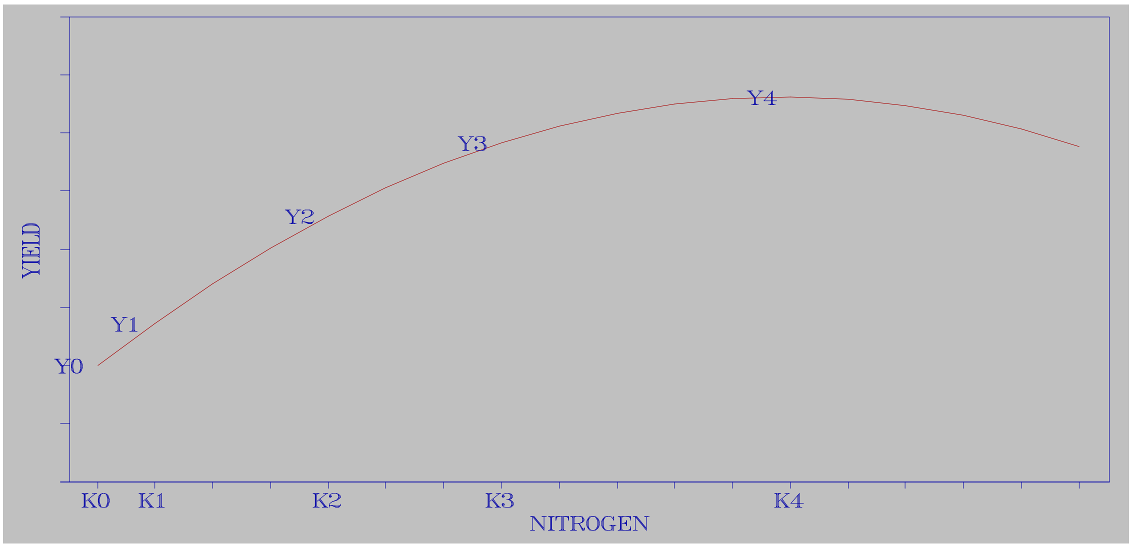


Figure 6.1 - Wheat Yield Response to Nitrogen

- Supply of Nitrogen by other Crops	- Buying Nitrogen	+ Nitrogen Requirements at Response Levels K1,..., K4	≤ 0

with a minimum supply of nitrogen at planting

- Minimum Requirement of Input at Planting	+ Buying Nitrogen	≤ 0

and selection of an optimum level of nitrogen and output

- Hectares of Wheat at Response Level K0	+ Hectares of Wheat at Response Response Level K1,..,K4	≤ 0

- Output Produced at Response Level K0	- Increase in Output for Response Levels K1,...,K4	+ Selling Activities	≤ 0

The livestock sector was modelled on a flexible form, to allow for the modification of the production coefficients from one period to another and the growth of the herd. Coefficients, such as the fertility and mortality rate, can be modified from one period to another to reflect improvement of farm-management techniques. The optimum herd size was evaluated for each period based on previous herd size, acquisition of new animals, sale of existing animals and retaining young animals from one year to another.

Herd Composition

Female Activity	- Females from Previous Period	- Buying Females	+ Selling Females	+ Young Animals Kept	≤ 0
Male Activity	- Males from Previous Period	- Buying Males	+ Selling Males	+ Young Animals Kept	≤ 0

Number of Males Required

- Male Activity + Male Requirements per Female * Female Activity ≤ 0

Animals Born and Fattened

- Female Activity * Productivity*(1-Mortality) + Substitution Rate Activity + Selling Fattened Animals ≤ 0

Herd Substitution

(Substitution Rate + Mortality Rate * Female or Male Activity) - Substitution Activity ≤ 0

Selling Cull Animals

- Substitution Rate * Female or Male Activity + Selling Cull Animals ≤ 0

Besides the improvement of the herd management through the modification of productivity, substitution and mortality rate coefficients, alternative activities for sheep and goat production based on three production cycles in two years were considered for those farms with the capacity to adopt them.

The analysis of sheep and goat prices at the farm gate for the regional markets of Beja, Évora, Elvas and Portalegre showed a significant seasonal variation. As can be seen in Table 6.5 and Figure 6.2 for the Évora Market, prices reach a maximum during the months of November, December and January and a minimum during May, June and July. To reflect the opportunity of selling sheep and goats in the most favourable months, a sequence of alternative activities with production cycles that allow the selling of the animals in different months of the year was considered. The animals born during the summer that can be sold in the most favourable months in terms of prices, have a higher propensity to die than in other periods of the year, and consequently a higher mortality rate was used. Price differentiation also occurs if lambs are sold with a weight below or higher than 25 kilos. On average the price differential is around 6.5 %, varying from almost 10 % during the months of April and May to 6% during the months of November and January. To consider this price variation two different selling activities were allowed. Prices also vary between the different regional markets and this variation was taken into account by identifying each farm selected with its own regional market.

Table 6.5 - Average Monthly Lamb Prices in Évora Market
(Based on Average Values of the Period 1986-1992)

Month	Price (Escudos/Kg Liveweight)		Lamb Price >25 /Lamb Price<25 (%)	Monthly Price/Average Annual Price (%)	
	Lamb < 25 Kg	Lamb > 25 Kg		Lamb < 25 Kg	Lamb >25 Kg
January	353.75	330.27	93.36	106.84	106.60
February	322.19	306.56	95.15	97.31	98.95
March	310.47	295.47	95.17	93.77	95.37
April	302.66	283.75	93.75	91.41	91.59
May	277.34	257.86	92.98	83.77	83.23
June	277.81	252.97	91.06	83.91	81.65
July	309.69	284.32	91.81	93.53	91.77
August	334.22	312.27	93.43	100.94	100.79
September	349.06	324.82	93.06	105.43	104.84
October	358.91	336.38	93.72	108.40	108.57
November	388.22	363.44	93.62	117.25	117.31
December	388.80	369.69	95.08	117.43	119.32
Average	331.09	309.82	93.52	100.00	100.00

Source: SIMA

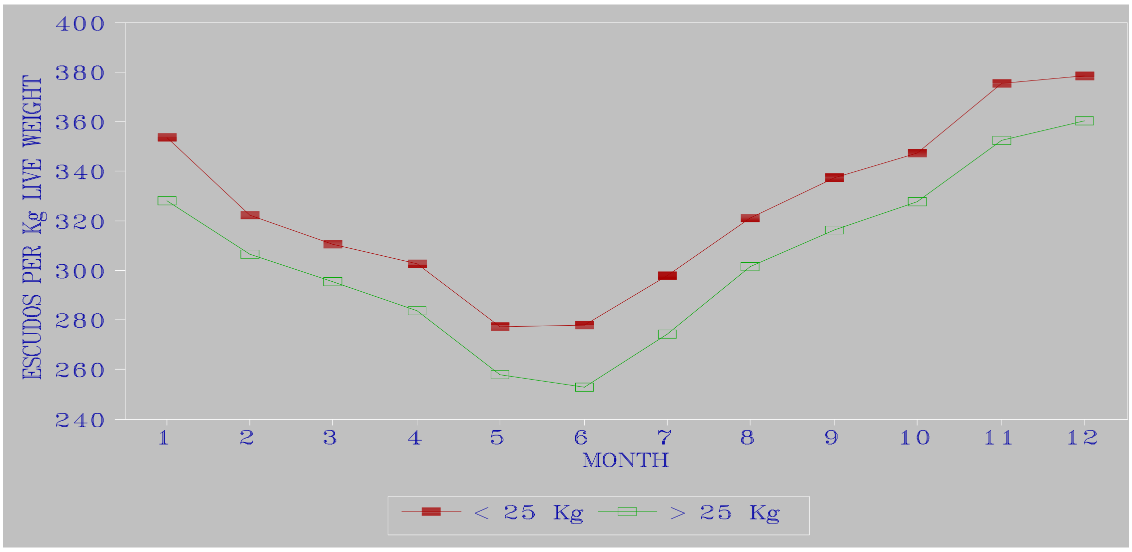


Figure 6.2 - Monthly Average Lamb Prices in Évora Market (Average 1986-1992)

Source: SIMA

With respect to beef prices, the values observed in the Évora market, the most representative market of the region, show that there is a small variation of the prices during the year, while a significant difference between the prices of males and females was observed, as can be observed in Figure 6.3 and Table 6.6. The difference between male and female prices is greater for calves for which male prices are approximately 20 percent higher. For 18 month-old animals the difference in prices is smaller, reaching values close to 6 percent.

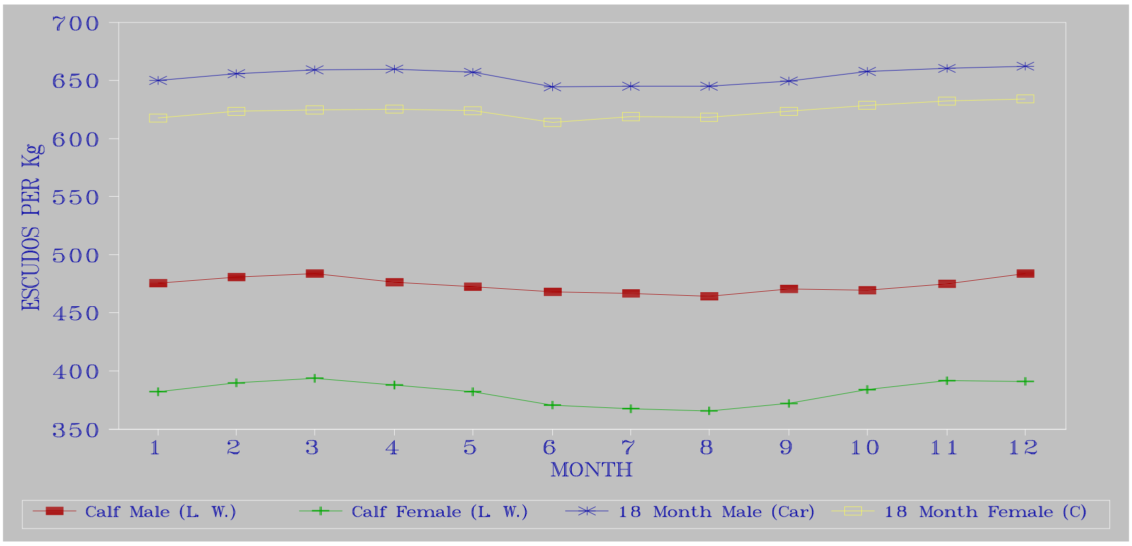


Figure 6.3 - Average Monthly Beef and Calf Prices in Évora Market (Average 1986-1992)
Source: SIMA

The monthly price variation is very small when compared with the seasonality observed in lamb prices. Only during the period June to August do beef prices have a slight decrease of 2 percent from their annual average. Although the annual price variation in percentage is small, three periods of selling beef were defined to reflect the prices differences when prices are expressed in monetary value. Each selling period was divided into male and female selling activities, and alternative cow activities were specified to allow calves to be born in the different months of the year to reflect the opportunity that farmers have to match feed demand and supply with market opportunities.

Table 6.6 - Variation Between Male and Female Prices and Monthly Variation in the Évora Beef Market (Based on Average Values of the Period 1986-1992)

Month	Female Price / Male Price (%)		Monthly Price / Average Annual Price (%)	
	Calves	18 Month	Male Calf	Male 18 Month
January	80.24	94.95	100.41	99.46
February	81.03	95.11	101.46	100.27
March	81.28	94.83	102.16	100.78
April	81.46	94.74	100.44	100.92
May	80.89	94.98	99.68	100.51
June	79.14	95.32	98.76	98.55
July	78.71	95.98	98.46	98.65
August	78.64	95.88	98.00	98.63
September	79.02	95.96	99.29	99.37
October	81.85	95.60	98.99	100.59
November	82.50	95.76	100.21	100.99
December	80.76	95.82	102.12	101.28
Average	80.47	95.41	100.00	100.00

Source: SIMA

The adoption of the alternative livestock production cycles will be limited by the availability of forage during the critical periods of the end of Spring - Summer and the beginning of Autumn. Feed supply was modelled, taking into consideration requirements for energy and dry matter by livestock activities. Energy requirements represent energy needs of livestock activities to produce a certain level of output, while dry matter requirements represent the maximum intake capacity of dry matter by livestock activities. The following constraints were specified

Energy Requirements of Livestock Activities	≤	Energy Supply of Crop activities	+	Energy Supply of Feedstuffs

Maximum Dry Matter Intake of Livestock Activities	≥	Dry Matter Supply of Crop Activities	+	Dry Matter Supply of Feedstuffs

to accomplish those criteria. To reflect the scarcity of feed supply from crop activities in matching feed requirements in certain periods of the year, feed supply was divided into three periods as shown in Table 6.7, based on the availability of forage and pastures during the year. To compute the amount of forage and pastures available in each period the values shown in Table 6.8, estimated by Crespo (1975), were used for sown forages and pastures and by Vera y Vega (1986) for natural pastures.

Table 6.7 - Periods Considered for Feed Supply and Demand

Periods	Period of the Year	Available Feeding
Period 1 (FS1)	1 October to 31 February	Autumn and Winter Forages, Conserved Forages - Supply Depending on Weather Conditions
Period 2 (FS2)	1 March to 31 of May	Spring Pastures, Conserved Forages - Plentiful Supply
Period 3 (FS3)	1 June to 30 September	Summer Dry Pastures, Conserved Forages - Scarce Supply

Table 6.8 - Distribution of Dry Matter for the Three Periods Considered (percentage)

Pastures and Forages	Period 1	Period 2	Period 3
Irrigated Pastures	21.3	32.6	46.0
Dryland Pastures and Forages	25.0	68.4	6.6
Dryland Natural Pastures	18.8	74.6	6.7

Source: Crespo (1975) and Vera y Vega (1986)

6.4.2 - Investment and Disinvestment Sector

The activities of this sector allow farmers to take decisions about the purchase and the sale of durable assets. The investment decisions are mainly dependent on the profitability of the set of activities defined in the production sector, and on the capacity of the farmer to finance the purchases of durable assets.

The conceptualization of investment and disinvestment activities is based on the theory of asset fixity. This theory assumes that a factor is fixed if its use value is smaller than the acquisition cost and larger than the sales price. The use value is represented by the present value of the expected income of the asset. The expected income of a durable asset depends on the farm's organization in future periods. Information about future periods is usually limited, and farmers take decisions with a lack of knowledge about future expected revenues for durable assets. To overcome this limitation, Heidhues (1966) suggested the estimation of durable asset costs based on depreciation, interest, and fixed maintenance costs, and assumed that these costs were distributed over the expected useful life of the durable asset. This assumption implies that investment decisions are made on the basis of current expected annual returns and costs, and that marginal returns over the useful life of the asset are constant. Funds available to purchase durable assets come from the money capital sector and the following constraint

Investments	≤	Income from Previous Period	+	Long Term Borrowing	+	Investment Subsidies	+	Long Term Deposits

must be satisfied.

The annual costs of durable assets such as machinery and buildings were connected to the activity or set of activities that consume them. This allowed the evaluation of the profitability of activities and investments based not only on the variable costs but also considering the role of fixed costs.

Due to the nonexistence of a second hand market that allowed the estimation of the second-hand market value for the tradable durable assets, it was assumed that durable assets were trapped on the farm and consequently the farmer will incur depreciation costs until the end of the expected useful life of the assets. In this situation disinvestment and obsolescence activities were not explicitly modelled.

6.4.3 - Policy Sector

This sector integrates in the model the policy instruments that will be available during the period of analysis at farm level. Policy instruments might bias the profitability of production activities, could influence farmers' decisions, and could determine important aspects of farm development and growth in the future. Some of the policy instruments available are subsidies for inputs, subsidies for specific activities, set-aside incentives, set aside requirements and investment subsidies. Direct subsidies for inputs and activities have the effect of decreasing cost and increasing revenues, respectively. Subsidies for investments have the result of decreasing the amount of funds required to purchase durable inputs and annual depreciation costs. Set-aside subsidies represent new activities that are competitive with the set of crop and livestock activities available. The separation of the variables included in this sector was made to allow simulations on their predicted levels. The objective is to identify other alternative agricultural policies that could be implemented, if the future intention of the Portuguese government is to maintain in farming some of the farms being studied.

6.4.4 - Money Capital Sector

This sector evaluates the farm's financial performance during each period of analysis. It is assumed that the farmer's goal is to maximize the returns to capital and management. This sector is composed of borrowing, annual funds flow, income tax and farmers' expenditure activities. A long-term loan activity was defined to supply funds for investments as referred to previously. Long-term loans are limited by the farmer's total net assets in each period. This assumption corresponds to the present requirements made by the agricultural credit cooperatives in supplying long-term loans to agriculture.

The following constraints ensure that farmers' long term debt is kept at a realistic level.

$$\text{Long Term Borrowing} - \text{Net Assets from Previous Period} - \text{Outstanding Debt} \leq 0$$

$$\text{Net Assets} = \left(1 - \frac{\text{Asset Use}}{\text{Asset Life}}\right) * \text{Value Durable Assets}$$

$$\text{Value Durable Resource Assets} = \text{Value Durable Assets from Previous Period} + \text{Investment} - \text{Disinvestment} - \text{Obsolescence}$$

In order to guarantee the repayment of the principal and interest of the long-term outstanding debt each year, the following constraints were specified

$$\text{Principal and Interest Paid} = \text{Principal and Interest Due}$$

$$\text{Principal and Interest Due} = \text{Principal Payments} + \text{Interest Payments}$$

Short-term loans are available to finance short-term capital needs in each one of the three annual funds flow periods included. The three annual fund flow periods were considered to reflect the seasonality of a substantial part of revenues and costs such as cereal and livestock activities and the need farmers will have to finance any short-term lack of operating capital. A short-term deposit activity was included to absorb any surplus of capital generated in any period. This short-term deposit activity was differentiated from the long-term deposit activity defined to absorb the income from the previous period not needed to finance long and short-term loans and which paid a higher interest rate.

Since 1988 a new tax law has been applied to agriculture, enforcing income taxes on agricultural activity. The objective was to extend income taxes to all sectors of activity and to put agriculture on the same level as other businesses. The income tax scheme approved for agriculture was progressive; that is, as the level of taxable income increases, a higher marginal rate is charged. To model the progressive income tax scheme the following constraints were used for each level of tax rate (T_t) and taxable income:

Tax Rate Activity <= Maximum Taxable Income for each Tax Rate Class (one equation for each T_1 until T_{t-1})

Sum of Tax Rate Activities = Taxable Income.

For each period, fixed expenditures were considered to meet the basic needs of the farm family. These expenditures were based on the average agricultural salary of the region and were imposed on the model as a constraint. At the end of each period, farmers could increase their level of consumption by using a proportion of the disposable income generated.

A proxy of the marginal propensity to consume was estimated based on time-series aggregated family disposable incomes and consumption expenditures for Portugal. The use of aggregate data instead of cross-section data for the agricultural household has the disadvantage of the value obtained being an average for all Portuguese families which does not take into consideration the particularities and different patterns of consumption and expenditures of agricultural households. It also has the disadvantage of allowing marginal consumption to fluctuate sharply when changes in income occur, not yielding a marginal consumption rate for different levels of income.

Data for the period 1960 - 1990 in the following variables - disposable income, private consumption and population - was used to estimate the marginal propensity to consume. Consumption was defined as a function of income through the following relationship:

$$C_t = \alpha + \beta\, Y_t + u_t \qquad (6.5)$$

where C_t = consumption per capita
Y_t = income per capita
β = marginal propensity to consume
u_t = disturbance term

Initial estimation of the consumption equation by ordinary least squares allowed the detection of the presence of autocorrelation using the Durbin-Watson and the Lagrange Multiplier (LM) tests. An autoregressive form was estimated based on equation 6.6

$$u_t = \theta_1 u_{t-1} + \theta_2 u_{t-2} + ... + \theta_p u_{t-p} + \varepsilon_t \qquad (6.6)$$

and the order of the autoregressive equation was defined by an LM test on the error term of ordinary least squares estimation. The result of the LM test allowed us to conclude that the coefficients of the lagged error term were significant at order two. The method used to estimate the consumption function in its autoregressive form was the Cochrane - Orcutt estimator and the results are presented in Table 6.9.

Table 6.9 - Estimates of the Marginal Propensity to Consume with AR(2) Processes

Estimation Periods	Intercept	Marginal Propensity	R Square	DW-Statistic	Significance Levels θ_1	θ_2
1960-1990	29698.7 (3.38)	0.61731 (9.30)	0.98	1.91	0.0001	0.030
1965-1990	36670.8 (1.89)	0.58329 (6.43)	0.97	1.88	0.0001	0.026
1970-1990	40368.9 (1.59)	0.56719 (5.06)	0.97	1.89	0.0001	0.006

( ) t Ratio

The results show that the marginal propensity to consume is between 56 and 61 percent and it was assumed for the different models that farmers will have a marginal propensity to consume of 60 percent of the positive income generated each year.

Funds available for the next period was determined by the following equations

General Costs of Animal and Crop Activities + Buying Inputs + Hiring Activities + Renting Activities + Depreciation + Interest on Long Term Loans

- Interest on Long Term Deposits - Selling Activities - Subsidies to Input and Activities + Farmer Fixed Expenditures + Taxes

- Short Term Loans + Short Term Deposits + Returns to Capital and Management $\leq$ 0

Returns to Capital and Management + Depreciation - Principal Repayment $\geq$ Cash Available (Disposable Income) at end of Period

Cash Available at end of Period *(1 - Marginal Consumption) + Long Term Deposits _ Cash Transferred to Next Period

Income transfer to the next period could be interpreted as the ability of the farmer to accumulate investment capital and could be seen as the farmer long term goal in the multiperiod programming model. Besides the fixed consumption that was imposed on the model as a constraint, the model allowed a marginal consumption activity based on the marginal propensity to consume, estimated above, and as result of considering present and future consumption as farmers' goals, the objective function to be maximized was the sum of net present values of annual disposable income and terminal net worth.

6.5 - SELECTION AND CHARACTERISTICS OF FARMS STUDIED

The empirical model described in the last section was applied to individual farms belonging to the four farming systems selected in Chapter IV, Intensive (IS) semi-intensive (SIS), Extensive (ES) and Poor Land (PLS). The selection of individual farms was made using only the RICA sample for 1988, because at the time this task was performed, this was the only RICA data set available. Variations in production, cost and economic structure as well as differences growth rates and efficiency levels occur for different farm sizes as shown in chapters IV and V. Also as already noted in sections 3.2.2, 3.3 and 6.3 small and medium size classes are important not only in terms of number of farms but also in terms of agricultural GDP generated. To consider the differences by farm size, the sample of farms was divided by farming system into the following three farm size classes: 0 - 50 hectares (small farms), 51 - 200 hectares (medium farms) and greater than 201 (large farms) already used in chapter III, when the farm structure was characterized and in chapter IV when the farming systems were characterized by farm size classes.

6.5.1 - Methodology

The methodology to select the farms to be studied was canonical discriminant analysis. Canonical discriminant analysis is a multivariate statistical technique used to separate m groups being compared based on a set of selected variables X_1 , X_2 ,..., X_k by determining a set of linear combinations Z_1 , Z_2 , ..., Z_p of the X variables

$$Z_i = \alpha_1 X_1 + \alpha_2 X_2 + ,..., + \alpha_k X_k.$$

The linear functions Z_i are called canonical discriminant variables, while the coefficients α_1, α_2 ,..., α_k, called canonical coefficients or weights are calculated in such a way that the F ratio for a one way analysis of variance is maximized (Hand, 1987).

The maximum number of canonical variables (Z_i) is the minimum of: 1) the number of variables and 2) the number of degrees of freedom in the comparison (the number of groups or systems minus one). The first canonical variable, Z_1 , gives the maximum possible F ratio on a one way analysis of variance for the variation within and between groups. The second canonical variable, Z_2, gives the maximum possible F ratio on a one way analysis of variance subject to the condition that Z_1 and Z_2 are uncorrelated. Summarizing, Z_i is a linear combination of the selected quantitative variables, for which the F ratio on a one way analysis of variance is maximized, subject to the fact that Z_i is not correlated with Z_1, Z_2, ... , Z_p. The canonical variables are linear combinations of the selected variables in such a way that Z_1 discloses the group differences as much as possible, Z_2 captures the group differences not displayed by Z_1 , as much as possible, and so on. The group composed by the first canonical variables is the best possible set that discloses the between-group difference pattern (Manly,1986).

The X variables used were a set of production, cost, product and profitability indicators derived for the 1988 RICA sample of farms and the m groups were the four farming systems being analyzed in this study. The selection of indicators followed a two-stage procedure that consisted of the removal of the variables with high correlation and of a final selection of the variables that had a higher contribution in separating the farming systems based on a stepwise discriminant analysis. After this procedure the indicators selected were: agricultural area, oilseeds area/agricultural area, cropped area/agricultural area, sheep livestock units/agricultural area, cow livestock units/agricultural area, investment, family labour/total labour, total labour/agricultural area, fertilizer costs/agricultural area, seeds costs/agricultural area, livestock costs/agricultural area, operating costs/total costs, land costs/total costs, labour costs/total costs,livestock costs/total costs, general cost/total costs, total costs/agricultural area crop product/total product, other product/total product, return to family labour/agricultural area, return to total labour, profit/agricultural area, total product/total costs (input profitability). Then these selected indicators were used to evaluate the differences among the four farming systems using canonical discriminant analysis. The mean value of the canonical discriminant functions (Z) were used as a measure of the relative distance among the four farming systems being compared and the farms that were closer to each farming system canonical discriminant function's mean were chosen to be studied.

6.5.2 - Selection of Farms

The results of the canonical discriminant analysis performed are displayed in Table 6.10 and show that the three canonical variables were only significant when all observations were considered; the second canonical variable was only significant for medium farms and the first canonical variable was significant in all situations.

Table 6.10 -Likelihood Ratio Test, Proportion and Means of Canonical Variables by Area Classes

Item	All Observations			Small Farms			Medium Farms			Large farms		
	Can1	Can2	Can3	Can1	Can2	Can3	Can1	Can2	Can3	Can1	Can2	Can3
Likelihood Ratio												
	0.0001	0.0001	0.004	0.008	0.29	0.73	0.0001	0.01	0.50	0.08	0.56	0.56
Proportion of Canonical Variables												
	59.6	25.9	14.5	59.4	28.2	12.4	50.8	35.9	13.2	66.4	18.6	14.9
Canonical Systems Mean												
IS	2.0	-0.4		2.4	-0.2	-0.2	0.5	2.3	-0.5	2.3	-0.7	2.7
SIS	-0.2	-0.2		-1.3	-1.2	0.4	0.1	0.1	1.0	2.4	0.4	-0.8
ES	-1.2	-0.6		-1.5	0.7	-1.5	-1.5	-0.4	-0.4	-2.3	-1.8	-0.5
PLS	-0.1	1.2		-0.5	2.0	0.9	1.5	-0.9	-0.4	-2.7	1.7	0.4

In all classes considered, the first canonical variable explained more than 50 percent of the differences between the different farming systems. The variables with a higher contribution in discriminating among the four farming systems were the ones that showed higher standardized canonical coefficients for the first canonical variables, because they account for the majority of the difference observed among the four systems. The standardized canonical coefficients were chosen because they are not affected by any arbitrary choice of units used. The variables that showed a standardized canonical coefficient greater than one are displayed in Table 6.11. The variables related to the farm cost and production structure were the ones with a higher contribution in differentiating the four systems. With standardized canonical coefficients between 0.5 and 1, some profitability indicators were also important in differentiating among medium farms as well as additional cost indicators for small and large farms.

Table 6.11 -Variables with Higher Contribution in Differentiating the Farming Systems

Area Class	Variables
All Observations	Crop Product/Total Product, Return to Labour, Total Labour/A.A., Livestock Costs/ A.A. and Total Cost/A.A.
Small Farms	Operating Costs/Total Costs, Crop Product/Total Product, Total Labour/A.A., Livestock Cost/A.A., Labour Cost/Total Cost and Total Cost/A.A.
Medium Farms	Operating Costs/Total Costs, Crop Product/Total Product, Livestock Cost/A.A., Total Costs/A.A.
Large Farms	Operating Cost/Total Cost, Input Profitability, Cows/A.A:, Total Labour/A.A., Profit/A.A., Seeds Costs/Agricultural Area, Cropped Area/A.A., Return to Family Labour, Labour Costs/Total Costs, Total Cost/A.A.

To visualize the relative distance among the farming systems, Figure 6.4 to 6.6, show the position of each farming system based on their mean values for the first two canonical variables. With respect to the small and large farms, the first canonical variable has similar values for the semi-intensive and extensive systems (Figure 6.4) and for the intensive and semi -intensive systems (Figure 6.6) respectively, while for medium farms the four agricultural systems are well separated when analyzed in terms of the first two canonical variables (Figure 6.5). The combination of the above information for small and medium farms with the fact that the second canonical variable was not significant, allowed us to aggregate for future analysis the semi-intensive and the extensive systems for small farms, and the intensive and semi-intensive systems for the large farms. An additional simulation was made, excluding from the analysis those farms which were specialized in permanent activities, such as olive oil and wine, and the results confirmed the aggregation chosen.

Each agricultural system can be represented by its mean value of the first two canonical variables, the ones which have a higher explanation power and significance level. The farms that better represent each one of the different farming systems are the ones with canonical values closer to the mean canonical values of its farming system, and this was the procedure used to select the farms for each farming system. In some cases, the original farms selected and closer to the system's canonical mean, had to be abandoned because their cooperation with the farm accounting system had ended at the time of the farm interviews. Several attempts were made to choose a small farm for the combined semi-intensive and extensive system. However, each attempt met with difficulties, and as a consequence this category was dropped from subsequent analysis. Figures 6.7 to 6.15 show for each farming system and area class the 9 farms selected.

After the selection of farms, interviews were undertaken with each farmer to complement the accounting RICA data about each farm with more detailed information regarding the aspects related to the structure of production, levels of capital employed and technologies used. The interviews were conducted during 1991 and 1992.

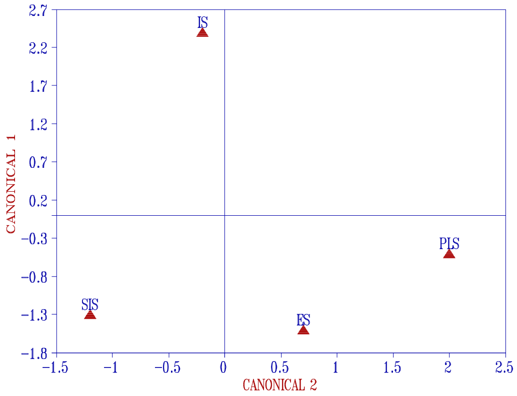


Figure 6.4 - Farming Systems Canonical Means for Small Farms

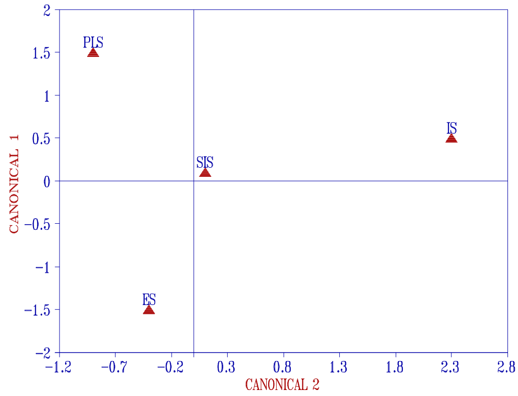


Figure 6.5 - Farming Systems Canonical Means for Medium Farms

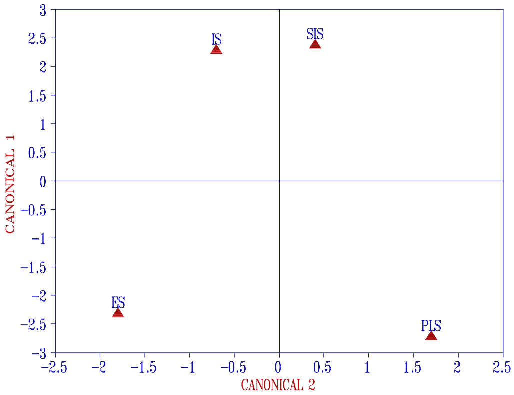


Figure 6.6 - Farming Systems Canonical Means for Large Farms

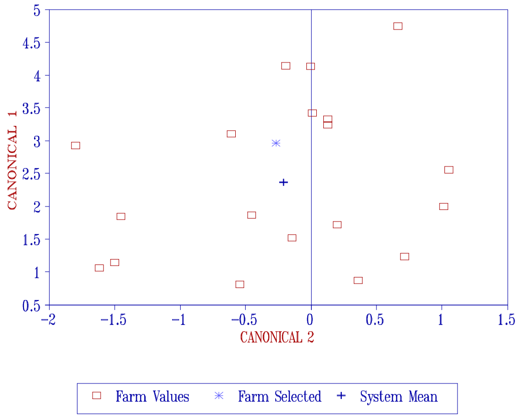


Figure 6.7 - Selection of Small IS Farm

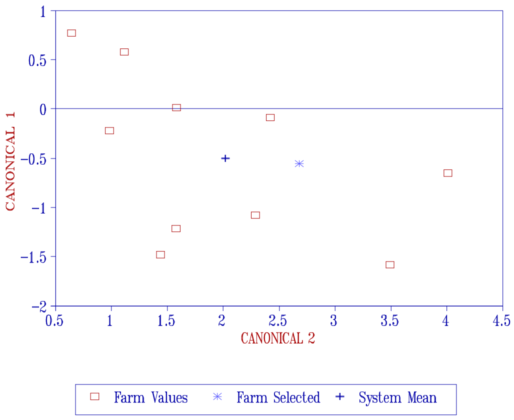


Figure 6.8 - Selection of Small PLS Farm

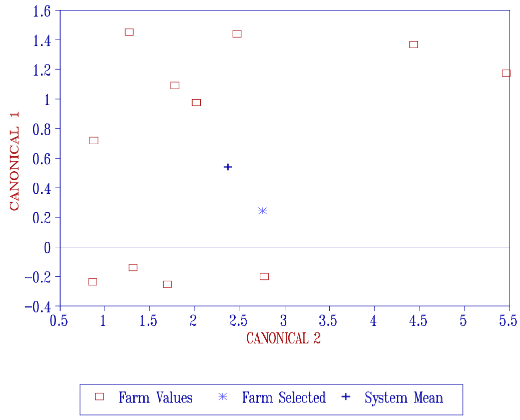


Figure 6.9 - Selection of Medium IS Farm

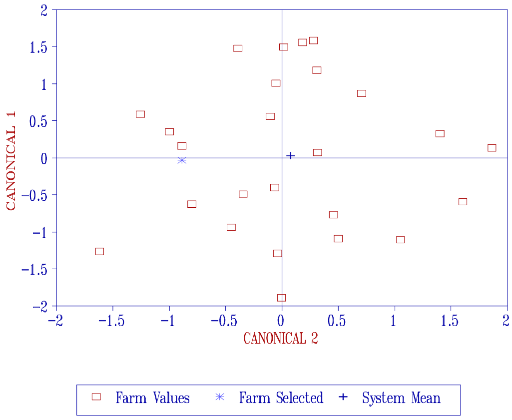


Figure 6.10-Selection of Medium SIS Farm

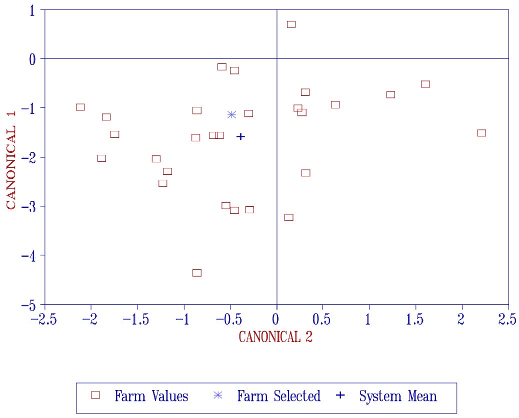


Figure 6.11 - Selection of Medium ES Farm

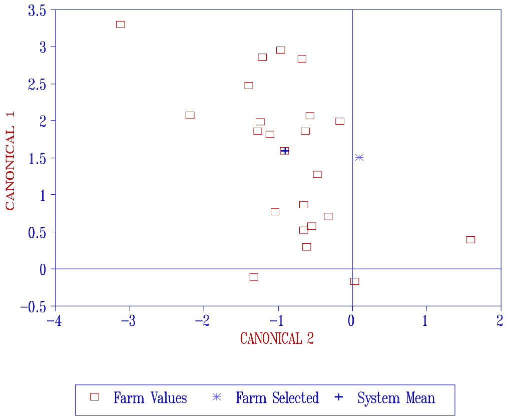


Figure 6.12 - Selection of Medium PLS Farm

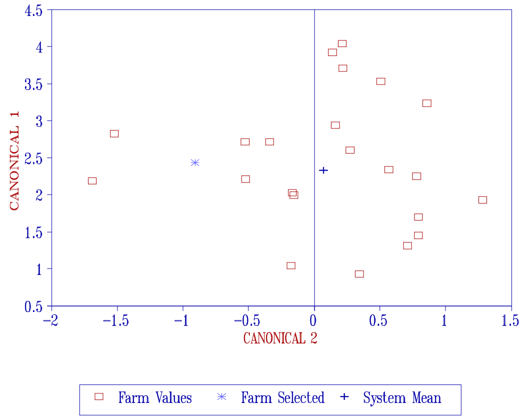


Figure 6.13 - Selection of Large IS-SIS Farm

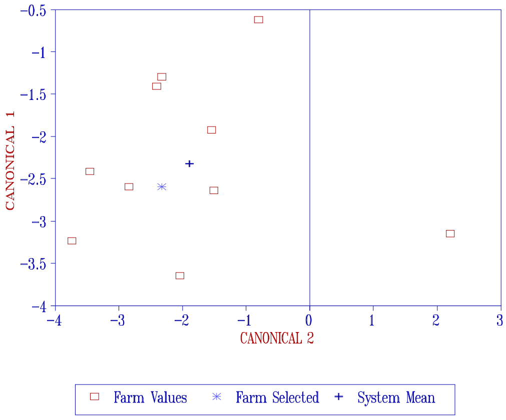


Figure 6.14 - Selection of Large ES Farm

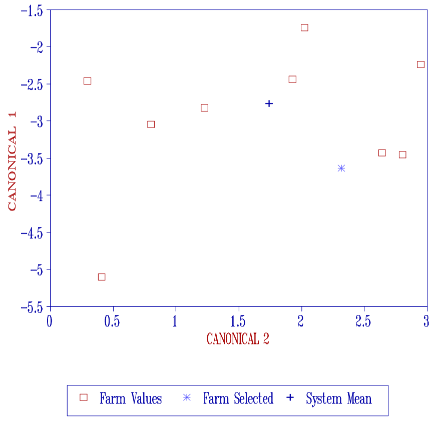


Figure 6.15 - Selection of Large PLS Farm

6.5.3 - Characteristics of Farms Selected

Table 6.12 summarizes some of the features of the 9 farms selected and to be analyzed with the application of the empirical model developed in section 6.4. With respect to small farms, the IS-S farm has an area of around 15 hectares, in which 6 hectares can be irrigated. The main crop activities have been tomatoes and melon in the irrigated area and sunflower and wheat in the dryland area. These crop activities are complemented with an sheep herd with a reasonable dimension due to short term renting of pasture land. The PLS-S farm with an area of around 38 hectares is characterized by a dryland rotation of cereals and natural pasture, which was complemented after 1988 with a small herd of sheep.

Regarding the medium farms, the IS-S farm with an area of 54 hectares, shows a dryland rotation based on wheat and sunflower which is complemented by a sheep herd while the SIS-M farm is characterized by a dryland rotation of cereals and natural pastures and a sheep herd. The ES-M farm is a cattle specialized farm with a small sheep herd in which the crop activities are dominated by dryland forage production and with a small irrigated forage area of two hectares. The PLS-M farm is characterized by a dryland rotation of cereals and natural pasture complemented by sheep activities and cattle after 1988.

With respect to large farms, the IS-L is a typical specialized dryland cereal farm without livestock activities, in which the rotations are based on wheat, sunflower and barley, the ES-L farm is a typical extensive farm based on natural pastures and sheep, while the PLS-L farm is a mixed cereal-sheep farm in which the dryland rotations are based on cereals, forages and natural pastures.

Permanent crops are represented in the PLS-S, SIS-M, ES-M, IS-L, ES-L and PLS-L by olive trees and in the PLS-S and PLS-L by vineyards. Family labour is predominant in the IS-S, PLS-S, IS-M, SIS-M, PLS-M, ES-L farms while the majority of the labour is hired for the ES-M, IS-L and PLS-L. All farms have their own tractor power and basic equipment for the majority of the operations required for the crop activities, with exception for the cereal harvester which is rented for the IS-S, I-M, ES-M, PLS-M, ES-L and PLS-L. The cereal harvesters that belong to the PLS-S and SIS-M farms are hired out which is an important source of income.

Table 6.12 - Main Characteristics in 1988 of the Farms Selected

Indicators	Small Farms		Medium Farms				Large Farms		
	IS-S	PLS-S	IS-M	SIS-M	ES-M	PLS-M	IS-L	ES-L	PLS-L
Agricultural Area Ha.	15.3	38	54.5	73	150.5	155	286	339.4	344
Irrigated Area Ha.	6	0	0	0	2	0	0	0	0
Cereals Area %	29	86	57	58	13	30	73	0	23
Olive Tree Area %	0	12	0	30	3	0	5	5	10
Cow Number	0	0	0	0	86	0	0	0	0
Sheep Number	373	0	41.3	13.5	47.8	97	0	132	425
Total Labour L.S.U.	2.6	1.5	1	2	4.2	1.1	5	3.3	12.4
Hired Labour %	9	34	0.0	50	72	11	80	39	97
Operating Capital %	100	48	100	42	93	100	34	77	24
Long Term Loans %	61	0	0	0	0	100	100	100	35
Investment - 1988 1,000 Esc.	523	1302	4356	0	4986	0	0	0	2982
Crop Product %	18	89	82	82	22	63	80	7	71
Livestock Product %	42	2	11	13	78	21	0	84	18
Variable Costs/A.A.1,000 Esc.	62	85	38	16	20	10	47	4	34
Fixed Costs/A.A. 1,000 Esc.	60	30	23	15	18	2	34	4	29.5
Agri. Product/A.A. 1,000 Esc.	293	71	56	25	103	20	58	45	55

6.6 - MODEL VERIFICATION

In this section a comparison of the results obtained for each one of the models developed for the nine farms selected with the data observed in reality is made in order to choose the models that will be adopted in the next section. In general, models are always a simplification of reality, in which assumptions are made, simplifications imposed, data collection limitations accepted, and some quantitative and qualitative decisions made by the decision-maker remain unknown to the researcher or difficult to include in the model. These limitations cause a deviation of model results from reality, and thus there must be a subjective judgment of whether or not a model could be accepted as a good representation of reality.

For our models several assumptions were made that could explain some of the deviations of the model results from reality. These were:

-the input and output data used in the model were based on interviews with farmers and on the production structure and capabilities of each farm, and on regional data available both in the Regional Statistics and Regional Agriculture Service. RICA data was not used explicitly to generate input-output coefficients, because its level of aggregation was unable to produce input-output coefficients to satisfy the demands of the model structure adopted.

-the models built took into consideration several cost items that sometimes farmers do not incur or do not have every year, such as insurance for buildings, insurance for cereals, provision for repairs and maintenance of building, machinery and equipment and social security payments for hired labour. The model also included an estimation of the cost of using the equipment needed by the different activities and not owned by farmers. For some farmers and some type of equipment no cost is incurred, because equipment is borrowed from family, friends or

neighbours. The occurrence or not of these items in the year of comparison could partially explain some of the variation observed between model results and reality.
-crop activities were assumed to follow a pattern that was dictated by the rotations reported by the farmers. However, the values reported by RICA and the ones obtained by the model differ slightly regarding the area occupied by the different crops and this difference will have an effect on the operating costs and revenues.
-with respect to total revenues, the model considered the possibility of selling livestock output in the best selling periods which for some farms could differ from reality. Also the output level for the crop activities was based on average values and could not correspond to the values observed for a particular year. These reasons could explain some of the variation between model and observed total revenues.

It is believed that the model structure described in section 6.4 to represent the four farming systems under analysis, among the alternatives available, represents closely the reality and responds to the objectives of the research undertaken in this Chapter. The comparison of the models results with the data observed in reality was made for 1988/89, in which farmers' performance in terms of resource use and financial results reported by RICA was compared with model results.

Table 6.13 compares the model results for the farms selected with the RICA observed values, where the model results are expressed as percentage deviation from the values observed in reality. The values of -100 per cent are relate to those situations in which the model result was 0, while the value of 100 per cent correspond to those situations in which the RICA observed value was 0. The last row reports the percentage absolute deviation (PAD) for each model. The PAD excludes cultivated area and returns to capital and management since the differences regarding these items are already captured in the crop area, and cost and revenue items. Hazell and Norton (1986) claim that PAD values below 15 percent are acceptable, which in our case would lead to accept six of the models built and reject the SIS-S, PLS-S and PLS-M models. However, for these models, if one excludes the differences in the area of forages reported (2, 2.5 and 3 hectares reported by RICA, respectively) and for the PLS-M the difference in the depreciation cost (RICA reported value of 0), the PAD values decrease to 12.5, 14.0 and 7.3 respectively, which would lead to acceptable PAD values for these three models.

Considering that our models will be used to predict farm behaviour over time, an additional verification procedure for another year would have been preferred to test the model behaviour when prices changes are introduced. However, at the time the only RICA data available was for 1988/89.

Table 6.13 -Comparison of the Model Results with Observed Data for the Farms Selected in 1988/89

	SMALL FARMS				MEDIUM FARMS								LARGE FARMS				
	IS		PLS		IS		SIS		ES		PLS		IS-SIS		ES		
	88/89	Model	88/89	Model	88/89	Model	88/89	Model	88/89	Model	88/89	Model	88/89	Model	88/89	Model	88/8
ture (88/89 - Area in Hectares and Labour in Labour Standard Units (LSU) and Model - Percentage Deviation from 88/89)																	
	11.1	-6.3	41.5	-8.4	54	-5.4	68.5	-33.6	70.5	-7.2	46	-15.7	214	-1.9	22	-4.5	260.
es	0.8	25.0							2	0.0							30
	5.3	-11.3	27	-3.7	27	-11.1	43.5	-41.4	33.5	-15.8	43	-9.8	171	0.0			118.
	3	56.7			24	0.0							30	-53.3			32.3
	2	-100.0	2.5	-100.0	3	3.3			30	0.7	3	-100.0			14	-7.1	30.4
			12	0.0			22	0.0	5	0.0			10	0.0	8	0.0	36
																	13
asture									41	-2.4							50
nted in	600	0.0															
	300	0.0	6.2	-3.2	43	-7.0	27.3	-1.1	42	-4.8	50	0.0			151	-0.7	435
									86	2.3							
	2	0.0	1	0.0	1	0.0	1	0.0	1	0.0	1	0.0	0.5	0.0	2	0.0	0.3
	1.2	-16.7	0.3	66.7	0.2	-100.0	1	30.0	2.9	-31.0			3.2	-6.3	1.3	-23.1	11.8
00 EScudos)																	
	2945	7.8	3054	-15.1	3264	0.0	2531	16.3	6911	1.3	2599	7.2	19842	-4.3	1510	-9.6	1817
sts	546	-12.5	783	-17.6	676	12.6	1063	-4.4	1102	21.9	0	100.0	4371	-8.4	367	8.4	2014
	3491	4.6	3837	-15.6	3940	2.1	3594	10.2	8136	2.6	2599	18.3	24213	-5.1	1877	-6.1	2019
	4525	2.8	2701	4.5	5247	4.0	4516	2.3	17951	-32.5	3276	8.5	19788	33.8	1541	9.3	2105
al and	1034	-3.3	-1133	-63.4	1300	10.3	922	-28.5	9938	-62.0	677	-29.2	-4425	-178.9	-336	-76.5	863
		19.8		22.6		14.0		11.7		8.9		30.5		12.4		7.1	

The first Column shows the actual outcome reported in 1988/1989, whilst column 2 shows the percentage variation of the model reults compared with the actual 1988/89 outcome.

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6.7 - SCENARIOS CONSIDERED

The analysis of the evolution and growth of the farms belonging to the farming systems selected was undertaken for the period 1992-2000, and two basic scenarios were considered. The first scenario analyzed farm evolution considering that average farm technology and size was equal to that observed during the period 1988/1989 and thus assumed that no opportunities for farm growth was available. The second scenario analyzed farm evolution considering the introduction of improved technologies and new activities, the expansion of each farm's production capacities, and consequently assumed opportunities for growth. This second scenario is justified by the conclusions reached in the previous chapter in which there was room to improve the technical and scale efficiency of Alentejan farms and also in the planning and management techniques used in each farm. The individual levels of technical efficiency of the nine farms studied are not reported here since some of them were not in the panel used in chapter V.

The alternative crop and livestock activities considered are summarized in Tables 6.14 and 6.16, crop yields considered are shown in Table 6.15, while opportunities for growth took in consideration the investment subsidies shown in Table 6.17. Each of the above basic scenarios was evaluated for the prices and subsidy levels that resulted from the rules agreed for the second stage of the transition period and 1992 CAP reform and shown in Tables 6.18, 6.19, 6.20 and 6.21.

With respect to inputs, prices were considered constant at the 1992 level, with exception of labour and feedstuffs. The wage rate was increased by 1.5 percent per year in real terms and this was based on the assumption made by Fox (1987), while the price of feedstuffs was assumed to decrease 15 percent over three years reflecting the fall in price of cereals (Wallace and Kirke, 1993).

Regarding the adoption of the new and improved technologies, they were considered available for all farmers at the beginning of 1993 and for all the subsequent years of the model. This option, although it may be considered controversial, simplifies the model structure and leaves to the model the opportunity to choose the best timing to change or introduce new technologies and activities. As a result of this assumption, it was further assumed that farmers' management skills were able to respond from 1993 on, to the needs required by the improved technologies and activities considered.

The two basic scenarios defined above to compare Alentejan farm evolution during the period 1992 -2000, in which the first scenario assumes the maintenance of farm technology and size equal to that observed during the period 1989-1992, and the second scenario considers the introduction of improved technologies and new activities and growth through the expansion of farms' production capacity, set an upper and a lower bound for farm evolution, considering the economic, technical and model assumptions. With these assumptions in mind, some of the farms analyzed will probably develop a path of evolution that will balance between those two scenarios, while others will find a different way for survival and probably not analyzed in this study.

Departing from the second basic scenario, additional model results were obtained for each farm considering the abolition of all direct subsidies, the introduction of minimum tillage techniques, the non-adoption of the set-aside condition and a reduction of 15 percent on sheep prices between 1993 and 1995.

With respect to increases in farm size through renting or buying more land, specific simulations were not performed for each farm. However, for the IS-S farm, short term land renting was considered because this was a practice that has been followed by that farmer. When the farmer interviews were made, the general opinion from them, was that it was not easy to rent additional land and one of the reasons pointed out was the persistence of some remaining tensions that the process of agrarian reform has created in the region, regarding land ownership. Although increases in area were only tested for one farm, the range of farm sizes considered along with he analysis of the shadow land price, could help us to make some indirect judgements, principally for small and medium farms, about their development if farm size was allowed to increase.

Table 6.14 - Alternative Crop Rotations and Activities Considered for Each Farming System

IS	SIS
IRRIGATED ROTATIONS Tomatoes - Melon Tomatoes - Wheat Tomatoes - Barley Vicea*Oats - Maize - Tomatoes - Wheat DRYLAND ROTATIONS Fallow*sunflower - Wheat Fallow*Chick Peas - Wheat Fallow*Broad Beans -Wheat Fallow*Sunflower - Wheat - Wheat Fallow*Chick Peas - Wheat - Wheat Fallow*Broad Beans - Wheat - Wheat Fallow*Sunflower - Wheat - Barley Fallow*Chick Peas - Wheat - Barley Fallow*Broad Beans - Wheat - Barley	DRYLAND ROTATIONS Fallow*Sunflower - wheat - Oats - Natural Pasture Fallow*Sunflower - Triticale - Barley - Natural Pasture Fallow - Wheat - Oats - Vicea*Oats Fallow - Wheat - Oats - Lupines*Oats Fallow - Wheat - Barley - Natural Pasture Fallow - Sunflower - Wheat - Barley - Natural Pasture Fallow - Chick Peas- Wheat - Barley - Natural Pasture Fallow - Wheat - Oats - Natural Pasture Fallow - Sunflower - Wheat - Oats - Natural Pasture Fallow - Chick Peas- Wheat - Oats - Natural Pasture Fallow - Wheat - Vicea*Oats - Natural Pasture Fallow - Wheat - Lupines*Oats - Natural Pasture Subterranean Clover - (5 Years) - Wheat Subterranean Clover - (5 Years) - Oats
ES	**PLS**
DRYLAND ROTATIONS Fallow - Oats - Vicea*Oats - Natural Pasture Fallow - Oats - Lupines*Oats - Natural Pasture Fallow - Oats - Vicea*Oats - Natural Pasture (2 Years) Fallow - Oats - Lupines*Oats - Natural Pasture (2 Years) Fallow - Wheat - Oats - Natural Pasture (3 years) Fallow - Wheat - Vicea*Oats - Natural Pasture (2 Years) Fallow - Wheat - Lupines*Oats-Natural Pasture (2 Years) Fallow - Triticale - Vicea*Oats - Natural Pasture Fallow - Triticale - Lupines*Oats - Natural Pasture Fallow - Triticale - Vicea*Oats -Natural Pasture (2 Years) Fallow - Triticale - Vicea*Oats -Natural Pasture (2 Years) Fallow - Oats - Vicea*Oats - Triticale - Natural Pasture Fallow - Oats - Lupines*Oats - Triticale - Natural Pasture Subterranean Clover (5 years) - Wheat - Vicea*Oats Subterranean Clover (5 years) - Wheat - Lupines*Oats Subterranean Clover (5 years) - Oats -Vicea*Oats Subterranean Clover (5 years) - Oats - Lupines*Oats Subterranean Clover (5 years) - Wheat Subterranean Clover (5 years) - Oats	DRYLAND - ROTATIONS Fallow - Oats - Natural Pasture (2 Years) Fallow - Barley - Natural Pasture (2 Years) Fallow - Triticale - Natural Pasture (2 Years) Fallow - Wheat - Natural Pasture (3 Years) Fallow - Wheat - Vicea*Oats - Natural Pasture (2 Years) Fallow - Wheat-Lupines*Oats - Natural Pasture (2 Years) Fallow - Wheat - Oats - Natural Pasture (2 Years) Subterranean Clover (5 Years) - Vicea*Oats Subterranean Clover (5 Years) - Lupines*Oats Subterranean Clover (5 Years) - Wheat Subterranean Clover (5 Years) - Oats

Table 6.15 - Yield Levels for Alternative Crop Activities

Items	Farms				
	IS-M IS-L	IS-S	SIS-M	ES-M PLS-L PLS-L	ES-L PLS-S PLS-M
Irrigated Activities (Kilograms)					
Tomatoes	42000	42000			
Melon	12000	12000			
Maize	8000	8000			
Dryland Activities (Kilograms)					
Wheat 1 Year	3500	3000	2200	1800	1400
Wheat 2 Year	3000				
Barley	3000	2800	2200	1850	1500
Barley After Wheat	3000	2200	2000		
Oats			2000	1700	1400
Triticale			2300	1950	1600
Broad Beans	2400				
Chick Peas	750	750	500		
Sunflower	950	950	600		
Forages and Pastures (Kilograms of Dry Matter)					
Maize Silage	9315	9315			
Fallow	813	697	581	465	349
Natural Pasture 1 Year	1162	996	830	664	498
Natural Pasture 2 Year	1328	1162	996	830	664
Natural Pasture 3 Year	1494	1328	1162	996	830
Vicea*Oats Pasture	3510	3128	2702	2560	2417
Vicea*Oats Hay	4250	3740	3230	3060	2975
Vicea*Oats Silage	4860	4277	3694	3499	3229
Lupines*Oats Pasture	2948	2594	2358	2122	2004
Lupines*Oats Hay	2620	2306	2096	1886	1782
Lupines*Oats Silage	2625	2310	2100	1890	1680
Subterranean Clover 1 Year			2592	2203	1944
Subterranean Clover other Years			3240	2754	2430

Table 6.16 - Alternative Animal Technologies

Sheep Technology 1	Sheep Technology 2
Birth per Year - One Fertility Rate - 85 % Prolificity Rate - 115 % Mortality Rate Adults - 2 % Mortality Rate Youngsters - 4 % Mortality Rate Youngsters (Summer) - 6 % Substitution Rate - 15 % Females First Birth - One Year Old Rate Male/Female - 1/30	Birth per Year - One Fertility Rate - 90 % Prolificity Rate - 120 % Mortality Rate Adults - 2 % Mortality Rate Youngsters - 4 % Mortality Rate Youngsters (Summer) - 6 % Substitution Rate - 17 % Females First Birth - One Year Old Rate Male/Female - 1/30
Sheep Technology 3	Cattle Technology
Birth per Year - One and Half Fertility Rate - 85 % Prolificity Rate - 120 % Mortality Rate Adults - 5 % Mortality Rate Youngsters - 6 % Substitution Rate - 20 % Females First Birth - One Year Old Rate Male/Female - 1/25	Fertility Rate - 80 % Prolificity Rate - 100 % Mortality Rate Adult - 2 % Mortality Rate Youngsters - 2 % Substitution Rate - 12.5 % Rate Male/Female - 1/40 Females First Birth - 2 Years Old
Fattening Lambs	Fattening Calves
Fattening 1 - 25 Kilos - 4 Months Fattening 2 - 30 Kilos - 5 Months Fattening 3 - 25 Kilos - 3 Months Fattening 3 - 30 Kilos - 4 Months	Fattening 1 - 200 Kilos - 6 Months Fattening 2 - 400 Kilos - 18 Months Fattening 3 - 500 Kilos - 24 Months

Table 6.17 - Capital Investment Subsidies

Item	Investment subsidies (Percentage)
Land Improvements	45
Buildings	45
Permanent Crops	45
Livestock	30
Machinery and Equipment	30

Table 6.18 - Crop Prices and Production Aids for the Period 1992-2000

Item	1992	1993	1994	1995	1996	1997	1998	1999	2000
	(Escudos per Kilo)								
Wheat Price	34.8	24.5	22.6	21.0	21.0	21.0	21.0	21.0	21.0
Production Aid	21.4	19.7	17.8	15.8	13.8	11.8	9.9	7.9	5.9
Barley Price	33.0	24.5	22.6	21.0	21.0	21.0	21.0	21.0	21.0
Production Aid	14.7	13.5	12.2	10.8	9.5	8.1	6.8	5.4	4.1
Maize Price	34.8	24.5	22.6	21.0	21.0	21.0	21.0	21.0	21.0
Production Aid	11.3	10.5	9.4	8.4	7.3	6.3	5.2	4.2	3.1
Sorghum Price	33.0	24.5	22.6	21.0	21.0	21.0	21.0	21.0	21.0
Production Aid	9.8	9.0	8.1	7.2	6.3	5.4	4.5	3.6	2.7
Durum Wheat Price	47.0	24.5	22.6	21.0	21.0	21.0	21.0	21.0	21.0
Wine[a] Price	79	79	79	79	79	79	79	79	79
Olive Oil[a] Price	409	409	409	409	409	409	409	409	409
Production Aid	109	133	133	133	133	133	133	133	133
Sunflower Price	34	34	34	34	34	34	34	34	34
Field Beans Price	105	105	105	105	105	105	105	105	105
Chick Peas Price	130	130	130	130	130	130	130	130	130

[a] Escudos per Litre

ble 6.19 - Crop and Set-Aside Subsidies per Hectare

Item	Farming System			
	IS	SIS	ES/PLS	ES/PLS
Subsidy per Hectare 1993 (1,000 Escudos)				
Dryland Cereals	15.71	12.57	7.33	5.24
Dryland Sunflower	58.95	47.16	27.51	19.65
Irrigated Cereals	41.90	26.19	15.71	0.00
Irrigated Sunflower	157.21	98.26	58.95	0.00
Protein Crops1 (Small Producer)	15.71	12.57	7.33	5.24
Subsidy per Hectare 1994 (1,000 Escudos)				
Dryland Cereals	22.00	17.60	10.27	7.33
Dryland Sunflower	58.95	47.16	27.51	19.65
Irrigated Cereals	58.67	36.67	22.00	0.00
Irrigated Sunflower	157.21	98.26	58.95	0.00
Protein Crops1 (Small Producer)	22.00	17.60	10.27	7.33
Subsidy per Hectare 1995-2000 (1,000 Escudos)				
Dryland Cereals	28.29	22.63	13.20	9.43
Dryland Sunflower	58.95	47.16	27.51	19.65
Irrigated Cereals	75.43	47.14	28.29	0.00
Irrigated Sunflower	157.21	98.26	58.95	0.00
Protein Crops1 (Small Producer)	28.29	22.63	13.20	9.43
Subsidy per Hectare 1995-2000 (1,000 Escudos)				
Dryland Sunflower (Small Producer)	57.65	46.12	26.91	19.22
Irrigated Sunflower (Small Producer)	153.74	96.09	57.65	0.00
Protein Crops1 (General Producers)	40.86	32.69	19.07	13.62
Dryland Set-Aside (General Community)	28.29	22.63	13.20	9.43
Dryland Set-Aside (Specific to Portugal)	22.63	18.10	10.56	7.54
Irrigated Set-Aside (General Community)	75.43	47.14	28.29	0.00
Irrigated Set-Aside (Specific to Portugal)	60.34	37.71	22.63	0.00
Protein Crops2	15.71	15.71	15.71	15.71
Durum Wheat	62.23	62.23	62.23	62.23

Protein Crops1 - Field Beans, Green Peas, Sweet Lupines

Protein Crops2 - Lentils, Chick Peas and Vicea

Table 6.20 - Beef Prices and Premium

Item	1992			1993			1994			1995-2000		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
Prices												
Male Calf [a]	479.6	540.5	485.6	455.6	513.5	461.3	432.8	487.8	438.3	411.2	463.4	416.4
Female Calf [a]	390.8	439.0	379.4	371.3	417.1	360.4	352.7	396.2	342.4	335.1	376.4	325.3
Male Heifer [b]	666.7	728.8	690.9	633.3	692.3	656.4	601.7	657.7	623.6	571.6	624.8	592.4
Female Heifer [b]	652.5	708.0	670.0	619.9	672.6	636.5	588.9	639.0	604.7	559.4	607.0	574.4
Cull Cows [b]	440.0	490.5	431.3	428.0	466.0	409.7	397.1	442.7	389.2	377.2	420.5	369.7
Premiums (Escudos per Head)												
Suckler Cow	10,315			14,667			19,905			25,443		
Extensification	6,286			6,286			6,286			6,286		
Beef	8,252			12,571			15,714			19,905		

[a] Escudos per Kilo of Liveweight and [b] Escudos per Kilo of Carcass

P1 - October-December, P2 - January - May and P3 - June - September

Table 7.21 - Monthly Sheep Prices by Regional Markets and Premium (1992-2000)

Month	Évora		Beja		Elvas	
	Lamb < 25 Kg	Lamb > 25 Kg	Lamb < 25 Kg	Lamb > 25 Kg	Lamb < 25 Kg	Lamb > 25 Kg
Prices (Escudos per Kilo Liveweight)						
January	400.0	386.3	405.0	382.5	395.0	376.7
February	350.0	341.3	357.5	347.5	371.3	358.3
March	310.0	298.8	302.5	290.0	330.0	313.8
April	291.3	272.5	280.0	265.0	285.0	276.7
May	270.0	255.0	270.0	252.5	285.0	272.5
June	277.5	262.5	277.5	257.5	260.0	250.0
July	315.0	292.5	310.0	290.0	293.8	272.5
August	347.5	322.5	340.0	320.0	320.0	296.7
September	392.5	372.5	390.0	370.0	371.3	350.0
October	397.5	377.5	414.1	391.6	395.5	366.9
November	422.5	400.0	425.6	415.3	388.4	383.9
December	385.0	371.3	448.6	427.2	418.8	395.2
Premium (Escudos per Head)						
Sheep	5,037.4					

[a] Escudos per Head

6.8 - RESULTS

The results of the models developed for the 9 farms selected are presented in this section. For the purpose of analysis the 9 farms were divided into two groups. The first group includes the farms belonging to the more intensive farming systems IS-S, IS-M, IS-L and SIS-M farms and in the second group the farms belonging to more extensive farming systems ES-M, ES-L, PLS-S, PLS-M and PLS-L farms. A summary of the basic results obtained from the multiperiod linear programmming models is shown in Appendix III.

6.8.1 - More Intensive Farming Systems

6.8.1.1 - INCOME AND PROFITABILITY

The evolution of disposable income and returns to capital and management for the first scenario, which considers no changes in farm structure and technology, presented in Figures 6.16 and 6.17, shows a general decline of disposable income and returns to capital and management during the period of analysis. Regarding disposable income, small and medium farms show the lower levels with negative values in some years while the IS-L exhibits the better result with a decreasing disposable income but always positive during the period of analysis. The SIS-M farm displays the most adverse results with disposable income dropping to zero and negative values after 1994.

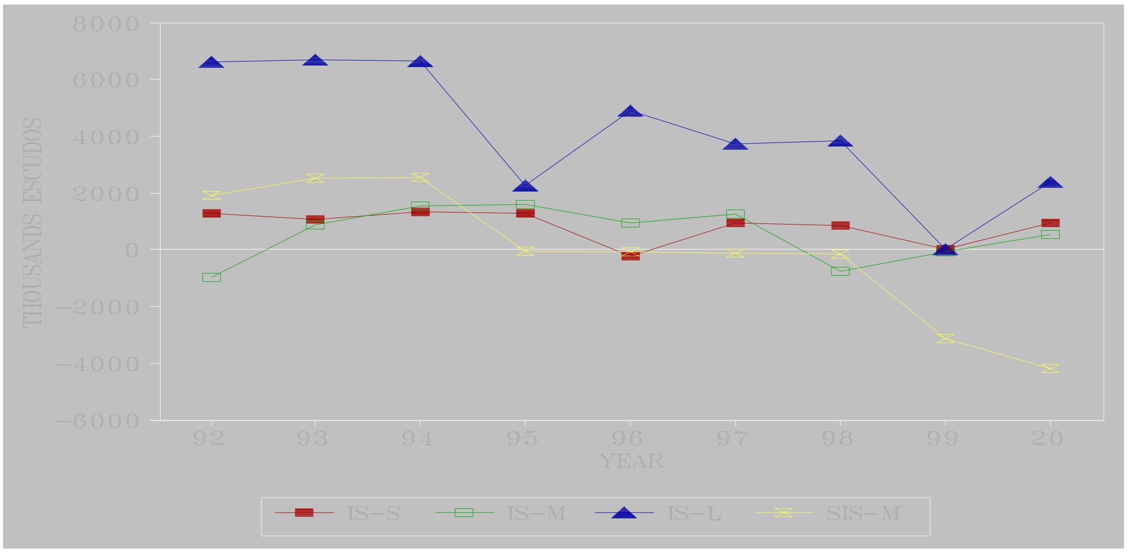

Figure 6.16 - Disposable Income without Technological Change for IS and SIS

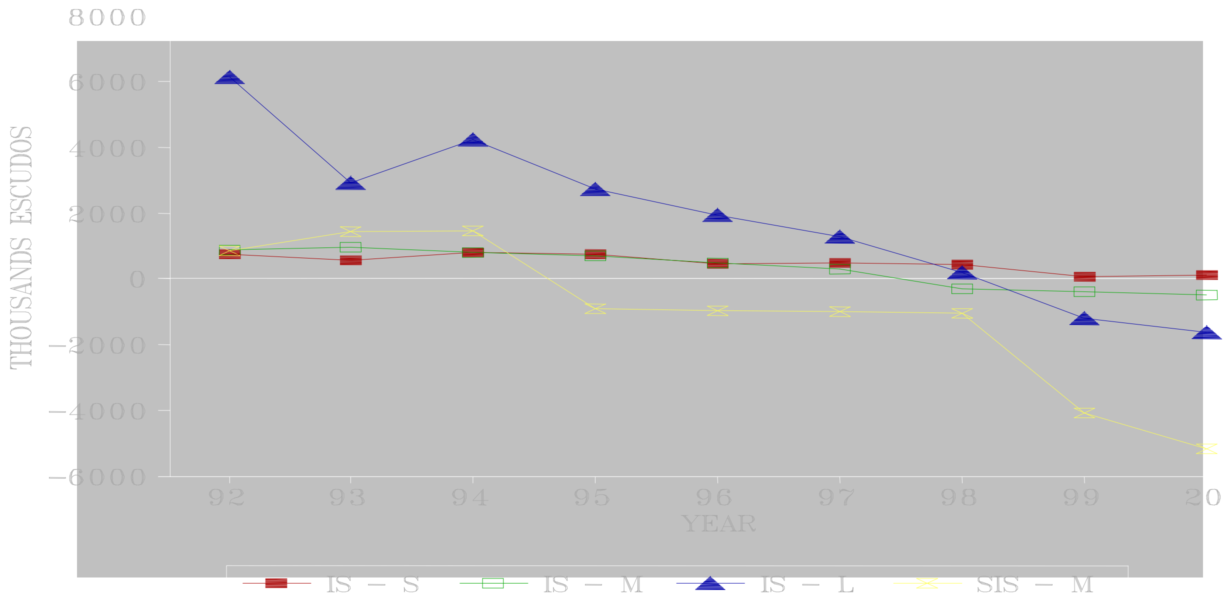

Figure 6.17 - Returns to Capital and Management without Technological Change

With respect to return to net assets, the results show that there is a substantial reduction after 1994. The SIS-M farm shows the worst evolution while the IS-S displays the best results with positive values in all years. Returns to capital and management drop to negative values after 1994 for the SIS-M farm and in the final years of the period for the IS-M and IS-L, showing that farms are not able to generate enough funds to remunerate with positive and satisfactory margins the capital invested.

The predicted values of disposable income and returns to capital and management for the farms that occupy the best farming soils of the Alentejo region display an apprehensive picture about the future of the farms belonging to intensive and semi-intensive farming systems. To a certain extent it is expected that farmers will respond to the prospect of a global income and profitability decline through the adoption of new technologies and new activities, as well as growth in farm size. For this scenario, Figures 6.18 and 6.19, which present the evolution of disposable income and returns to capital and management, show that all farms display positive disposable income and returns to capital and management for the period considered, with the exception of the SIS-M. This farm is not able to generate positive disposable income and returns to capital and management after 1998 and 1994 respectively. Returns are dependent on farm size and farming systems. The SIS-M shows the lower returns, while the farms belonging to the intensive systems are ordered by farm size. The large intensive farm shows a higher decrease in profitability during the period of analysis because of its almost total dependence on cereal production. The other farms with a mixed crop livestock structure, in which the weight of cereals output is smaller, show a smaller reduction in income.

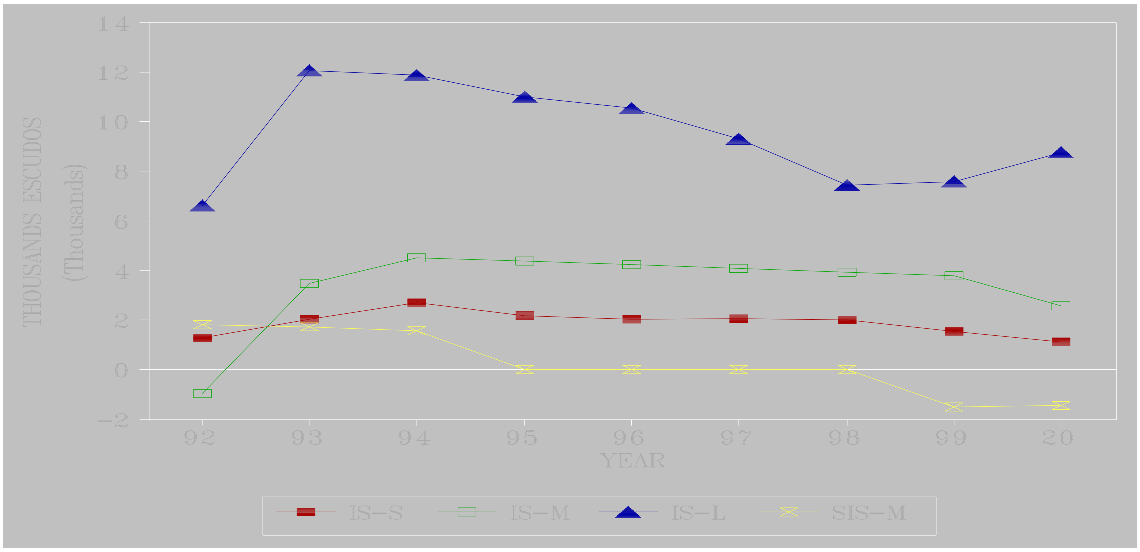

Figure 6.18 - Disposable Income with Technological Change for IS and SIS

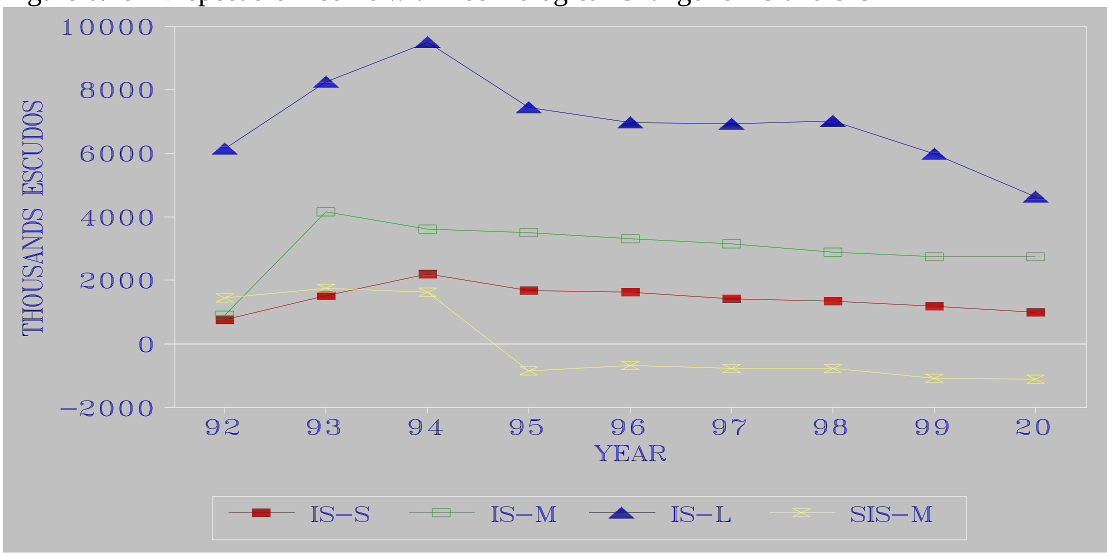

Figure 6.19 - Returns to Capital and Management with Technological Change for IS and SIS

As a result of the implementation of the CAP, the contribution of production subsidies (all direct subsidies that farmers receive, which includes production aids, compensatory payments and premiums) to total product increases and will have in the future a decisive role on the profitability of these farming systems. For both scenarios (Figure 6.20 and 6.21) direct subsidies increase in the beginning of the period and then a decline is observed principally for those farms with a higher weight of cereal production (IS-M and IS-L). For farms that will not innovate and expand, the contribution of income subsidies in total product reaches higher percentages than for those farms that will introduce new technologies and expand production capabilities.

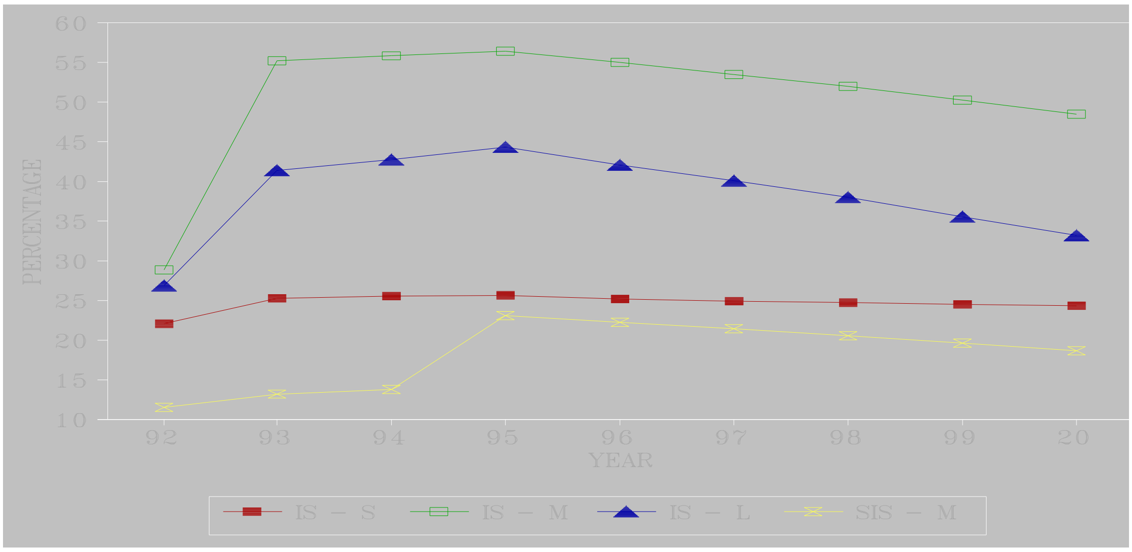

Figure 6.20 - Percentage of Subsidies in Total Product without Technological Change for IS and SIS

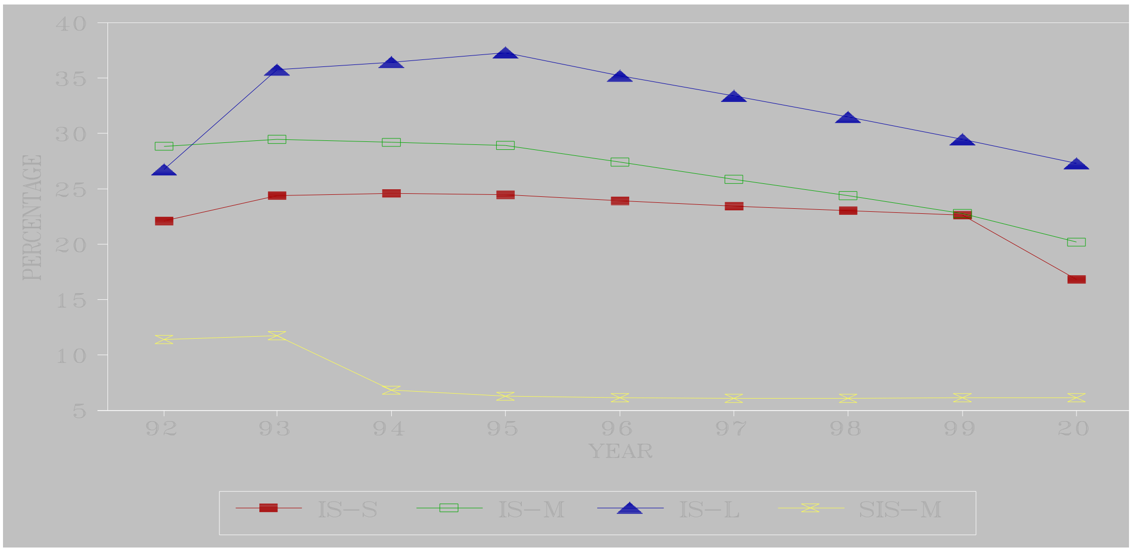

Figure 6.21 - Percentage of Subsidies in Total Product with Technological Change for IS and SIS

Farms based mainly on cereal production and that do not innovate and expand will have an extreme dependency on subsides: their percentage value in total product varies between 33 and 56 percent. For farms based on a mixed cereal-livestock structure (IS-S and SIS-M), subsidies represent between 20 and 30 percent of the total product. On average the percentage of subsidies in total product represents 50, 38, 25, 18 percent for the IS-M, IS-L, IS-S and SIS-M farms respectively.

When technological change and expansion are considered, the contribution of subsidies to the total product is in general reduced for all farms with the IS-L reaching a maximum of 37.3

percent and the SIS-M reaching a minimum of around 5 percent. On average they represent 32, 26, 22 and 7 percent of the total product for the IS-L, IS-M, IS-S and SIS-M respectively. These values confirm that with the common agricultural policy larger farms and with better production potential receive higher amount of subsidies.

Direct production subsidies represented on average 85 and 80 per cent of the total amount of subsidies received by the more intensive farms for the first and second scenario considered. These percentages shows that the weight of investment subsidies is relatively small when compared with the weight of production subsidies in total subsidies and that the weight of investment subsidies increases slightly when technological change is incorporated.

The results demonstrate that farms which do not innovate will be more sensitive to future changes in the amount and structure of subsidies than farms that do innovate. However, this is only partially true because the profitability of the farming systems that will innovate is also vulnerable to changes in the amount and structure of the direct subsidies. Figures 6.22 and 6.23 show disposable income when direct subsidies are deducted and confirm for both scenarios the vulnerability of these farming systems arising from the amount and structure of the subsidies. Without technological change and farm expansion, disposable income is negative in almost all years and for all farms, while with technological change and expansion the only exception is the IS-M farm that displays positive values for disposable income after 1993. These results emphasize the fact that direct subsidies will have an important role in helping maintain some of these farming systems and support the income of those farmers that make a living from farming. These conclusion would be reinforced if investment subsidies were also deducted from disposable income.

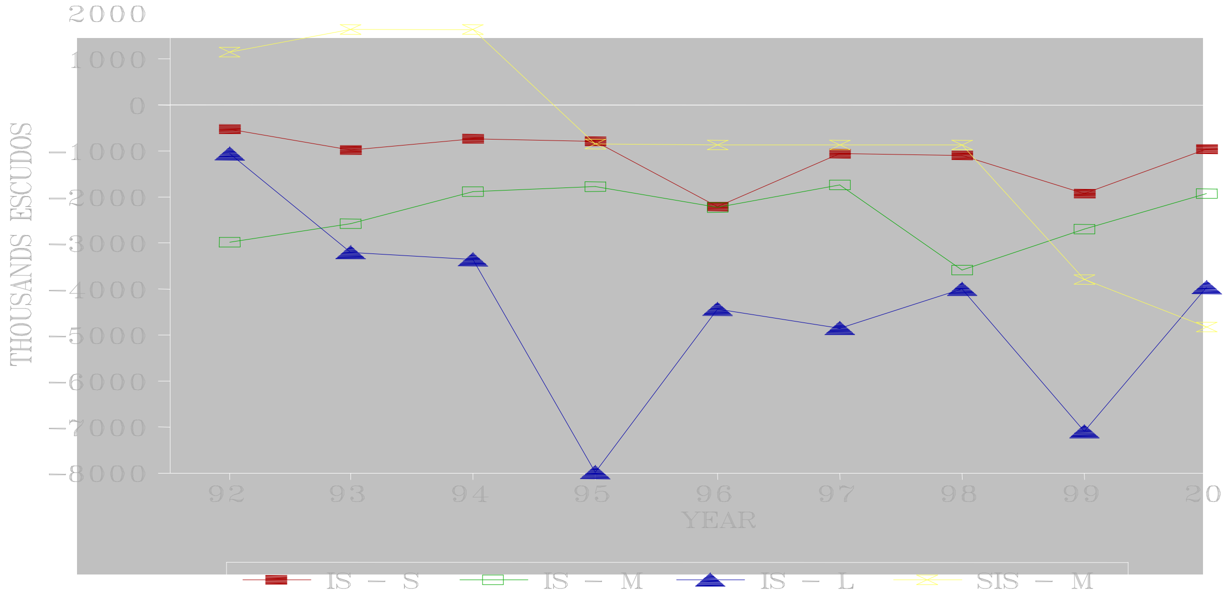

Figure 6.22 - Disposable Income without Subsidies and Technological Change for IS and SIS

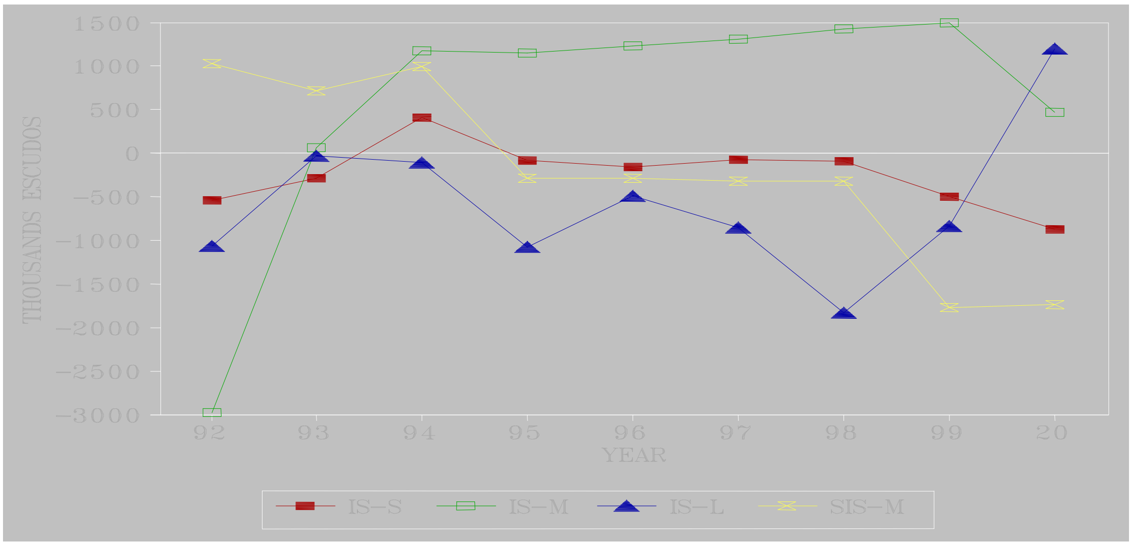

Figure 6.23 - Disposable Income without Subsidies and with Technological Change for IS and SIS

6.8.1.2 - Family Consumption

The model assumed two components for consumption at farm level: 1) a fixed component with the objective of meeting the minimum consumption requirements of the farms' family and set equal to the minimum annual wage for agriculture in the Alentejo region and 2) a marginal component which is expected to increase the basic consumption level when disposable income reaches values greater than zero and was equal to the marginal propensity to consume times the income available at the end of each period. The levels of total consumption for the first scenario without technological change are presented in Figure 6.24 in which total consumption per farm is expressed as the number of minimum wage rates for agriculture generated. This value was obtained by dividing total consumption by the minimum annual wage rate. The IS-L farm shows the higher levels of consumption, while the medium and small farms show much lower, but on average, similar levels of consumption. Family consumption decreases throughout the period of analysis, this decrease being more evident in the IS-L farm in which the consumption level decreases from 7 to around 1 minimum annual wages at the end of the period. For the small and medium farms the long-term tendency is for consumption levels to decrease to the minimum consumption requirements, meaning that farmers are operating with a zero or negative disposable income creation. On average for the period considered, family consumption is 1.38, 1.46, 4.36, 1.49 minimum annual wages per family LSU for the IS-S, IS-M, IS-L and SIS-M respectively.

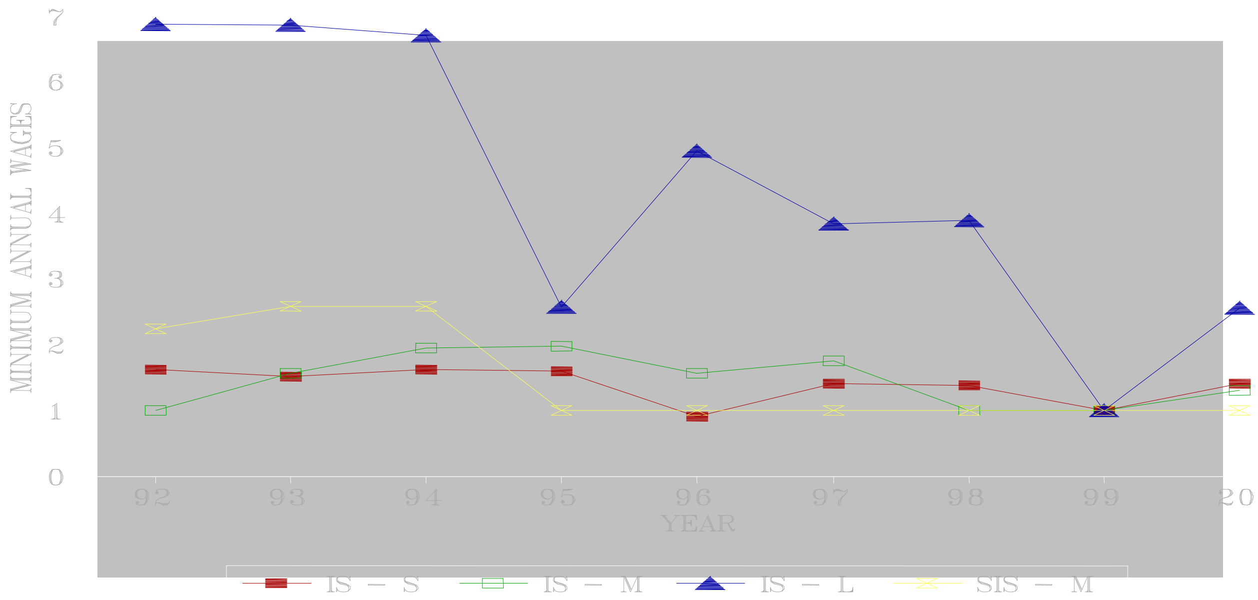

Figure 6.24 - Consumption per Family LSU without Technological Change for IS and SIS

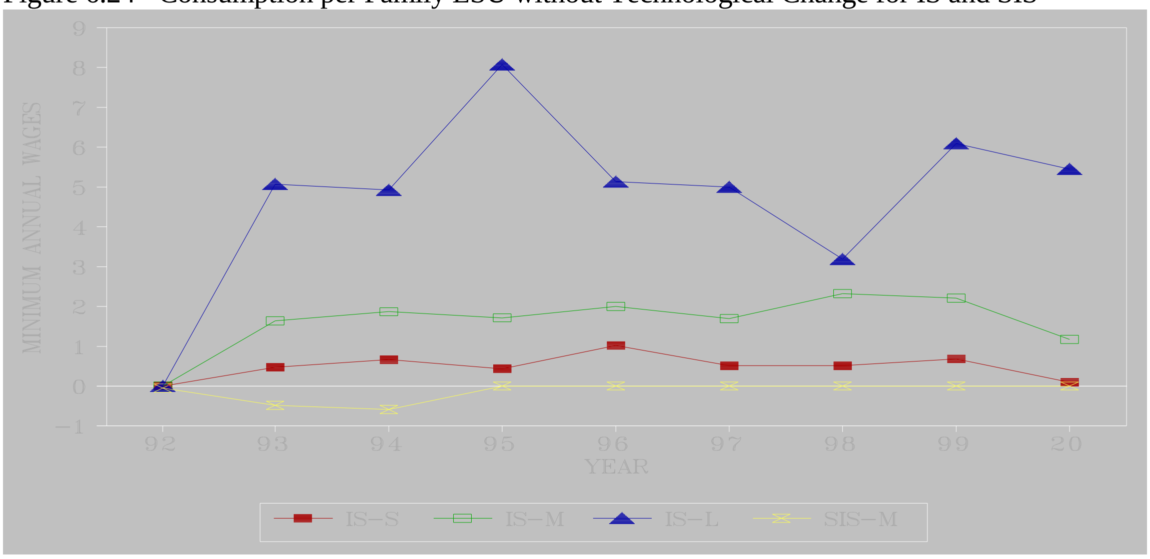

Figure 6.25 - Increase in Consumption per Family LSU with Technological Change for IS and SIS

When Technological change and opportunities for expansion are considered, the consumption levels increase on average by about 0.5 minimum annual wages for the IS-S farm, 1.6 minimum annual wages for the IS-M farm and 4.8 minimum annual wages for the IS-L farm, while the SIS-M farm displayed a decrease of 0.1 minimum annual wages. This decrease in consumption for the SIS-M was observed during the first years as shown in Figure 6.25 because the disposable income generated in those years was used for investment rather than consumption. This result shows that if farmers want to take opportunities for growth it will be worth sacrificing present for future consumption or, even if the total level of consumption does not increase, it is worth sacrificing present consumption for a future viable farm. However, considering the average levels of family consumption for the period analyzed, the IS-S and SIS-M farms still show low average annual levels of consumption of 1.9 and 1.4 minimum annual wages per family LSU used respectively, while the IS-M and IS-L farms exhibit 3.1 and 9.1 respectively.

6.8.1.3 - INVESTMENT AND DEBT

Investment is comprised of two components, a first one that corresponds to replacement of assets that have reached the end of their useful life and a second which is composed of new investments necessary to introduce new activities or technologies and the expansion of production capabilities. With respect to the two scenarios tested, the first scenario includes only substitution investments while the second scenario incorporates substitution and new investments.

Table 6.22 compares the total investment made by each farm for the two scenarios considered as well as the number of years of debt incurred. The comparison of the investment levels for both scenarios shows that the investment levels increase when technological change is considered, and this increase in the level of investment is greater for those farms with a mixed crop-livestock structure than for those farms mainly based only on crop activities. Investment increased 49, 23, and 54 for the mixed crop-livestock farms IS-S, IS-M and SIS-M respectively, and only 1 percent for the crop farm IS-L. The reduced increase levels in investment in crop-based systems with the introduction of new technologies is due to the fact that introduction of new crop activities or improved technologies in existing crops, does not generally require the purchase of additional assets.

Table 6.22 - Total Investment and Number of Years with Debt for More Intensive farms

Farm	Total Investment *		% Increase in Investment	Number Years with Debt	
	Without New Technologies	With New Technologies		Without New Technologies	With New Technologies
IS-S	7568	11294	49	1	0
IS-M	10740	13164	23	3	1
IS-L	37139	37520	1	1	0
SIS-M	7781	13556	54	6	2

* Total During the Period 1992-2000 in Thousands Escudos

The level of debt as well as the number of years during which it occurs is a measure of the long-term capacity for survival of the farms. With respect to the 4 farms belonging to the more intensive farming systems, the results show that without technological change the survival of the SIS-M is more doubtful in the long run in that for six of the nine years of the simulation it had outstanding borrowing and that the farm after 1995 is not able to generate enough receipts to accumulate capital investment to substitute old assets. The IS-L will not have any problems in surviving in the long run without technological change, while the IS-S and IS-M show debts in some years, although its size does not put the survival of these farms in danger for the period studied. However, the survival of IS-S and IS-M without any technological change will mean low levels of consumption or consumption at the minimum requirement levels and zero or negative remuneration of the capital invested. Considering technological change and growth the results show that all farms will be able to survive in the long run, though, as noted earlier, the SIS-M farm is not able to generate enough income to increase the consumption level to more than a minimum annual wage.

6.8.1.4 - Crop and Livestock Activities and Technologies

The adoption of new technologies and activities, as well as their expansion, is an important commitment for farmers in this decade in order to adapt to the new policy and market conditions. Access to information, the ability to analyze market and agricultural policy changes and the capacity to envisage the correct answers to a more rapid and uncertain production environment will be qualities that farmers will have to have or to acquire. The nostalgia confessed by most of the farmers interviewed about the old price scheme for cereals is an example of the difficulties that farmers are having in adapting to the new market conditions and policy arrangements. The inability and indecision displayed by the farmers interviewed to envisage and find new solutions reinforce the difficulties that farmers are having in discovering and reaching a new development and balanced strategy for their farms.

The results show that on the better soils (farms belonging to the IS) wheat will be profitable in the long run and improvements in the technology level are still available as well as a better capacity to associate weather predictions with the crop production cycles. The estimated production function for wheat incorporated in the model showed that until 1998 it is profitable to produce wheat at 97.1 percent of the maximum physical production, while after that period the optimum level of production is located at a lower level, 90.8 percent of maximum physical production. These results show a tendency, to a certain degree towards extensification in the long-run, once the subsidies are paid for the area cultivated and not for the quantity produced. To complement cereal production on the better soils, protein crops appear to be an alternative to dryland sunflower in intensive cereal rotations. The yield of dryland sunflower increases with the advancement of the seeding period, with production almost doubling when the traditional seeding period is brought forward from April to February. A simulation with alternative activities considering different seeding periods for sunflower proved that even in this situation protein crops can be competitive with sunflower.

With respect to the semi intensive farm (SIS-M), the results show that the best strategy in the long run is to abandon cereal production and to adopt a production scheme based on forages, pastures and livestock activities. This strategy corresponds to a specialization in livestock activities. This result will be latter reinforced by the ones obtained for the more extensive farming systems.

In the past livestock activities based on sheep production were a complementary activity to cereal production for farms belonging to the intensive and semi-intensive systems. The results show that large farms belonging to the intensive system will be able to survive without extending their range of crop activities to livestock activities. Livestock has an important role as an income-generating activity for small and medium farms of the intensive systems and the results show that for small and medium intensive farms, livestock activities will increase their importance and role in the production structure of those farms in the long run. The results show that expansion of the livestock herd is the optimum strategy for the development and survival of these farms in the long run.

The expansion of the livestock herd will be limited by farm size, the capacity to produce forages able to satisfy feeding needs in the most critical periods of the year, that is the end of Spring, Summer and the beginning of Autumn, flexibility in acquiring forages outside the farm and the ability to manage short-term renting in of pasture land such as fallow land or land right after cereal production. The IS-S farm is a good example of a small farm in which the strategy followed to overcome the area size limitations was to increase the livestock herd combined with short term renting in of pasture land. Though this strategy carries its own risk, because it is not able to guarantee from a long-term perspective a secure pasture land area, it could be an alternative for small farms to increase their production capabilities if they were able to find short medium-term agreements to rent in pasture land.

As described in section 6.4.1, the model allowed livestock activities to be chosen in a flexible procedure by allowing different potential birth periods and consequently selling periods of fattened animals as well as choosing the best selling weights. With respect to sheep activities, the results showed that two birth periods were chosen. The first corresponds to the end of Summer and the second to the beginning of Winter. The animals born in the first birth period were fattened and sold at the end of Autumn/beginning of Winter which corresponds to the best selling periods, while the animals born at the beginning of Winter were kept for replacement. These results confirm to a certain extent the traditional production strategies followed by farmers, in which birth is concentrated in two main periods, the beginning of Autumn and the end of Winter, the animals born in the second period being a result of females not served in the first period.

The Alentejo sheep markets show a price differential between animals with less and more than 25 kilos. Although the price differential is favourable to animals with less than 25 Kilos, the results of the models show that the optimum strategy is to sell animals around 30 kilos of live weight with between 4.5 and 5 months of age. The results also showed that it is profitable to supplement the fattening of the animals with feedstuffs. During the interviews it was observed that farmers have perceived that it had become profitable for them to supplement the fattening process with feedstuffs. The results confirm what some farmers have already adopted as an optimum strategy for sheep production.

With respect to the sheep technologies available for adoption by farmers, the structure of forage production does not allow us to consider the adoption of three births in two years. The improved technologies considered implied increased productivity rates for ewes and lower mortality rates, coupled with shortening and lengthening of the fattening period for lambs. The results showed that the best strategy is to adopt a medium sheep technology with longer fattening periods, because the marginal costs of adopting a more intensive technology are greater than the marginal revenues obtained.

6.8.1.5 - SUBSIDIES

As seen in 6.8.1.1, subsidies have an important role in the profitability of all more intensive farms. Subsidies can be divided into two groups, investment and production subsidies. The first group includes all subsidies related to regulations of the structural policy, while the second group includes all national or Community subsidies paid as direct production aids to activities or outputs as well as to variable inputs. The long-term profitability of farms and individual activities will be affected by both kinds of subsidies.

Under both scenarios, investment subsidies were granted for replacement and new investments, though investment subsidies should be applied only to new investments. However, in reality most farmers undertake renovation of their asset structure using the structural policy through the presentation of a reconversion plan of their farm that includes the replacement of assets. To test the effect of the actual subsidy structure on long-term farm profitability and activities a simulation was performed on the model with technological change excluding production and investment subsidies. This simulation has the objective of testing the role of subsidies in the process of farm growth and expansion.

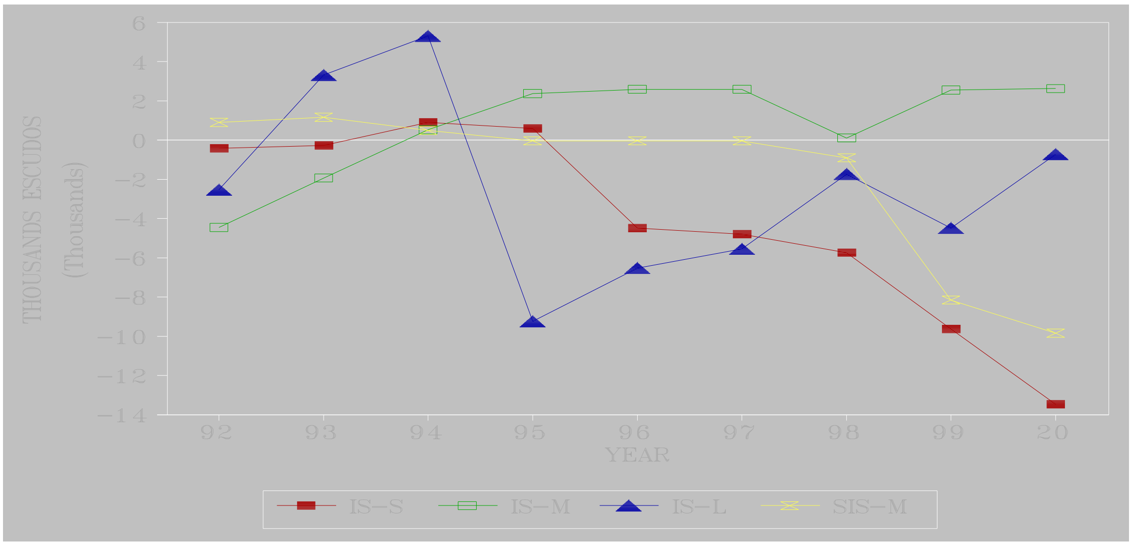

Fig. 6.26 - Disposable Income without Production/Investment Subsidies for IS and SIS

The evolution of disposable income and returns to capital and management shown in Figure 6.26 emphasizes the importance of investment and production subsidies. If direct subsidies were to disappear in the future, the small intensive farms and the medium semi-intensive will have many difficulties staying in business in the long run as well as the large intensive farms. The medium intensive farms will be able to survive. However, consumption levels, and consequently farmers' living standard, will be reduced.

The results show that the pace of growth is substantially reduced when production and investment subsidies are excluded. The level of investments is reduced to between 19 and 23 percent for all farms. The optimum levels of livestock activities are substantially reduced for the medium sized farms, by 29 and 36 percent for the IS-M and SIS-M respectively. The optimum level of production for wheat decreases which confirms the importance of extensification, and wheat is no longer profitable to grow from a long-term perspective in soils of classes B and C.

These results show that the more intensive agricultural systems will be very sensitive to any future changes in agricultural policies. Modifications in the actual policy structure will have to be made very cautiously because it could have important implications for the long-term survival of these farms.

6.8.1.6 - Set Aside

A simulation was performed to test to what extent farmers should adopt the set aside scheme or drop out from it. The simulation was performed in the IS-M (48 hectares of annual crop area) and IS-L (261 hectares of annual crop area) farms.

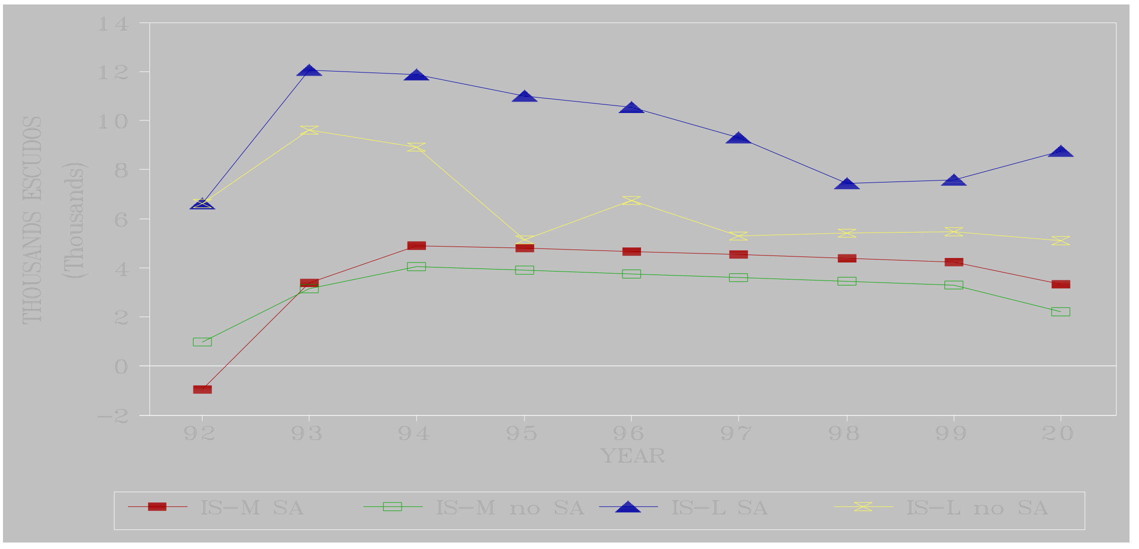

Figure 6.27 - Disposable Income with and without Set-Aside for IS

The results shown in Figure 6.27 allow us to conclude that in both cases the best solution is to accept the set aside scheme. The adoption of a small producer scheme will have the effect of reducing the disposable income by 5 percent for the IS-M and 31.6 percent for the IS-L. Simulations were not performed for the IS-S and SIS-M. The reasons were the fact that the area occupied for annual crop area is very small (15.4 hectares) for the IS-S, while for the SIS-M the optimum combination of activities excluded the presence of annual crop activities subject to set aside rules.

6.8.1.7 - Minimum Tillage Techniques

Minimum tillage techniques have been agronomically tested in the region and the results obtained are encouraging in terms of the production levels obtained, not only at the level of cereals but also forage production. The implications of the adoption of minimum tillage techniques at farm level are a reduction in production costs, principally machinery and tractor costs, and positive improvements in soil conservation with a reduction in the levels of erosion and consequently the maintenance of the soils' long-term fertility and production potential. However, the adoption of this technique requires special seeding equipment that in most cases has to be acquired by farmers.

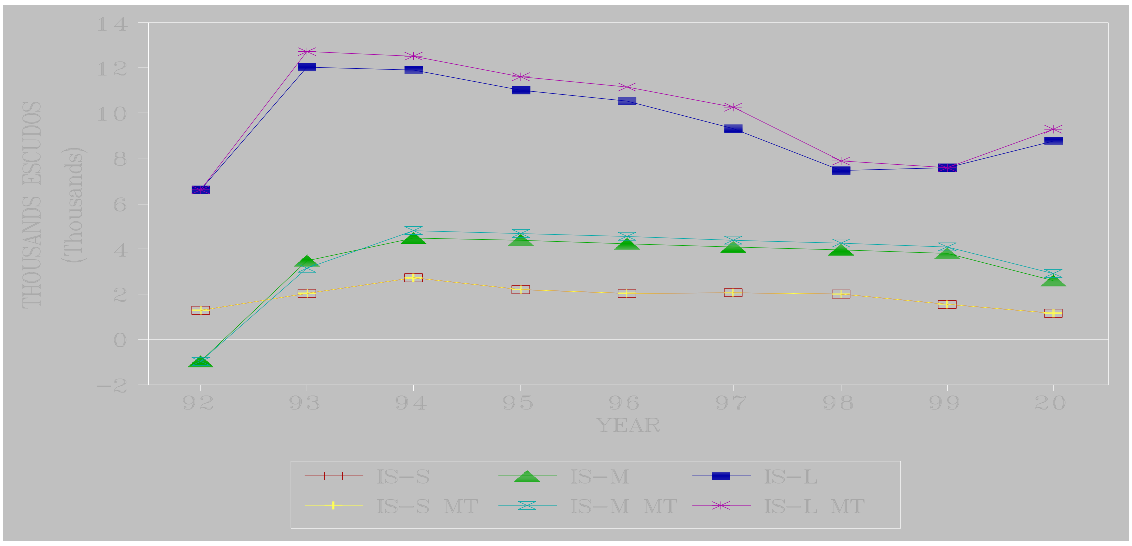

Figure 6.28 - Disposable Income with and without Minimum Tillage for IS and SIS

A simulation was performed allowing the model to choose between minimum tillage and traditional tillage techniques for wheat production in the IS-S, IS-M and IS-L farms. No consideration was included in the model to account for the long-term benefits of a reduction in soil erosion. Figure 6.28 compares disposable income between the models with and without the minimum tillage techniques and allows us to conclude that marginal improvements in disposable income are expected to occur for the IS-M and IS-L farms. On average, disposable income increased 6 and 5 percent for the IS-M and IS-L respectively. With respect to the IS-S farm, minimum tillage techniques were not adopted because the area of cereals is not enough to compensate the marginal cost incurred by the additional investment required.

6.8.1.8 - Simulations of Sheep Prices

In 1992 a stagnation of nominal prices of lamb in the Alentejo markets was observed. Thus a reduction in sheep prices similar to the one proposed for beef, 15 percent price reduction over the period 1993 - 1995, was modelled to test the impact of a price reduction on income and farm growth. The results show that the reduction in sheep prices has the effect of slowing down the expansion of the SIS-M farms. Investment is reduced by 36 percent and this is reflected in a reduction in the herd size and livestock related investments. The IS-S and IS-M farms did not suffer any significant changes in their expansion of production capacities.

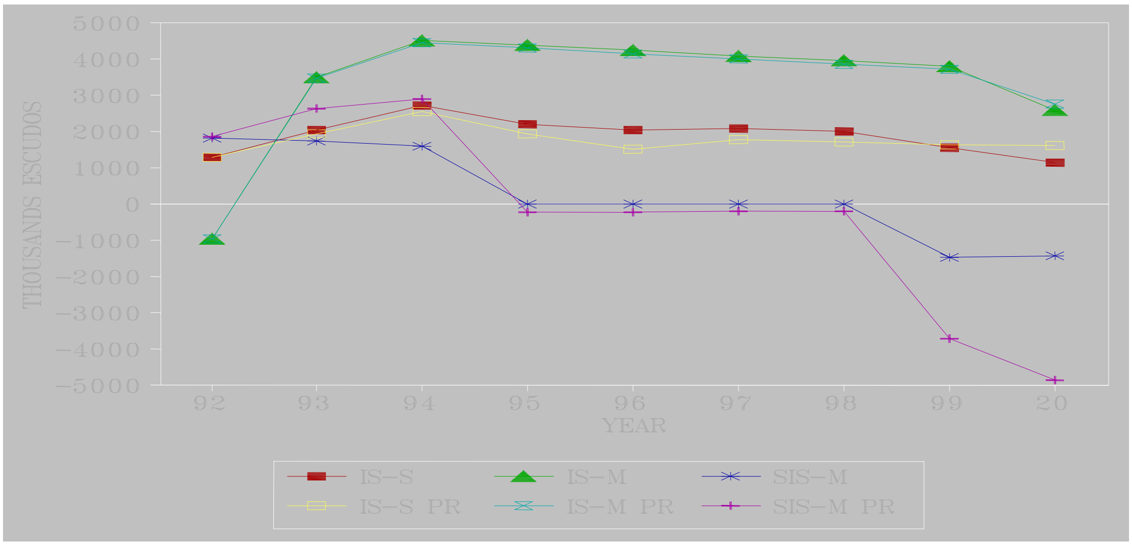

Figure 6.29 - Disposable Income with and without a 15% Sheep Price Reduction for IS and SIS

The decrease in sheep prices causes a reduction in disposable income and consequently consumption and return to net assets. As shown in Figure 6.29, disposable income is reduced slightly for the IS-S and IS-M farms, while for the SIS-M disposable income drops to negative values after 1994. No significant changes occur in the optimum combination of activities. If IS-S and IS-M farmers adopt new technologies and activities and take opportunities for growth, they will be able to survive in the long run even with a 15 percent reduction on sheep prices. The SIS-M farm based on forage and sheep production is very sensitive to reductions in livestock prices. This results in a decrease in the growth path and disposable income, increases the level and number of years of debt, and decreases the ability of these farms to survive in the long run.

6.8.2 - More Extensive Farming Systems

6.8.2.1 - Income and Profitability

The results of disposable income and returns to capital and management for the first scenario, presented in Figures 6.30 and 6.31, show a behaviour similar to the one observed for the more intensive farms, in which disposable income reaches negative values for some farms in the final years of the period considered. For PLS-S and PLS-M farms, disposable income reaches negative values after 1996 and for the ES-L farm disposable income is almost always negative during the period considered. For the PLS-S farm the positive income generated during the period 1994-1996 is mainly due to renting out the cereal harvester owned by the farm. However, after 1996, when it is scraped, a replacement machine is not profitable and this extra income finishes. The evolution of disposable income for the PLS-L and ES-M is always positive and could be a result of farm size and type of activities performed. Both farms have a production system based on forage-livestock activities in which beef activities dominate for the ES-M farm and sheep for the PLS-L. In addition the PLS-L farm takes a significant proportion of its income from vineyard activities. The evolution of returns to capital and management shows a similar picture to the one observed for disposable income, in which PLS-S, PLS-M and ES-M are not able to generate enough funds to remunerate the capital invested.

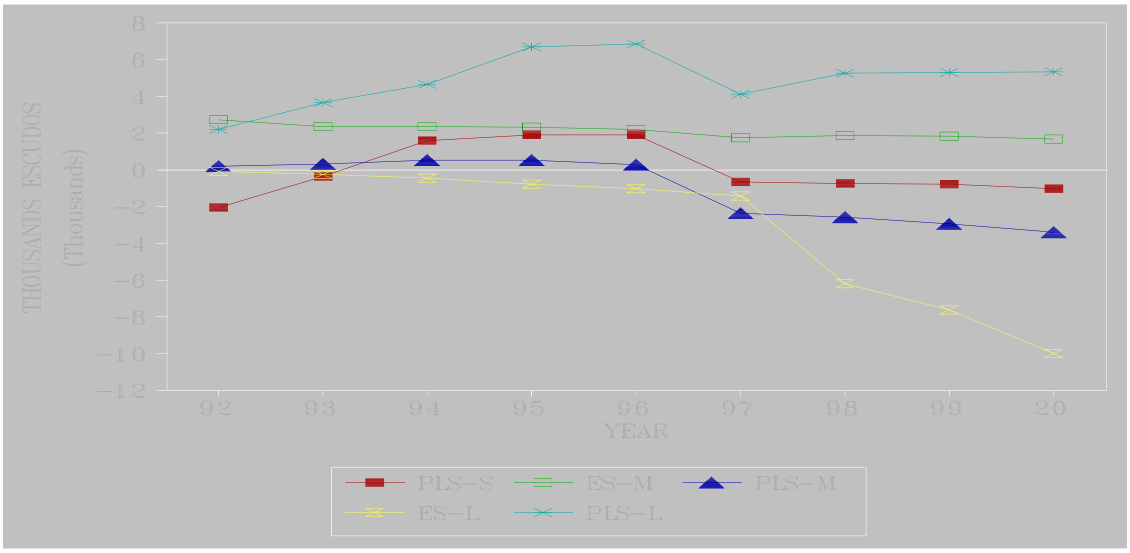

Figure 6.30 - Disposable Income without Technological Change for ES and PLS

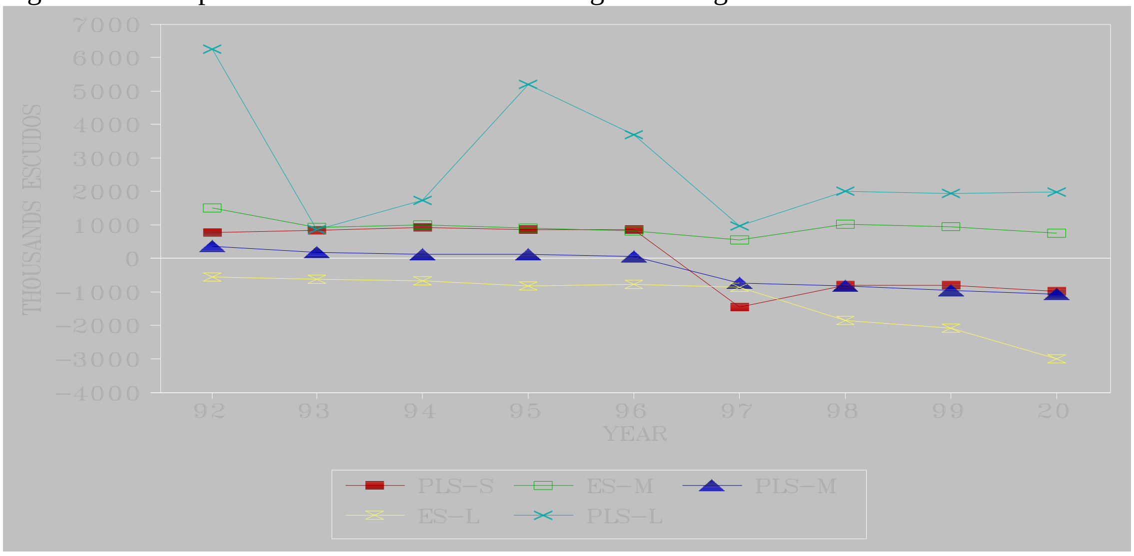

Figure 6.31 - Returns to Capital and Management without Technological Change for ES and PLS

When new technologies and activities as well as opportunities for growth were considered in the model, disposable income and returns to capital and management improve for all farms analyzed, as can be seen in Figures 6.32 and 6.33. Again the PLS-L and ES-M are the farms that show an overall better performance in terms of disposable income, while the PLS-S, ES-M and PLS-M show negative or zero values for disposable income in the first years as a consequence of using the income generated to expand their production capabilities. With respect to changes in the returns to capital and management, the PLS-S farm is not able to generate enough funds to remunerate capital invested after 1997 once returns to capital and management reach negative values, while PLS-L, ES-L and PLS-M are the farms that show a better performance in terms of returns to capital and management.

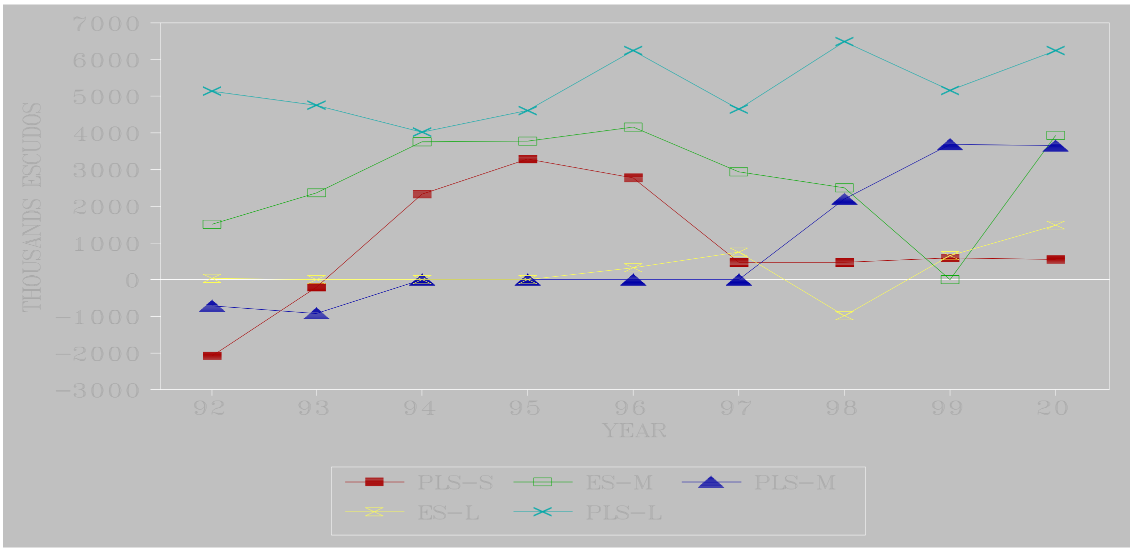

Figure 6.32 - Disposable Income With Technological Change for ES and PLS

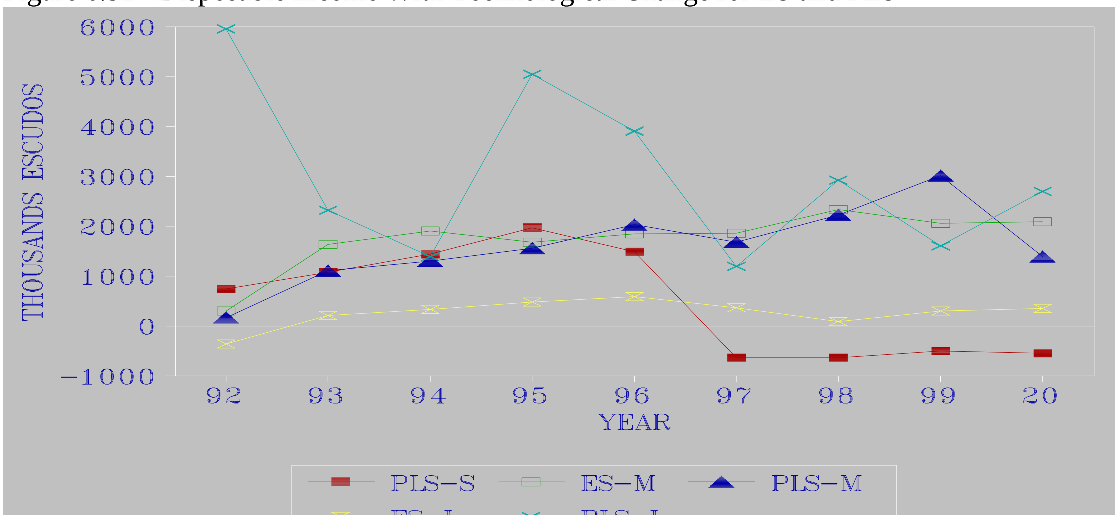

Figure 6.33 - Returns to capital and management with Technological Change for ES and PLS

Similar to what was observed for the more intensive farming systems, the extensive farming systems are also extremely dependent on production subsidies, as can be seen in figures 6.34 and 6.35. Without technological change the percentage of production subsidies in the total product is greater than 35 percent of the total product for the ES-L and PLS-M farms and between 20 and 30 percent for the ES-M and PLS-L. These values show that the farms with a better economic performance are not the ones that receive the higher levels of production subsidies when expressed in percentage of total product. On average for the period considered subsidies represented 18.4, 27.6, 38.5, 36.6 and 21.9 for the PLS-S, ES-M, PLS-M, ES-L and PLS-L respectively.

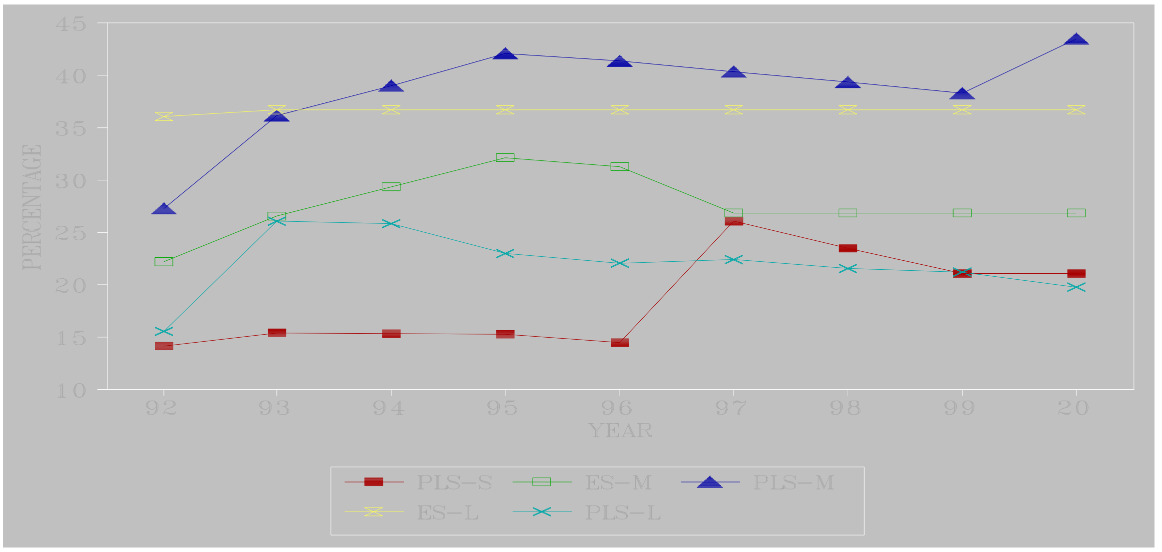

Fig. 6.34 - Percentage of Subsidies in Product without Technological Change for ES and PLS

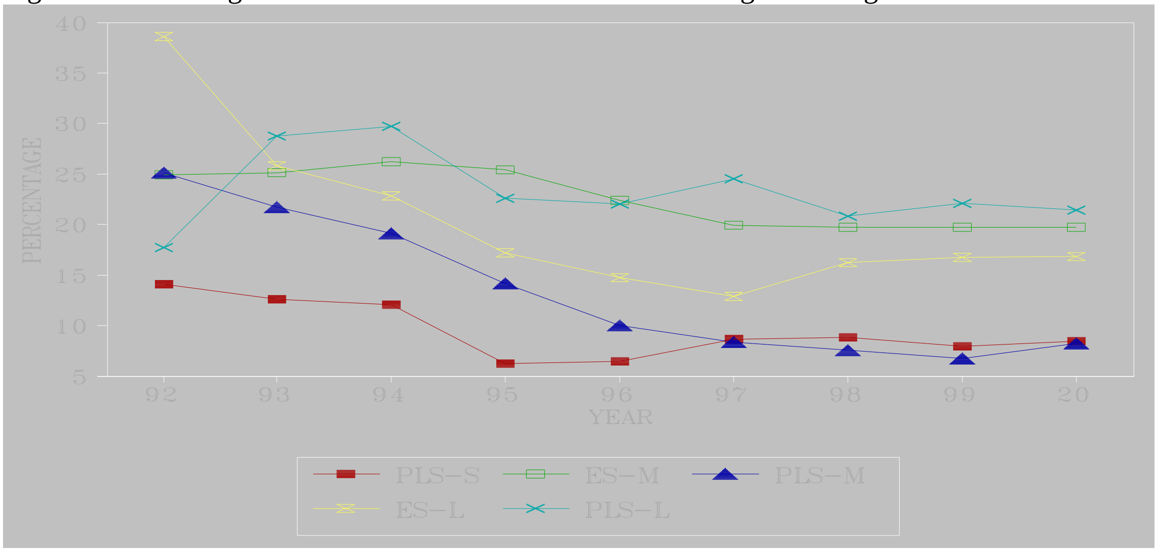

Figure 6.35 - Percentage of Subsidies in Product with Technological Change for ES and PLS

When new technologies and activities were considered, the percentage of subsidies in the total product decreases for all farms analyzed. The farms with higher levels of subsidies are the ones that show a better economic performance, that is the PLS-L and ES-M. On average the PLS-L, ES-M and ES-L are the farms that show higher levels of subsidies 23.3, 22.6 and 20.2 percent of total product respectively, while the PLS-S and PLS-M farms show the lower levels of subsidies 9.5 and 13.5 percent of the total product respectively.

The weight of production subsidies in total subsidies is on average 85 and 66 percent for the more extensive farms, for the first and second scenario respectively. Without technological change the value is similar to the one obtained for the more intensive farms, while with technological change the weight of investment subsidies increases to 34 percent of the total amount of subsidies.

Disposable income without the total amount of production subsidies for the two scenarios considered, are presented in Figures 6.36 and 6.37. Without technological change the income generated is negative in almost all years of the period considered, showing the vulnerability and dependence of the farms that belong to the more extensive farming systems to the amount and structure of the subsidies. In general the evolution of disposable income improves when new technologies and activities as well as opportunities for growth were considered. However, with the exception of the ES-M and the PLS-S farm, the results confirm the importance of subsidies for the generation of income in the more extensive farming systems.

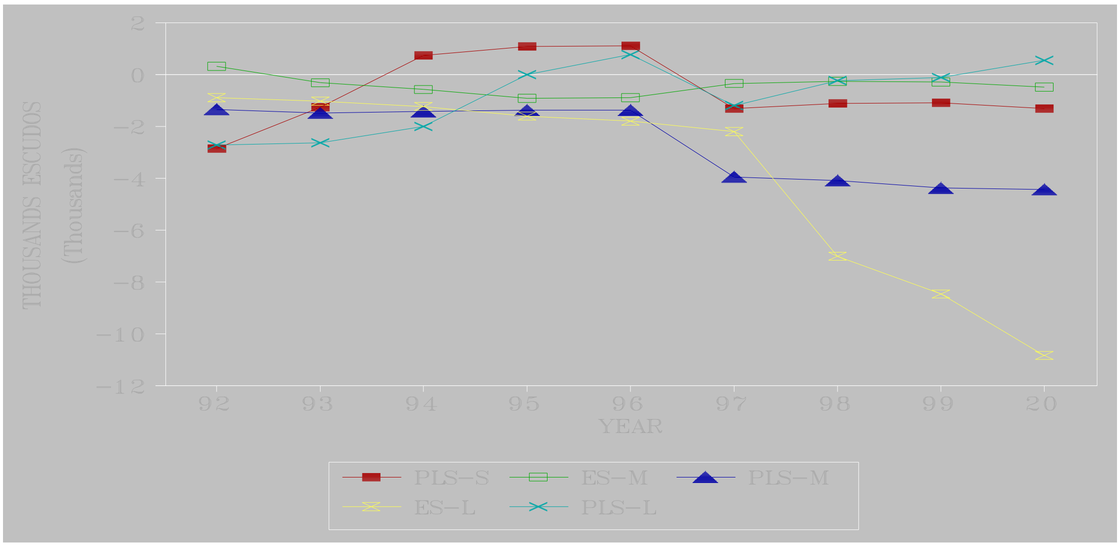

Figure 6.36 - Disposable Income without Subsidies and Technological Change for ES and PLS

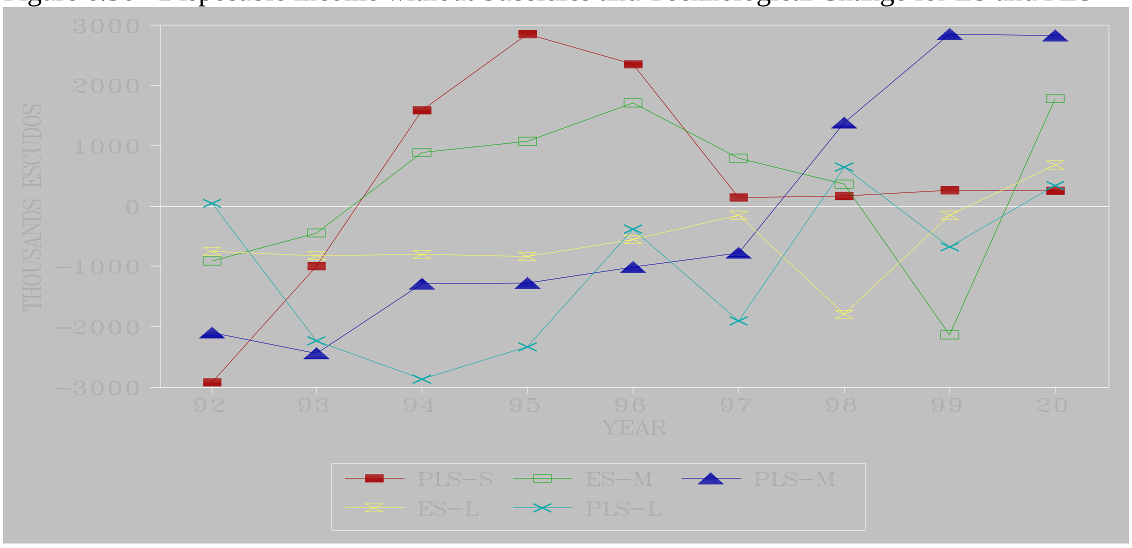

Fig. 6.37- Disposable Income without Subsidies and with Technological Change for ES and PLS

6.8.2.2 - Family Consumption

The levels of family consumption without technological change are presented in Figure 6.38. The results show that family consumption for the PLS-S, PLS-M and ES-M are reduced to the minimum levels of consumption after 1996. The PLS-S farm shows a consumption peak during 1994-1996 due to income resulting from renting out machinery activities already referred to before, the PLS-M farm shows a consumption level slightly higher than the minimum consumption levels for the period 1992-1996 and for the ES-L farm the consumption levels are maintained at the minimum level during the whole period of analysis. As expected the ES-M and PLS-L farms show the higher levels of family consumption but with a decreasing tendency. On average, during the period analyzed, family consumption corresponded to 1.6, 2.9, 1.2, 1.0 and 5.4 minimum annual wages per family LSU used for the PLS-S, ES-M, PLS-M, ES-L and PLS-L farms respectively.

When new technologies and activities as well as opportunities for growth were considered, the corresponding changes in family consumption presented in Figure 6.39, shows that in general the consumption levels increase, although in some years reductions in family consumption are observed as a result of using the income generated in that year in investments to improve the production capabilities of the farms. During the period analyzed the increases in family consumption were on average modest for all farms when compared with the more intensive farms and reached the following values 0.5, 0.6, 0.4, 0.3 and 0.3 minimum annual wages per family LSU for the PLS-S, ES-M, PLS-M, ES-L and PLS-L. These results confirm that, with technological change, the family consumption levels of the PLS-S, PLS-M, and ES-L farms are low and correspond to 2.1, 1.6 and 1.3 minimum annual units per family LSU, which is lower than the average national income.

6.8.2.3 - Investment and Debt

The results comparing investment levels and number of years of debt with and without technological change, displayed in Table 6.23, show that in general more extensive farms, to improve their optimal profitability, have to increase their investment levels from values that vary from 65 percent for the PLS-S to 422 percent for the PLS-M. The majority of these investments are associated with livestock activities as a result of the expansion of sheep or beef enterprises and, to a smaller extent, to vineyard activities for the PLS-S farm.

Table 6.23 -Total Investment and Number of Years with Debt for More Extensive Farms

Farm	Total Investment *		% Increase in Investment	Number of Years with Debt	
	Without New Technologies	With New Technologies		Without New Technologies	With New Technologies
PLS-S	5869	9665	65	6	0
ES-M	7960	19673	147	0	0
PLS-M	5712	29817	422	4	2
ES-L	5129	13157	156	9	1
PLS-L	26156	31733	21	0	0

* During the Period 1992-2000 in Thousand Escudos

Regarding the long-term survival of the more extensive farms, one can conclude that the ES-M and PLS-L farms will be able to survive in the future if no significant changes occur in the agricultural policies tested, even if they do not improve their production structure. The PLS-S, PLS-M and ES-L farms, in order to stay in agriculture in the long-term, will have to improve their production structure, because without technological change the accumulated debt and the number of years in which it occurs will be a serious limitation for their long-term survival. With technological change the economic performance of these farms improves and their survival is possible, but the income generated for family consumption will be lower than the national average income, imposing a serious limitation for their maintenance in the agricultural sector as viable economic units.

6.8.2.4 - Crop and Livestock Activities and Technologies

Regarding crop activities, the results showed that cereals have to be abandoned in farms belonging to the extensive and poor land farming systems, even in extended rotations with annual forages and pastures. With the exception of the PLS-L farm, the optimum decision to abandon cereal production is anticipated when technological change and opportunities for growth are considered. In this case the optimum production system is based on annual forages and pastures, and livestock activities in the form of sheep or sheep and cattle. Permanent crops such as olive trees and vineyards are a viable alternative crop activity for some of these farms. However, increases in area of these crops are legally restricted, which limits their free expansion at farm level as a possible alternative for farmers to specialize in those activities.

With respect to livestock activities sheep and cattle are both viable economic alternatives in the long run for these farms and the best strategy for herd growth is its gradual expansion. The optimum strategy for sheep production obtained for these farms is similar to the one described for the intensive farms, in which a medium technology of production is recommended, along with selling lambs of around 30 kilos and the inclusion of feedstuffs in the fattening process. The optimum cattle strategy depends on farm capacity to produce forage, and the sell of calves at 6 months or 18 months.

6.8.2.5 - Simulation on Sheep Prices

The effect on disposable income of a 15 percent price reduction in sheep prices for more extensive farms is presented in Figures 6.40a and 7.40b, allowing us to conclude that on average disposable income decreases by 11, 12, 28, 76 and 7 percent for the PLS-S, ES-M, PLS-M, ES-L and PLS-L respectively.

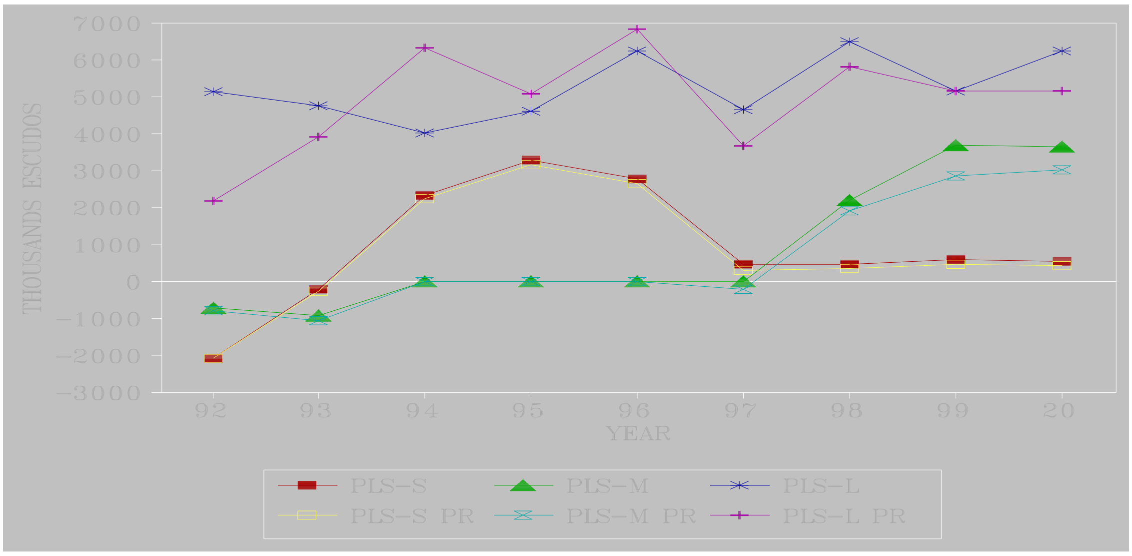

Figure 6.40a - Disposable Income with and without a 15% Reduction on Sheep Prices for PLS

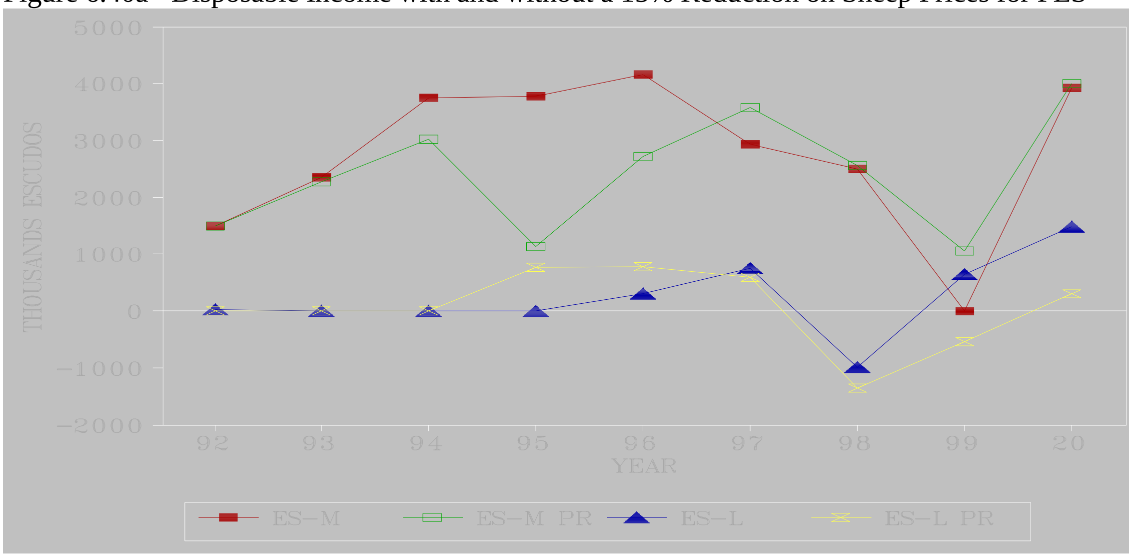

Figure 6.40b - Disposable Income with and without a 15 % Reduction on Sheep Prices for ES

The sheep price reduction simulation influenced negatively the sheep herd growth for those farms (PLS-S and ES-L) with a livestock system based only on sheep, while for the farms with a mixed sheep-cattle livestock system (ES-M and PLS-M), sheep herd growth was substituted by cattle herd growth. Regarding the PLS-L farm in which the sheep production technology is based on three birth in two years, the reduction on sheep prices did not influence the herd size and only changed the optimum serving, birth and selling periods. These results show that farmers strategy of growth with respect to livestock activities should be gradual and should incorporate market signals in terms of output prices.

6.9 - Farm Size and Farm Development

The interpretation of the results and the consequent conclusions that it is possible to draw from this chapter, should consider the characteristics of the process of farm growth identified in section 4.5 in which it was found that the process of farm growth was farming system and farm specific. This conclusion means that some prudence should be exercised before generalizing the results of this chapter to all farms of the same farming system by area class. This prudence should even be greater if one bears on mind the limitations and assumptions that are embodied in the models built, although it is believed the models are a close representation of reality and that the assumptions made about farm development are reasonable from an economic and technical view point.

Although increases in area size were not tested directly, the results show that in general larger area sized farms have a greater capacity to survive in the long run than smaller farms. One of the forms that smaller farms have to increase their capacity to survive in the long-run is to increase their area size through buying or renting more land. The example of the IS-S, in which renting of pasture land is able to increase the farm feed supply and maintain a sheep herd with a significant size, lead us to conclude that for small and medium sized farms a increase in area is an interesting alternative to increase the viability of them.

The average values of land shadow prices shown in Figure 6.41 for the more intensive and more extensive farms, indicates that in real terms land prices and (their rental value) are going to decrease in the long term which means that farms that have own land will see a fall in their capital values. The comparison of the average values of lands shadow price for the first half (1992-1995) of the decade with the values for the second half (1996-2000), shows that land prices will decrease around 40 per cent for the more intensive and 60 per cent for the extensive farming systems. The decrease in land prices associated with a probable exit of some farmers from agriculture could increase in the future the chances of small and medium farmers or even large farms to increase their area size. The most recent data shows that the number of farms in Alentejo was reduced by 9559 or 20 per cent of total in the last five-six years. However, some caution has to be exercised in the analysis of the role of area size increases through land renting in the development of small and medium farms, because of the agrarian problems that have occurred in the region.

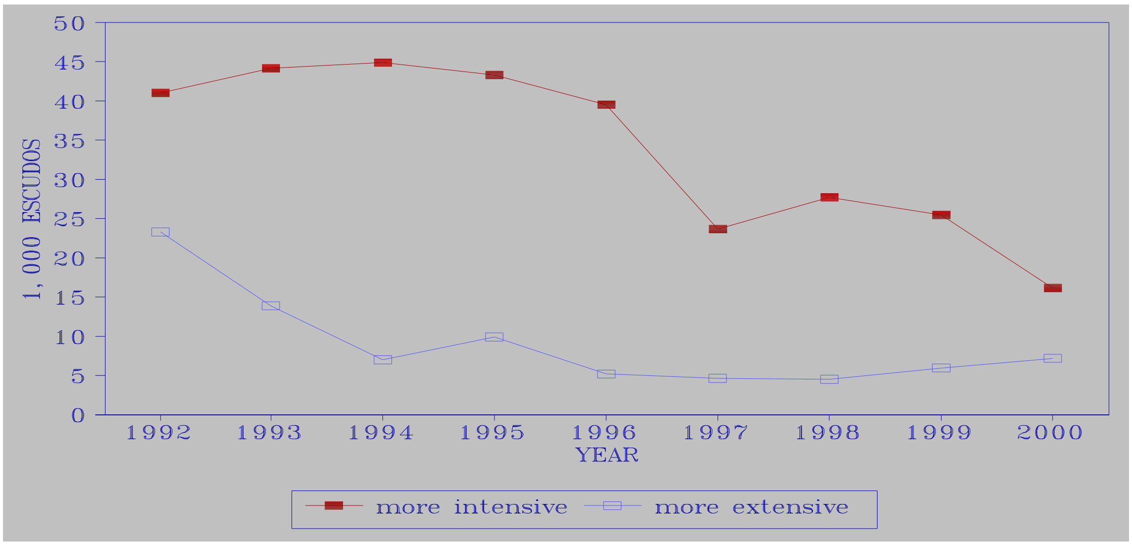

Figure 6.41 - Average Land Shadow Prices for the More Intensive and Extensive Farming Systems

The results obtained in the previous sections allowed us also to conclude that for the SIS, PLS and ES farms, there will probably be a tendency for the specialization in livestock production. For the farms belonging to these farming systems, the capacity to survive will be greater or easier for those farms that have already built a significant capital livestock either in terms of sheep or cattle as with the IS-S, ES-M, PLS-L farms - meaning that the capacity to survive increases with the size of livestock capital built in the past.

6.10 - SUMMARY

A multiperiod linear programming model was built to study during the period 1992-2000 under the 1992 CAP reform, the development of nine farms belonging to the four selected Alentejan farming systems (IS, SIS, ES and PLS). The model developed had a recursive nature and incorporated a set of a set of production, investment, policy and fund flows activities and constraints, to represent as close as possible to reality the production and economic environment that Alentejan farms will face. Two basic scenarios were compared, a first assuming that farms maintain their technology and size equal to that observed in 1988, and a second considering that farms would take opportunities for growth (except in area) and introduce new technologies and activities. Additional simulations were performed with respect to set-aside, minimum tillage techniques and sheep prices.

The results obtained showed by farming system and farm size the changes in disposable income, returns to capital and management, family consumption, subsidies, investment and debt, allowing us to identify the best strategy of development for those farming systems. If no opportunities for growth are taken, which corresponds to the first scenario considered, disposable income as well as returns to capital and management decrease over the period studied and the survival of the SIS-M and PLS-S, PLS-M and ES-L will be problematic. When opportunities for growth are considered, which corresponds to the second scenario analyzed, there are improvements in income and returns to capital and management generated. However, even taking opportunities for growth and new activities and technologies, farms belonging to the SIS-M, PLS-S, PLS-M, and ES-L, will have difficulties in generating in the long-term incomes above the basic requirement levels (minimum wage for agriculture) which puts their survival at risk.

For all farms and farming systems, direct subsidies have an important contribution to total product generated and its percentage of total product depends on farm as well as scenarios considered. The percentage of direct subsidies in total product is lower when opportunities for growth and new technologies and activities were considered, and for this scenario direct subsidies varied from around 9.5 per cent for the PLS-S to 32 per cent for the IS-L farm. If these subsidies are deducted from disposable income, the majority of the farms show on average for the period analyzed, negative values for disposable income with the exception of the IS-M, ES-M and PLS-S farms. These results show that any changes in the present agricultural policies, in order to reduce the actual level of direct subsidies, will have further negative effects on the long-term capacity to survive not only for the SIS-M, PLS-S, PLS-M and ES-L farms but also for the farms belonging to the extensive and intensive systems.

With respect to crop and livestock activities the results showed that cereals are profitable in the farms belonging to the intensive farming system which occupies the best productive soils of Alentejo region, while for the SIS, ES and PLS farming systems the area of cereals decrease through time. For these farming systems, the area of cereals would be gradually substituted by forages that supply the feeding needs of a livestock herd that tends to increase. The results showed that for the SIS, PLS and ES there is a tendency for a specialization in livestock activities either sheep or beef cows. For sheep a medium technology of production is recommended with the inclusion of feedstuffs in lamb fattening, while for beef cows the optimum strategy depends on the capacity of the farm to produce forages and consequently calves will be sold at 6 or 18 months.

For the farms that produce cereals, the wheat response curve modelled showed that an extensification in the production methods, with lower levels of input use, would be a good farm strategy for the future since subsidies are paid on the area cultivated and not on the quantity produced. Additional simulations showed that the adoption of minimum tillage techniques caused small improvements in farm income, that farms should opt for the set aside schemes and that a reduction of 15 percent in sheep prices reduces farm income and slows down the growth of herd size principally for the SIS-M, PLS-S and ES-L farms.

The results and conclusions obtained for the nine particular farms selected in this chapter can only be generalized with caution to each of the farming system and area classes of which they form a part, considering the discussion of section 4.5, where it was found that the process of growth of Alentejan farms was dependent not only on the farming system but also on the farm considered. This means that each farm - small, medium or large - will have a specific growth or decline pattern which will depend not only on the economic environment but but also on farmer characteristics.

Although not tested directly (with exception of IS-S farm), increases in area size can be considered as one of the methods of increasing the capacity of some of the small and medium, and even larger farmers to stay in agriculture and improve their scale of operations. This depends upon the availability of land in the market and of its price either to rent or to buy. The analysis of land shadow prices allows us to conclude that in real terms land prices will be decreasing in the future. This expected decrease in land prices might encourage some farmers to sell up the land now, while the prices are high, thus facilitating increases in area size of other Alentejan farms, either small, medium or large. For small farms such as the IS-S, it was shown that land renting either through permanent or temporary agreements is an important source of the feed supply which allows the maintainance of a large livestock herd than would otherwise be possible.

The general direction of the results obtained for income, returns to capital and management, and crop and livestock activities, in this research were similar to those reached by previous authors that analyzed the development of Alentejan farms in a comparative static framework, first in the context of the agreements for the first and second stage of the transition period and more recently for the 1992 CAP reform (as in the study performed by Carvalho (1994) for three Alentejan farms).

The development behaviour of the Alentejan farms will also be affected by the variability in crop and livestock activities due to weather fluctuations that are observed between different years. This variability was not incorporated in the models built since constant average yields were adopted. The conclusions reached by Carvalho (1994), regarding the incorporation of risk due to crop and livestock variability were: as expected diversification is a way of reducing the risk of variations in farm income, farms specialized in crop activities (cereals, oilseeds and protein crops) are associated with higher levels of risk, farms specialized in livestock activities are associated with lower levels of risk and irrigated crops when present have a stabilizing effect both either in terms of forage production or income generation.

The above conclusions generalized to our farms and results would imply that the specialized crop farm IS-L and the IS-M farm will show the highest income variability when variation in crop yields occur due to weather change, while the other seven farms that tended to specialize in livestock will show a lower variability in farm income. For these farms, in the years with unfavourable conditions for forage production, the amount of forage bought outside the farm will increase and the fattening periods may be reduced which could lead to a reduction in farm income.

CHAPTER VII - CONCLUSIONS

The objective of this chapter is to summarize the main conclusions of the research undertaken in this thesis, to list the principal limitations that were present and to propose future research work.

7.1 - GENERAL CONCLUSIONS

In this study four Alentejan farming systems - intensive (IS), semi-intensive (SIS), extensive (ES), and poor lands (PLS) - were selected and analyzed. The IS and SIS farming systems occupy the best soils of the Alentejo region and show more intensive production characteristics than the ES and PLS farming systems. The most important agricultural activities are crop enterprises for the IS, livestock enterprises for the ES and a mixture of crop and livestock for the PLS and SIS farming systems.

The analysis of the selected farming systems was undertaken considering the following aspects. First, the characteristics of the process of farm growth and the measurement of individual levels of technical efficiency were evaluated. This analysis was performed on a panel of farms based on RICA data for the period 1987-1991 and the methodologies employed were a covariance model, and parametric and nonparametric methods respectively. Second, a multiperiod farm growth model using linear programming techniques was built for the period 1992-2000 with the objective of predicting the impact of the 1992 CAP reform on the development of the four farming systems selected.

During the period 1987-1991 the aggregate data for each one of the farming systems selected allowed us to conclude that positive increases were observed in the area per farm of cereals and oilseeds, livestock herd size, capital stock, direct subsidies and total product, while negative changes were observed in the levels of labour use and profitability. The covariance growth model tested for labour, capital, livestock and product variables showed that the farms belonging to each farming system had a pattern of growth that was farm and farming system specific, meaning that farm growth rates vary between the farming systems and inside each farming system between the different farms. The relationship between farm size and farm growth was found to be negative and significant - small farms grow faster than larger farms - which allowed us to reject Gibrat's law of proportionate effect.

Technical efficiency levels measured for the period 1987-1991 using parametric and nonparametric approaches gave similar results with respect to farm ranking, although absolute levels of technical efficiency differed. As reported in other studies, the levels of technical efficiency measured by the nonparametric approach tend to be higher than the levels of technical efficiency estimated by the parametric methods. The parametric estimation used a Cobb-Douglas production frontier and the 'within estimator' was selected by the Hausman-Taylor test as the estimator that best described the data.

The average levels of technical efficiency (42.2 percent for the parametric and 61.3 percent for the nonparametric methods) showed that there is room to improve the levels of technical efficiency of the farms belonging to each one of the farming systems. This means that improvements in farm management and consequently in the best combination of input use could in the future be one of the ways that farmers should pursue with the objective of increasing the profitability of their farms. The need to improve the level of technical efficiency would be higher for the farms belonging to the ES and SIS farming systems, while the farms belonging to the IS farming system show lower requirements.

A further decomposition of nonparametric level of technical efficiency (OTE) showed that a significant proportion of the inefficiency observed was due to pure technical (average value 77.6) and scale (average value 84.3) efficiency, while congestion efficiency (average value 93.9) made a smaller contribution to inefficiency. Improvements in the levels of technical efficiency would demand not only a better use of inputs but also increases in the size of farms since the majority of them are located in the increasing returns to scale range. For those farms in which inputs were constraining production, land was found to be the input with the higher shadow price, or more able to generate higher increases in technical efficiency if one more unit of it was available, while for the farms that were inefficient the inputs that were more frequently in excess were land and machinery.

When farm size is expressed in hectares, larger farms are less efficient than smaller farms, while when size is expressed in the volume of sales larger farms are more efficient than smaller farms. A direct relationship between the levels of technical efficiency and the rates of growth of farms was not found, but for farms with the same size the ones that grow faster show higher levels of technical efficiency.

The relationship between technical efficiency and other farm characteristics such as experience, land ownership, irrigation, labour type, livestock and specialization showed that improvements in the level of technical efficiency would be more important for those farms in which farmers are more than 40 years of age, diversified, and specialized in livestock production in particular sheep production.

A growth model was built to study the impact of the 1992 CAP reform on Alentejan farms. Nine farms with different farm sizes were selected and analyzed, recognizing that farm development and growth depends upon farm size and farming system. Two scenarios were simulated: 1) considering that the level of technology and farm size was maintained constant, and 2) considering improvements in the level of the technologies used and increases in farm size (with exception of area size). This second scenario incorporated the need to improve the levels of pure technical and scale efficiency of Alentejan farms referred to above.

For the first scenario considered, farm income decreases for all farms during the period 1992-2000 and the survival of the SIS-M, PLS-S, PLS-M and ES-L farms will be difficult in the long-term without improvements in the technologies and size of the farms. The simulation of the second scenario resulted in an improvement in the profitability of all farms, but the income generated for farmer consumption is still close of the minimum requirement levels (minimum wage rate for agriculture) for the SIS-M, PLS-S, PLS-M and ES-L farms.

The results obtained from the two scenarios analyzed suggested that the development of Alentejan farms will depend on their farm size and on the farming system that farms belong to. For the farms belonging to the SIS, ES and PLS, the best development strategy will be through the growth and improvement of livestock activities, since most of the cereal activities that used to be an important component of their economic activity are already not profitable or will not be in the near future. This strategy to be implemented demands an effort of investment in herd growth and related durable inputs, in particular for the farms belonging to the PLS and SIS farming systems. Farmers belonging to the ES farming system will be at an advantage when compared with the PLS and SIS farms, because they are already specialized in livestock production, and could proceed to annual and gradual increases in their herd size with animals born on their farms.

If the above strategy is followed for the SIS, ES and PLS farms, small and medium-sized farms will struggle in the long-run to survive, because the income generated will not be able to remunerate adequately the investments made and the family labour employed. These results are confirmed by the most recent data available which showed that the number of small farms have decreased substantially between 1989 and 1993 (INE, 1995). The survival of the small and medium sized farms will demand increases in area size or probably the transformation of full-time into part-time farmers. This hypothesis was not tested, but increases in area size will depend on farmers' capacity to buy or rent more land and the availability of land in the market. Land shadow prices would tend to decrease during the period analyzed, suggesting a scenario in which there will be enhanced commercial incentives for some farms to expand their scale of operation by acquiring (or renting) the land of their neighbours.

The increase in part-time farming will mainly depend on the availability of new jobs outside agriculture, the willingness of farmers to accept a new activity and farmers' skills to fulfil the jobs available. At the moment, the age and labour skills of Alentejan farmers as well as the rate of unemployment in the region, are likely to act as a barrier to such attempts to complement farm income with off-farm work.

Regarding farms belonging to the IS farming system, these farms will not have many difficulties in surviving in the long-run, although for the IS small and medium farms, their survival will demand that cereal activities be associated with livestock activities, in particular sheep production, which is well adapted as a complementary activity to cereal production. Regarding the intensive small farms, the existence of a reasonable herd size complementary to cereal production will demand the renting in of pasture land to satisfy the feed requirements of the herd during critical periods of the year.

The specialization in livestock production for the SIS, PLS, and ES farming systems and the correspondent abandoning of cereals activity will cause a decrease in input use, which will affect the labour, machinery and equipment, and intermediate inputs markets and consequently important aspects of the economy of the Alentejo region. This decrease in input use will reinforced by the fact that the simulations showed that intensive production technologies are not the best farm strategy in terms of livestock and crop production, and that for the majority of the activities studied, extensive or intermediate technologies are the best strategy that farmers can adopt to take full advantage of the agricultural policies in place.

Considering only the IS farming system, the above conclusions were reinforced by the inclusion of a quadratic response function for wheat with different levels of nitrogen use, which showed that the decrease in output prices led to a decrease in the optimum level of nitrogen use and output produced since the cereal subsidies are paid in terms of area cultivated. Although not tested due to lack of data, this conclusion if generalized to other crop activities that receive area payments could indicate that the best farm strategy could be an extensification towards the use of lower levels of variable inputs. In this situation the area subsidies received can represent for farmers the minimum expected net margin from crop activities. If this strategy is profitable for adoption by farmers of the different farming systems for the different crops, then the predictions of the model in terms of annual crops and income for the SIS, PLS and ES would have been different. This hypothesis was not tested due to lack of data in terms of output response to variable inputs for other crops and farming systems.

If farmers perceive extensification as one of the viable economic alternatives to their farming activities, this will have serious implications in the labour market of the region, in which agricultural workers represent a significant percentage of the agriculturally active population of many Alentejan rural communities. The number of unemployed agricultural workers will tend to rise and if alternative jobs are not available, migration to regional and national urban centres as well as to foreign countries will probably be the option taken by the more skilled labour, while the unskilled and older labour force will be confronted with long-term unemployment, and the government and national institutions will probably face the chronic emergence of latent social problems.

The additional simulations performed allowed us to conclude: that adoption of minimum tillage techniques, which is another extensification strategy that farmers can pursue, leads to an improvement in farm income due to a reduction of machinery costs; that farmers should accept the Community set aside schemes; and that a reduction in sheep prices, besides reducing farm income, slow down the growth of the herd size for some farms.

For the farms that will stay in agriculture the evolution of their profitability and income will be highly dependent on the subsidies received from the European Community and from the Portuguese government for the national aids that are available. Any decrease in the present level of subsidies will have a negative impact on farmer incomes principally for those in which the amount of direct subsidy payments received represents the additional margin for their activities that allow them to stay in business. This means that further reductions in the support of agriculture by the agricultural policies that are in place, will imply further adjustments in the agricultural sector of the region. Thus, any further reduction in the level of price support as a result of the GATT agreement would impact on farm revenues.

Farmers' dependence on agricultural subsidies is introducing a new economic element into the farmers' decision-making process which will have social and economic implications for their future. The direct subsidy element is substituting farmers' dependence on fixed agricultural prices, a practice that was institutionalized by the Estado Novo regime and maintained until 1986, in which prices were fixed at a level that covered farmers' costs. Although both elements are different and with distinct social and economic implications, they have in common the fact that farmers continue to be dependent on the government and state institutions to receive a significant proportion of their basic income. The implications of this change on farmers' behaviour towards modernization and adaptation to the new competitive economic environment that they are facing remain to be observed in the future.

The objective of this research was to look at the Alentejo agriculture from the view point of its farming systems, and to analyze different and related aspects such as growth, efficiency and farm development. The research approach taken based on the Alentejo farming systems proved to be consistent and able to be recommended for future research works about the Alentejo agriculture, as well as the importance of studying for each farming system farms belonging to different farm size classes.

This study also widened the scope of previous research undertaken about Alentejan agriculture and farming systems to include aspects related with efficiency and growth based on historical data, and to build a growth model to predict the future development of Alentejan farms based on linear programming techniques. This growth model proved to be a good instrument for analysing farm development and could be utilized in the future as a valuable and practical farm planning technique as well as for purposes of testing the long-run impact of alternative agricultural policies.

although further improvements to include other aspects such as area size changes, variability in production and environmental considerations (erosion) are desirable.

The estimation and measurement of technical efficiency allowed us to estimate and measure technical efficiency for the farming systems selected and to further decompose it into three components. At the same time a comparison between two alternative methodologies of estimating technical efficiency (parametric and nonparametric methods) and between the results obtained and those shown in similar studies performed with the same objective was undertaken. In general, the methodologies employed proved robust and suitable for the available data and hypotheses tested.

7.2 - LIMITATIONS

The research conducted in this study had two types of limitations that reduced the scope of the analysis: 1) limitations related to data and software availability, and 2) limitations resulting from the assumptions embodied in the methodologies used.

First, RICA data was made available in two different time periods. The data for 1988 was available at the beginning of the research, while the panel data for 1987-1991 was only made available when the farm growth models had already been built and the results obtained. This limitation meant that the selection of the farms as well as the model verification was undertaken based only on the first RICA data set available. Second, the program used to solve the liner programming models - SAS/OR - was made available with some delay; and limits were placed on computer time as well as program use. These limitations reduced the number of simulations, and precluded the inclusion of risk in the analysis.

With respect to the estimation and measurement of levels of technical efficiency the conclusions should take into consideration the limitations due to the quality of the RICA data set, the omission of some variables such as management and risk, and the non-inclusion of quality differences between family and hired labour and between the different types of hired labour.

Regarding the farm growth model, besides the limitations derived from the linear programming assumptions, the conclusions drawn should also take into consideration that: 1) yield variability was not considered, which led to a worse approximation between the models built and the results obtained with the reality, 2) the results obtained for each one of the nine farms cannot be generalized in a direct manner for all farms by size class and farming system since farm growth depends upon farming system and farm, 3) the scenarios considered do not represent all the alternatives that farmers may have in terms of growth, technologies and activities available, and 4) for the second scenario analyzed it was assumed that the management capacities of farmers enable them to adopt the technologies considered and to take the opportunities for growth resulting from the model, and this might not be the case for some farmers.

7.3 - FUTURE RESEARCH

This research examined only four of the ten agricultural systems of Alentejo region, which implies that the permanent crop and forestry agricultural systems not analyzed in this study should also be considered in future studies either in terms of measuring the levels of technical efficiency or predicting their future development under the CAP reform.

Considering the life period of the activities involved in the permanent crop (wine, olive and fruit trees) and forestry agricultural systems, the prediction of its development will demand a longer programming model with the objective of analysing the revenue and cost flows during its full life period. With respect to Mediterranean forest, besides the agronomic research needed to preserve and improve its production potential, its economic viability should be evaluated not only in association with forage and livestock production activities, but also considering the positive externalities that this natural forestry ecosystem is able to generate, when compared with more intensive forestry activities that present negative externalities in the long-run.

With the availability of RICA data for the period post 1991, the measurement of the levels of technical efficiency of the farming systems studied through the parametric and nonparametric methods could be improved, and a comparison between the results obtained for the growth models of the nine farms selected with the real farm output could be made. It will also be reasonable to test if technical efficiency is time varying or not and to measure the rates of technical change of Alentejan farms, using both the parametric and nonparametric approaches.

For small and medium sized Alentejan farms, increases in area size as well as off-farm job opportunities were not directly tested in this research. Testing these two hypothesis should be a priority in future studies with the objective of evaluating the minimum area size of farms to be able to survive under the CAP and to test the competitiveness between on-farm and off-farm jobs respectively in Alentejo region.

If data becomes available on output response to different levels of variable input use for the different crops that benefit from area subsidies, then it will be of interest from the view point of farmers to calculate the minimum variable input use in order to maximize the profits of crop activities considering market prices and area payments.

Variability in yield levels of crop and livestock activities due to weather changes were not incorporated in the growth model of Alentejan farms since average yields were considered. The inclusion of yield variability in the programming model of farm growth through the use of risk programming techniques with the objective of relating farm growth with risk and to define the best strategies of farm growth in a risky environment should be considered in future studies to complement the results obtained in this research.

With respect to the methodological approach followed for the farm growth model built in which a multiperiod linear programming approach was chosen, computing problems were found in solving the models due to the size of the matrices and the presence of integer variables. A future alternative strategy to be developed and tested would be the utilization of a pure recursive linear programming approach, in which the sequence of the different years could be linked together through the appropriate transfer variables using computing programming techniques compatible with the linear programming algorithm chosen, in such a way that the output for the transfer variables of one year enters directly as the input for the next year. This approach would solve the model for the years in consideration at once and would reduce significantly the computing time needed, but will demand the inclusion and the knowledge about the flexibility constraints that bind in each year the growth of some farm variables.

In a broader perspective, a future research priority will be the identification of the zones or counties that will be most affected by the negative impact of the CAP in coming years, and to find alternative ways of softening that impact in order to create conditions to increase the levels of employment and income in the Alentejo rural areas. This demands integrated and objective studies about the future role and weight of the different sectors of activity in the zones and counties identified and their linkage with the regional economy and development strategy. Considering that the Alentejo region did not suffer the negative impacts of the industrial and urban development that occurred in Portugal during the last two to three decades, resulting in a rural and urban landscape that is very well preserved, tourism in its urban and rural forms complemented with recreational activities could be an alternative, but should not be the only one to be considered in those studies.

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APPENDIX I

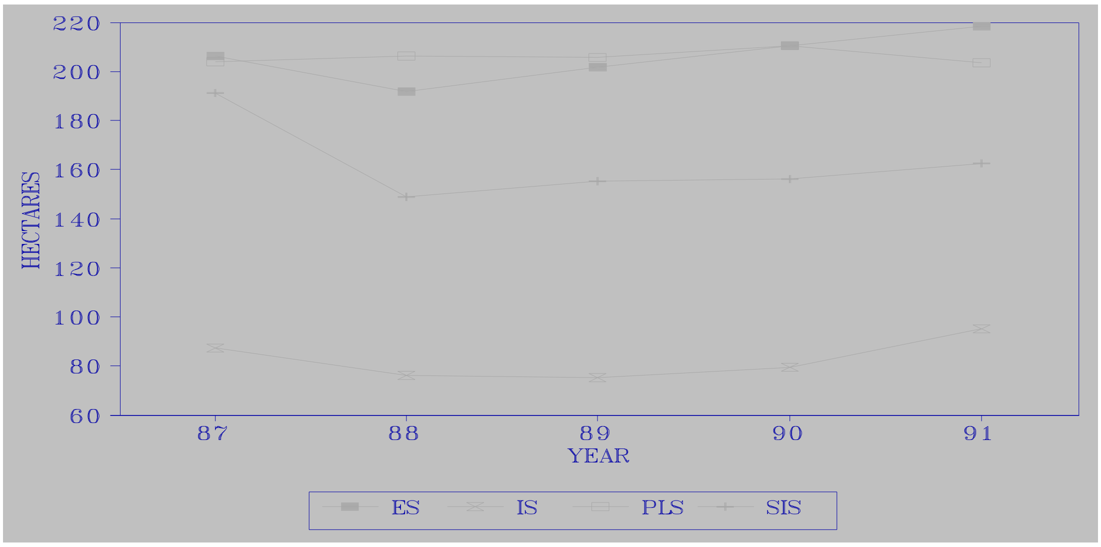

Figure 1 - Average Farm Size by Farming System

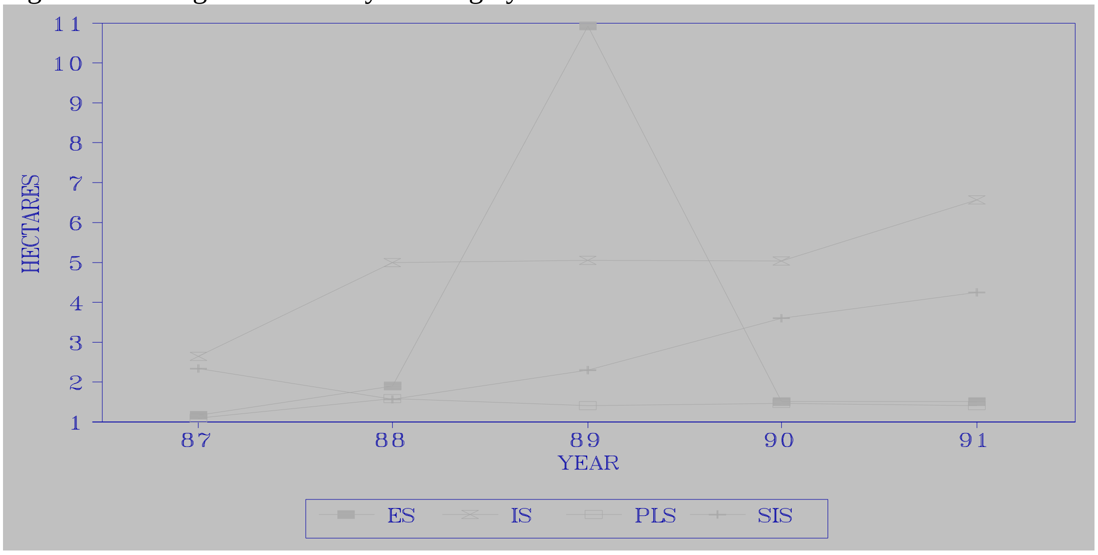

Figure 2 - Average Irrigated Area per Farm by Farming System

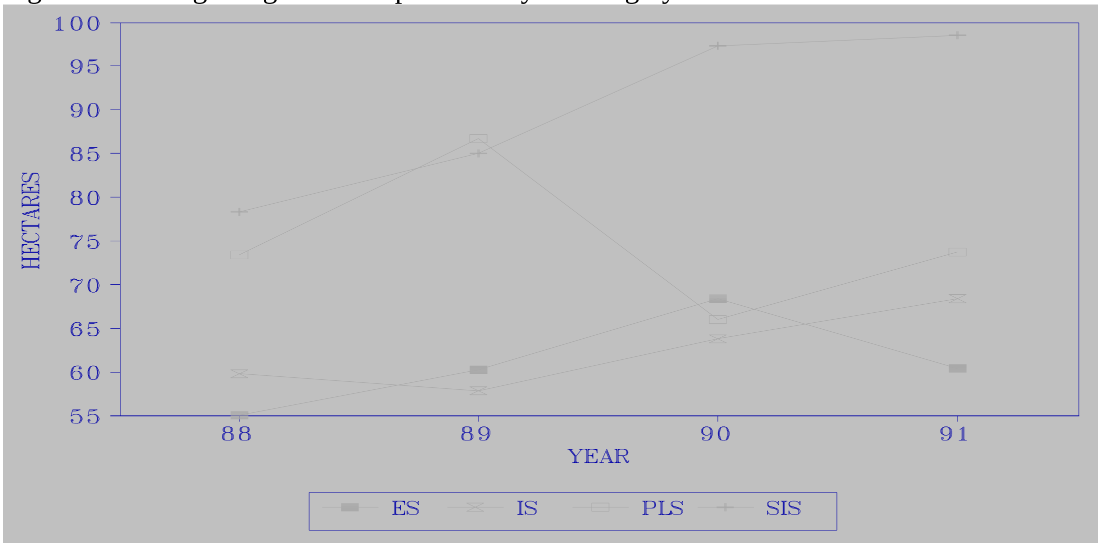

Figure 3 - Average Cultivated Land per Farm by Farming System

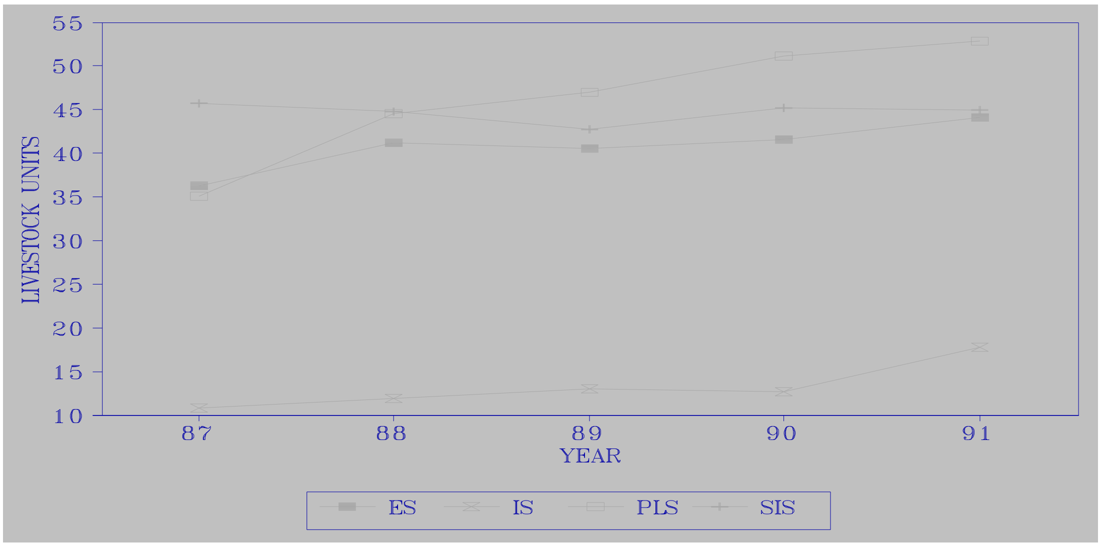

Figure 7 - Average Livestock Herd per Farm by Farming System

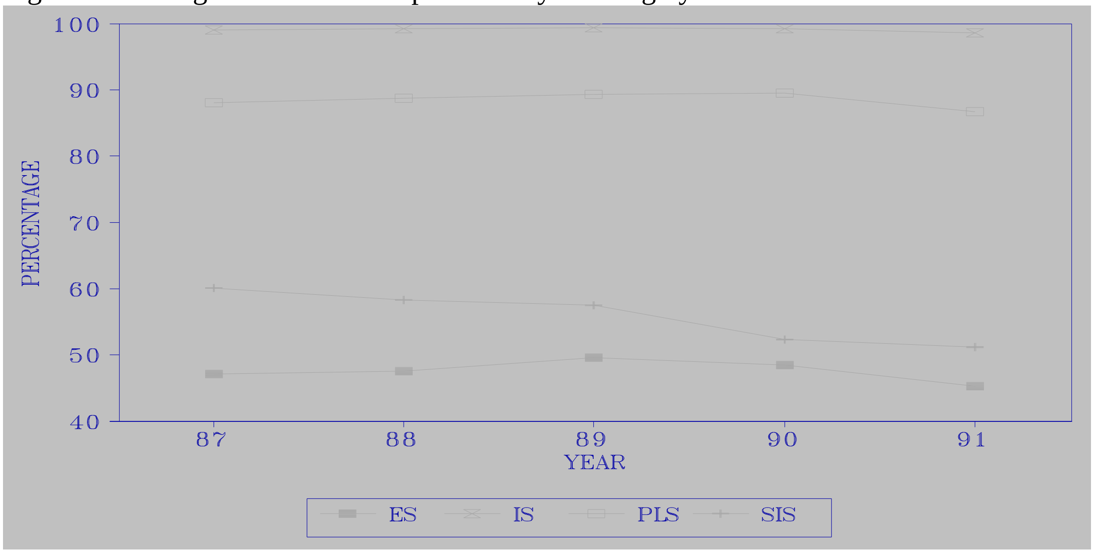

Figure 8 - Percentage of Sheep in Total Livestock Herd by Farming System

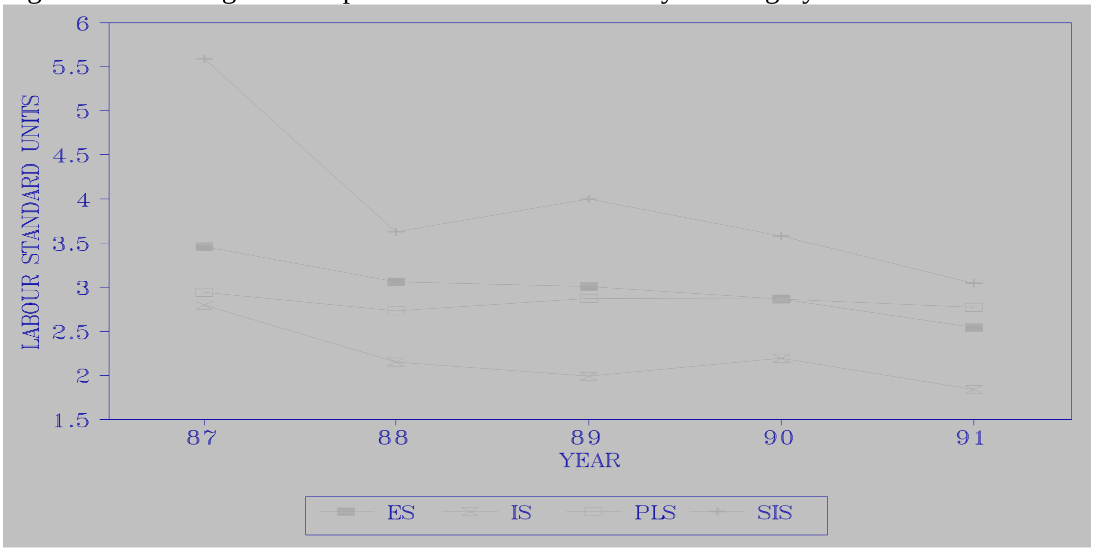

Figure 9 - Average Labour Size per Farm by Farming System

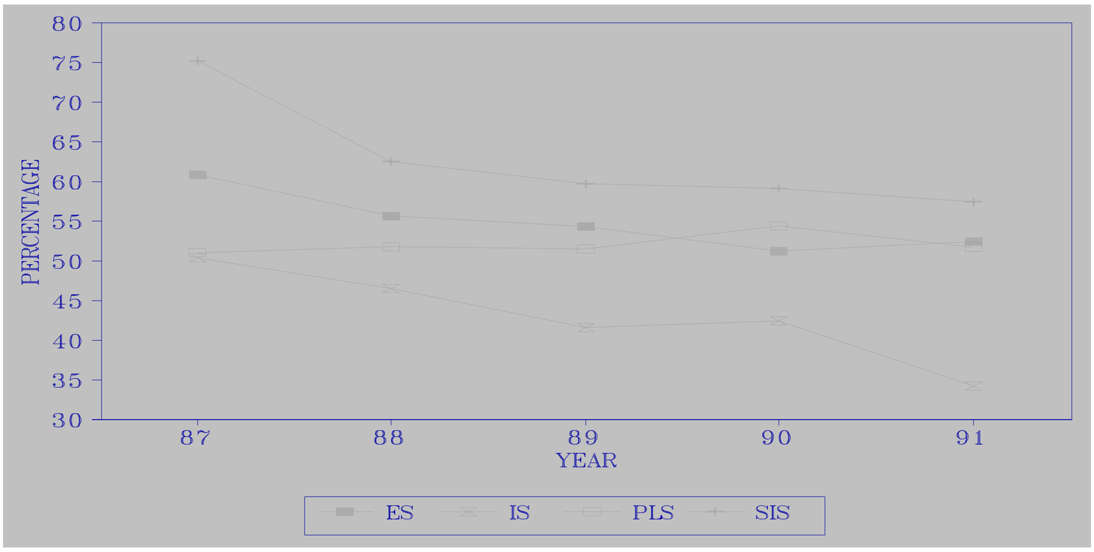

Figure 10 - Percentage of Hired Labour in Total Labour by Farming System

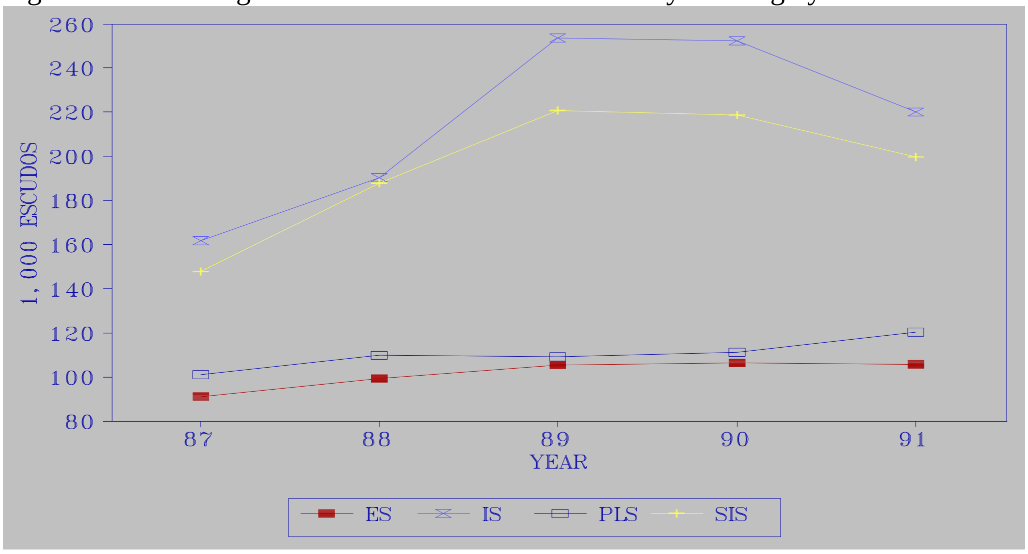

Figure 11 - Average Total Capital per Hectare by Farming System

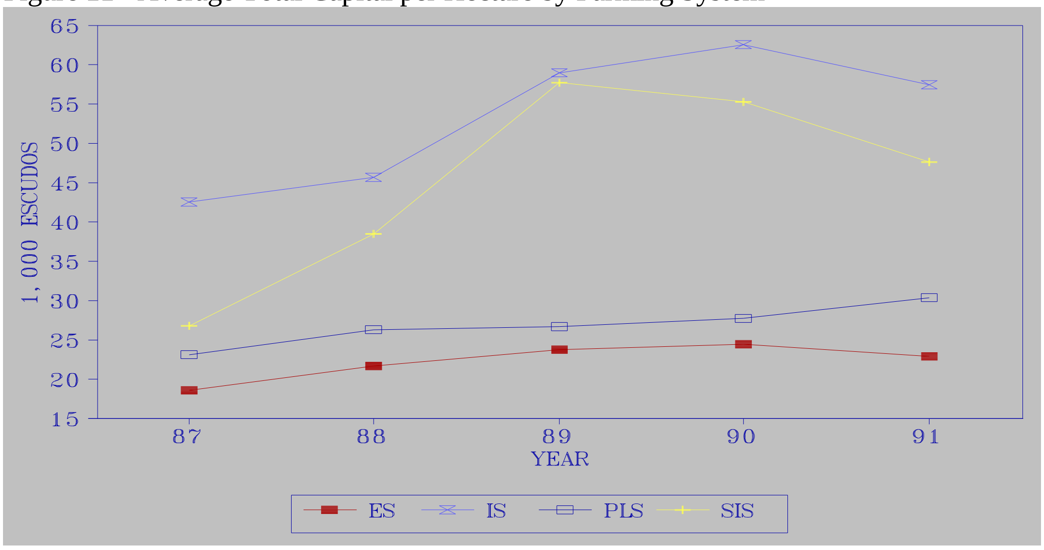

Figure 12 - Average Machinery and Equipment Capital per Hectare by Farming System

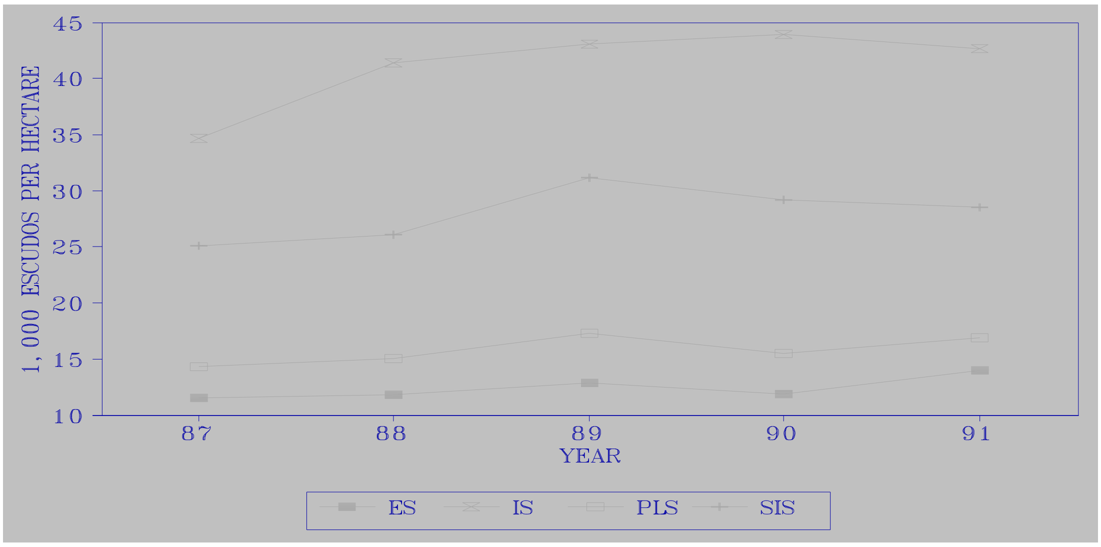

Figure 13 - Average Intermediate Costs per Hectare by Farming System

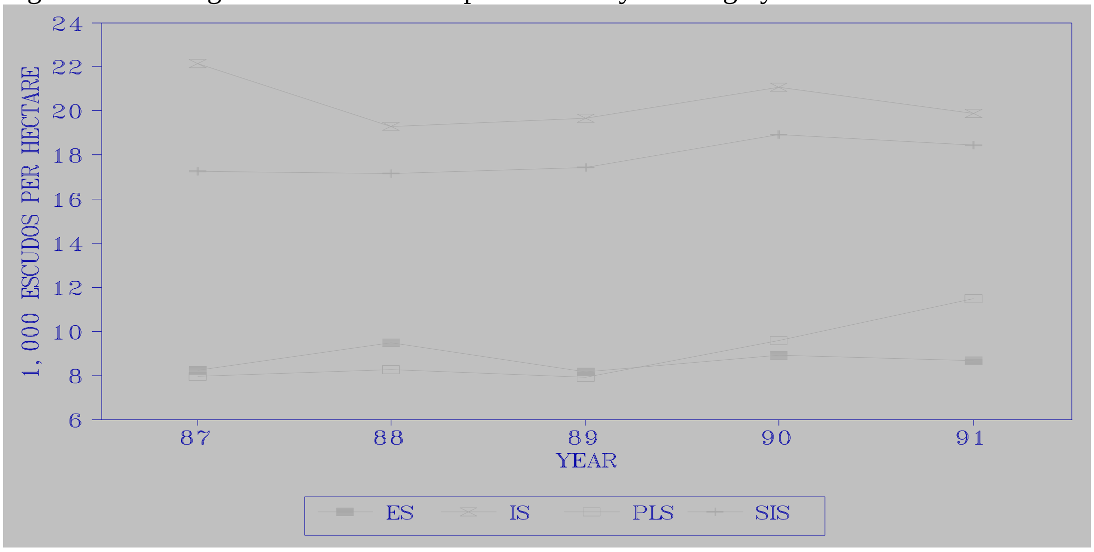

Figure 14 - Average Fixed Costs per Hectare by Farming System

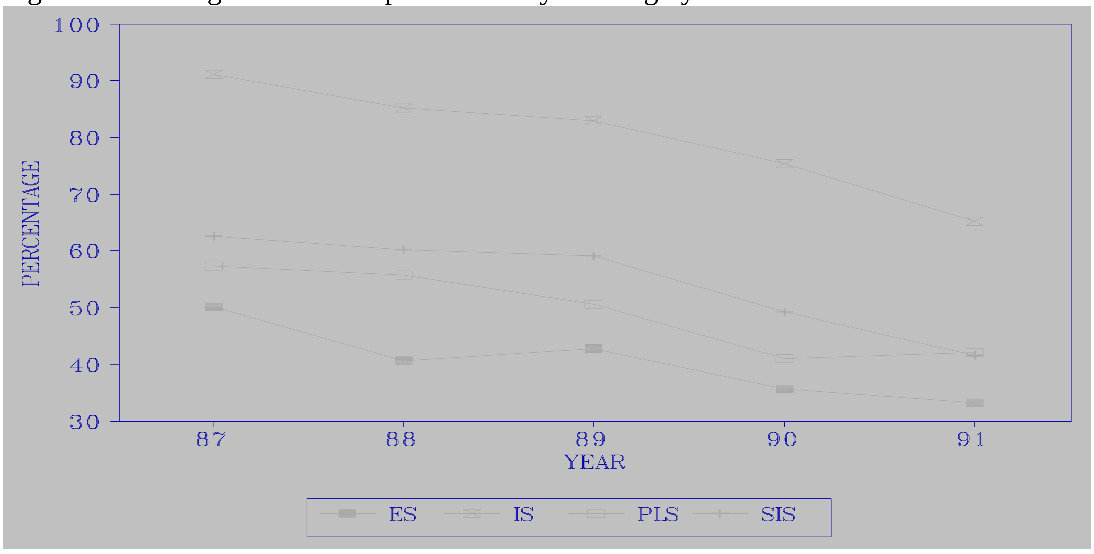

Figure 15 - Percentage of Crop Product in Total Product by Farming System

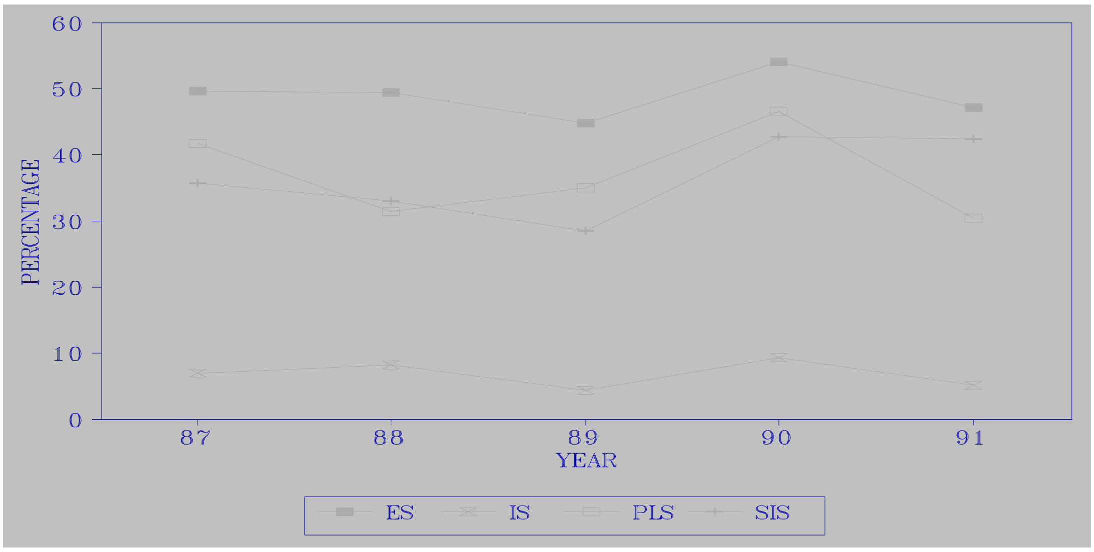

Figure 16 - Percentage of Livestock Product in Total Product by Farming System

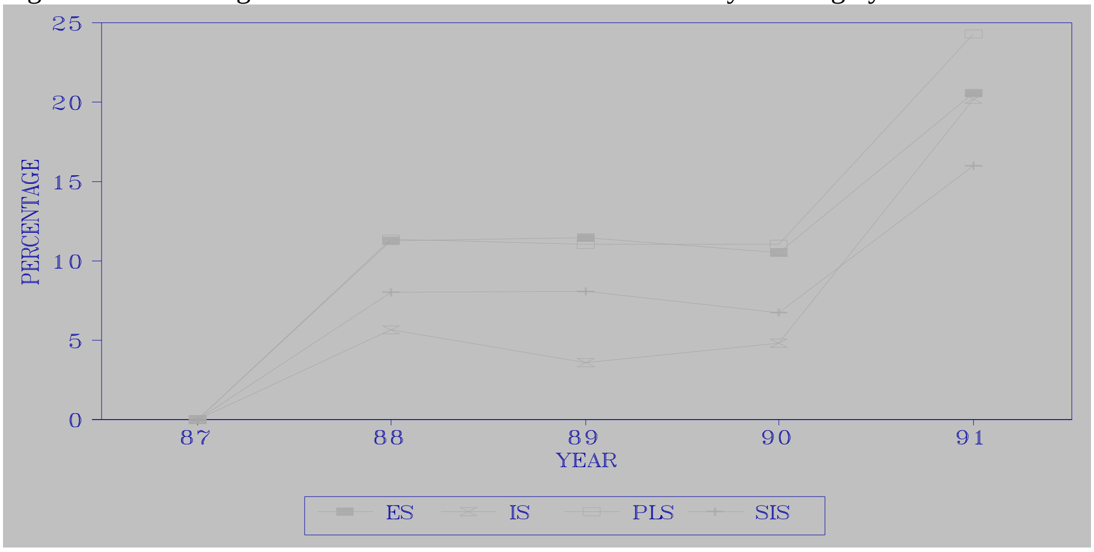

Figure 17 - Percentage of Subsidies in Total product by Farming System

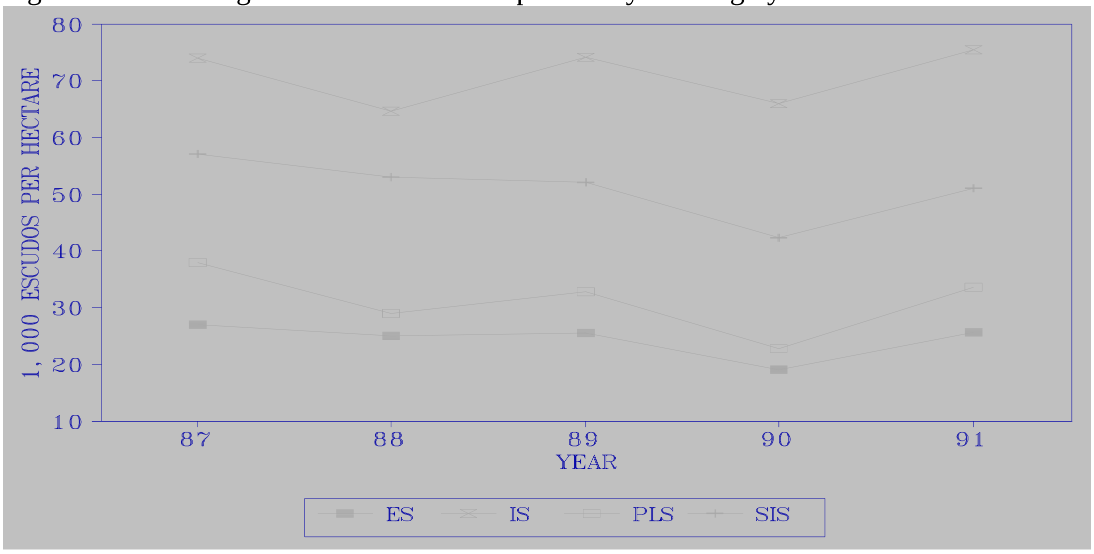

Figure 18 - Total Product per Hectare by Farming System

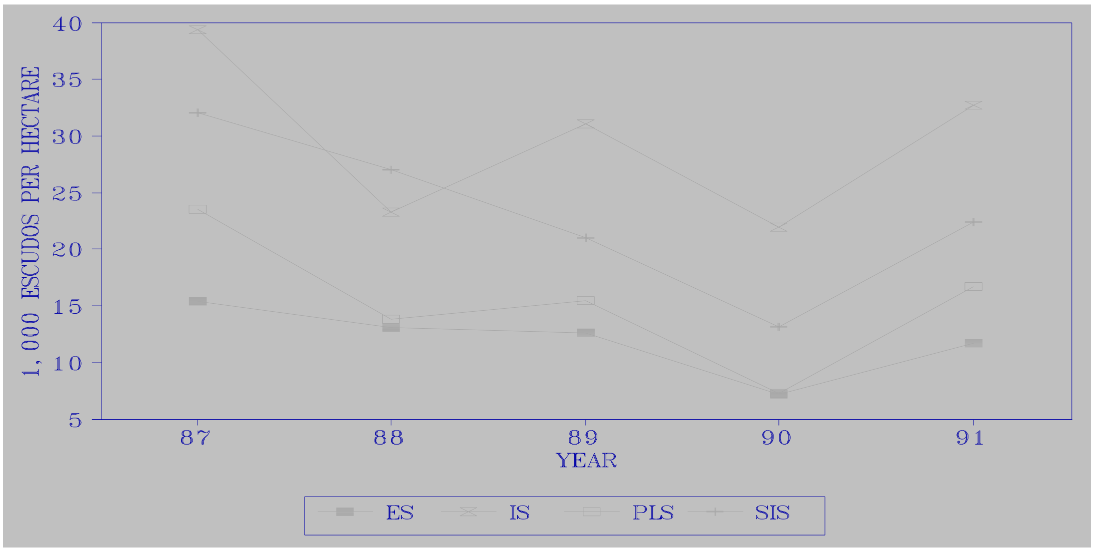

Figure 19 - Value Added per Hectare by Farming System

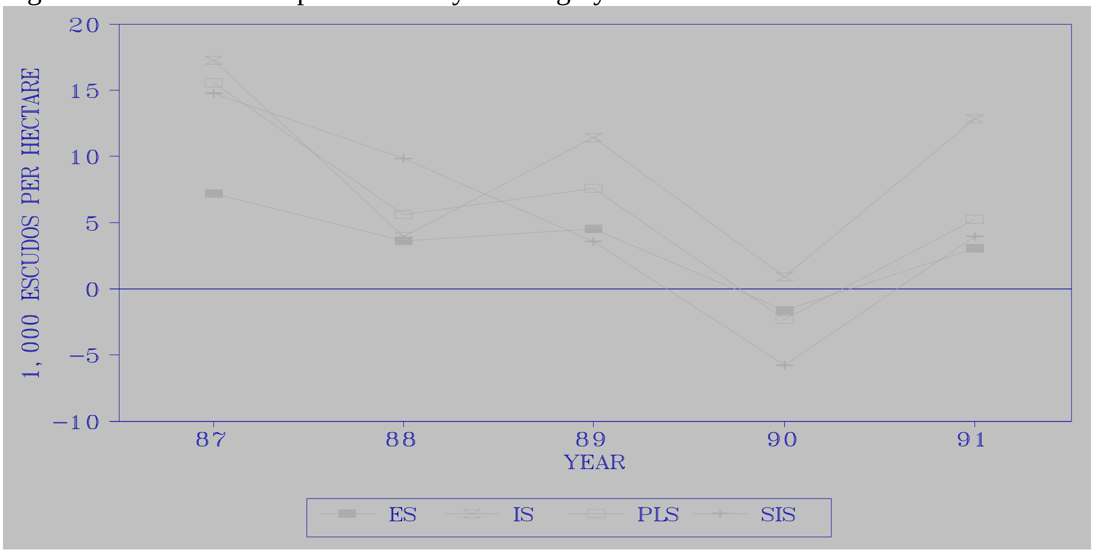

Figure 20 - Net Income per Hectare by Farming System

APPENDIX II

Table 1 - Output and Input Quantities Used to Evaluate Technical Efficiency by Farming System and Year

Farm Number	Farming System	Year	Product	Land	Labour	Crop Livest.	Machinery Equipment
50201	ES	1987	1964	100	8040	381	139
50204	ES	1987	1101	271	19704	791	181
50208	ES	1987	3717	316	13392	1799	401
50217	ES	1987	2152	136	8304	425	189
50218	ES	1987	1036	12	5376	376	61
50220	ES	1987	1852	68	3696	319	284
50300	ES	1987	780	70	3576	390	225
50301	ES	1987	13923	491	29880	3487	871
50302	ES	1987	3527	183	9096	1099	512
50316	ES	1987	1004	69	2832	233	33
50317	ES	1987	3182	75	5880	643	254
50318	ES	1987	972	115	2400	493	261
50319	ES	1987	670	94	2808	146	74
50321	ES	1987	2028	113	19224	414	705
50322	ES	1987	1686	379	12600	636	170
50323	ES	1987	6572	319	21216	1946	1400
50412	ES	1987	2024	21	5520	320	272
50413	ES	1987	9451	113	11952	1363	1368
52536	ES	1987	7208	93	6312	1164	431
52561	ES	1987	972	4	2928	848	78
52567	ES	1987	792	16	2808	274	220
52568	ES	1987	2332	24	3696	1160	185
55027	ES	1987	4138	66	6048	731	506
55038	ES	1987	7215	103	17328	903	1831
55052	ES	1987	10158	108	5784	882	704
55053	ES	1987	4599	80	2400	1012	781
56006	ES	1987	4312	124	6336	575	332
56020	ES	1987	9064	279	10032	2170	1381
50021	IS	1987	3883	145	9792	343	240
50039	IS	1987	7288	79	3720	569	2351
50044	IS	1987	1563	69	3216	186	189
50047	IS	1987	366	16	4824	34	18
50056	IS	1987	2765	35	3240	337	610
50060	IS	1987	9609	796	19848	1180	1620
55004	IS	1987	1870	69	6816	341	316
55010	IS	1987	7897	500	6720	651	609
55011	IS	1987	787	63	4008	143	168
55013	IS	1987	946	63	6120	204	143
55014	IS	1987	4157	145	2640	526	160
55017	IS	1987	3985	284	3048	1003	514
55019	IS	1987	1319	48	6912	466	306
55020	IS	1987	11659	315	4080	1041	816
55021	IS	1987	3044	172	2400	536	191
55026	IS	1987	4011	132	2496	581	430
55035	IS	1987	14373	1229	20616	1371	736
55055	IS	1987	19529	901	7824	3775	3568
56011	IS	1987	5619	161	9216	658	342
50045	PLS	1987	1247	156	3720	584	505
52527	PLS	1987	2835	152	8568	489	273
52538	PLS	1987	1239	35	5688	122	41
52541	PLS	1987	4471	186	2952	1310	587
52545	PLS	1987	13961	468	9432	1545	1045
52553	PLS	1987	1528	19	2904	283	126
52556	PLS	1987	14753	394	23904	978	1196

52558	PLS	1987	9678	66	5904	802	319
52559	PLS	1987	1123	17	3840	85	228
52560	PLS	1987	2986	38	3840	205	360
52563	PLS	1987	5800	111	2592	643	516
52564	PLS	1987	15323	507	12816	2498	1646
52565	PLS	1987	8408	274	6144	660	1485
52566	PLS	1987	5375	131	5088	987	434
52569	PLS	1987	4200	56	3792	437	165
53752	PLS	1987	1494	228	9504	673	517
53762	PLS	1987	16922	187	8280	4480	651
53766	PLS	1987	23915	547	17856	1103	1005
54007	PLS	1987	1464	120	8640	426	233
55015	PLS	1987	4287	612	2904	952	388
55018	PLS	1987	435	42	2520	90	142
56003	PLS	1987	3286	209	12120	1592	317
56004	PLS	1987	763	13	5112	160	215
56015	PLS	1987	1287	327	7032	327	327
56018	PLS	1987	2753	1217	8256	971	472
56019	PLS	1987	5397	215	7368	1677	180
56021	PLS	1987	12474	678	21048	2057	1495
50005	SIS	1987	7770	777	18192	1353	1669
50006	SIS	1987	2459	292	16920	624	396
50012	SIS	1987	40481	1137	109440	6024	3498
50026	SIS	1987	5828	48	15648	2217	169
50038	SIS	1987	4633	108	4872	764	161
50049	SIS	1987	2077	201	2904	740	198
50050	SIS	1987	2929	81	6936	637	46
50058	SIS	1987	1956	51	5088	350	196
50207	SIS	1987	5405	687	6528	2039	506
50212	SIS	1987	3371	61	9072	632	416
50303	SIS	1987	9380	297	13296	1188	581
50304	SIS	1987	1444	51	5856	196	216
50305	SIS	1987	2968	53	6552	726	132
50418	SIS	1987	11326	299	15144	1213	927
52510	SIS	1987	2078	194	8160	1022	654
52512	SIS	1987	4320	219	15552	791	363
52517	SIS	1987	5349	93	8064	1034	585
52529	SIS	1987	4951	271	10200	250	240
52562	SIS	1987	19256	926	19944	4439	1966
53759	SIS	1987	2063	12	3840	819	159
54001	SIS	1987	783	3	4200	68	51
54003	SIS	1987	4289	171	7272	438	234
54005	SIS	1987	5006	173	12960	1549	1618
56001	SIS	1987	24725	348	16800	2024	956
56002	SIS	1987	1733	43	6384	189	265
56008	SIS	1987	7579	378	25464	2532	707
50201	ES	1988	1044	107	4848	353	274
50204	ES	1988	1350	278	13752	828	160
50208	ES	1988	1538	325	16152	1503	266
50217	ES	1988	1804	157	7392	467	157
50218	ES	1988	1373	13	7272	603	38
50220	ES	1988	1781	69	4824	791	259
50300	ES	1988	423	27	5712	311	198
50301	ES	1988	10299	590	37248	4403	1224
50302	ES	1988	3055	188	7248	1565	693
50316	ES	1988	695	77	2760	194	85
50317	ES	1988	1818	77	3408	482	348
50318	ES	1988	706	118	2472	592	411
50319	ES	1988	1011	96	2640	280	19
50321	ES	1988	1136	115	9216	459	485

50322	ES	1988	2843	224	11880	620	177
50323	ES	1988	444	135	8736	338	75
50412	ES	1988	1647	22	5208	454	217
50413	ES	1988	9905	116	8784	1683	1666
52536	ES	1988	9651	96	10032	1529	664
52561	ES	1988	1163	4	2808	847	168
52567	ES	1988	881	17	2400	319	237
52568	ES	1988	3321	25	8136	1579	215
55027	ES	1988	3194	80	4800	606	471
55038	ES	1988	2950	106	6144	392	1469
55052	ES	1988	8498	111	4800	1894	1285
55053	ES	1988	2292	82	2400	1206	669
56006	ES	1988	2970	127	7608	745	381
56020	ES	1988	8785	287	11400	2393	1698
50021	IS	1988	3880	160	5856	363	163
50039	IS	1988	8586	125	2448	1127	1970
50044	IS	1988	1251	76	1176	186	172
50047	IS	1988	548	26	4200	31	21
50056	IS	1988	2782	87	3552	293	572
50060	IS	1988	4405	59	792	385	984
55004	IS	1988	2031	76	5256	830	302
55010	IS	1988	9147	590	8448	1260	927
55011	IS	1988	1023	69	4608	127	347
55013	IS	1988	1577	69	3000	186	53
55014	IS	1988	2539	160	2592	531	506
55017	IS	1988	3076	312	3072	1287	376
55019	IS	1988	1543	53	6168	630	368
55020	IS	1988	7117	347	5208	810	633
55021	IS	1988	1958	189	2400	508	283
55026	IS	1988	2194	146	2400	414	430
55035	IS	1988	6921	1354	20088	976	861
55055	IS	1988	10419	993	12000	3071	3248
56011	IS	1988	3153	132	4800	665	550
50045	PLS	1988	1542	121	5808	591	460
52527	PLS	1988	664	119	5616	244	83
52538	PLS	1988	347	28	4680	52	71
52541	PLS	1988	9315	145	2760	1029	780
52545	PLS	1988	4165	366	8280	1660	988
52553	PLS	1988	1112	32	3408	313	102
52556	PLS	1988	9545	308	29736	1454	1284
52558	PLS	1988	4528	52	5640	913	514
52559	PLS	1988	1103	14	3000	122	130
52560	PLS	1988	2734	30	3264	401	272
52563	PLS	1988	2253	87	3168	803	364
52564	PLS	1988	11947	396	10008	1927	1470
52565	PLS	1988	5573	214	5568	1234	1111
52566	PLS	1988	5651	102	3816	553	392
52569	PLS	1988	3978	52	4128	145	420
53752	PLS	1988	1122	178	9288	590	350
53762	PLS	1988	7768	146	6576	7354	749
53766	PLS	1988	2948	443	9576	698	905
54007	PLS	1988	1218	94	7056	448	291
55015	PLS	1988	3221	479	4800	1679	1155
55018	PLS	1988	821	33	4392	81	100
56003	PLS	1988	6543	163	10920	1109	429
56004	PLS	1988	462	11	5232	217	204
56015	PLS	1988	2018	256	5328	552	414
56018	PLS	1988	2408	952	7872	908	360
56019	PLS	1988	7046	169	8208	2290	106
56021	PLS	1988	9267	557	18144	2598	1478

50005	SIS	1988	10135	642	5448	2138	1163
50006	SIS	1988	2234	252	16368	500	332
50012	SIS	1988	3077	59	4320	290	543
50026	SIS	1988	7183	41	7200	3421	219
50038	SIS	1988	2458	91	5088	1034	216
50049	SIS	1988	1246	166	5640	782	125
50050	SIS	1988	2290	68	6168	1058	374
50058	SIS	1988	1710	43	6000	209	102
50207	SIS	1988	2099	224	7200	801	603
50212	SIS	1988	1185	119	6672	633	306
50303	SIS	1988	2778	253	12528	642	377
50304	SIS	1988	968	43	2760	212	214
50305	SIS	1988	1254	43	7320	612	234
50418	SIS	1988	18111	255	15552	2832	2026
52510	SIS	1988	2321	166	8232	1050	327
52512	SIS	1988	6693	187	12600	979	855
52517	SIS	1988	5777	79	5400	1755	638
52529	SIS	1988	3640	233	7440	699	372
52562	SIS	1988	16486	791	21360	4503	1975
53759	SIS	1988	882	10	3600	1321	154
54001	SIS	1988	534	3	4488	70	40
54003	SIS	1988	3409	146	4608	615	288
54005	SIS	1988	4115	148	12480	1232	1245
56001	SIS	1988	25264	230	31824	2713	1778
56002	SIS	1988	1823	36	5856	261	278
56008	SIS	1988	7597	312	17736	1730	751
50201	ES	1989	460	103	4272	271	202
50204	ES	1989	1256	256	17976	919	157
50208	ES	1989	3000	325	14832	1065	409
50217	ES	1989	941	104	10800	449	308
50218	ES	1989	967	13	7560	482	23
50220	ES	1989	1324	34	4800	555	286
50300	ES	1989	450	26	5376	200	207
50301	ES	1989	5456	572	32712	3867	1126
50302	ES	1989	6302	181	8928	1802	995
50316	ES	1989	1066	74	3096	198	65
50317	ES	1989	509	74	2928	419	239
50318	ES	1989	933	113	2928	572	380
50319	ES	1989	977	92	3360	460	10
50321	ES	1989	804	190	10392	417	148
50322	ES	1989	3409	368	14400	882	559
50323	ES	1989	651	145	2664	344	91
50412	ES	1989	3152	22	4992	1026	206
50413	ES	1989	7051	121	8256	1395	1788
52536	ES	1989	6323	117	9408	1669	725
52561	ES	1989	579	4	2400	684	138
52567	ES	1989	798	16	4992	280	237
52568	ES	1989	5884	24	4152	2668	181
55027	ES	1989	4600	61	5136	593	555
55038	ES	1989	5222	82	7920	652	934
55052	ES	1989	7013	109	4152	966	1267
55053	ES	1989	4772	80	2400	1212	651
56006	ES	1989	5131	122	5568	825	380
56020	ES	1989	9471	280	10104	2475	1924
50021	IS	1989	3052	96	8040	249	210
50039	IS	1989	6329	99	2280	911	1707
50044	IS	1989	1128	46	1392	328	162
50047	IS	1989	262	7	4392	39	62
50056	IS	1989	2716	52	4248	283	586
50060	IS	1989	2556	36	816	473	1061

55004	IS	1989	1058	46	5352	410	461
55010	IS	1989	7408	357	5208	1487	533
55011	IS	1989	652	25	3048	201	222
55013	IS	1989	1101	43	3576	128	78
55014	IS	1989	3604	89	2256	440	506
55017	IS	1989	7495	158	2400	1854	981
55019	IS	1989	1135	32	8784	668	354
55020	IS	1989	12295	215	4392	1200	636
55021	IS	1989	3155	114	2808	382	430
55026	IS	1989	3076	88	2400	451	329
55035	IS	1989	9661	818	13032	795	855
55055	IS	1989	13582	600	8832	2447	3049
56011	IS	1989	3971	80	7392	658	605
50045	PLS	1989	1904	108	6000	578	455
52527	PLS	1989	1510	98	4800	223	148
52538	PLS	1989	745	24	3648	68	83
52541	PLS	1989	6735	128	5160	1515	590
52545	PLS	1989	8085	324	9024	1316	904
52553	PLS	1989	948	22	3480	253	191
52556	PLS	1989	6542	257	28632	1026	1064
52558	PLS	1989	5664	48	5280	881	416
52559	PLS	1989	737	13	2712	86	127
52560	PLS	1989	1742	26	3888	221	193
52563	PLS	1989	4226	79	3000	837	467
52564	PLS	1989	10020	352	9264	1994	1589
52565	PLS	1989	6875	189	6888	1673	1204
52566	PLS	1989	3781	93	5232	590	341
52569	PLS	1989	2949	46	4056	525	229
53752	PLS	1989	1936	159	8400	812	790
53762	PLS	1989	13729	128	6000	10167	871
53766	PLS	1989	2468	393	13752	569	866
54007	PLS	1989	1481	76	11136	282	239
55015	PLS	1989	6345	419	7464	1301	753
55018	PLS	1989	817	36	2712	181	539
56003	PLS	1989	3542	144	11760	1539	482
56004	PLS	1989	546	9	5040	176	123
56015	PLS	1989	3002	226	5808	589	386
56018	PLS	1989	2209	841	10392	993	472
56019	PLS	1989	6876	149	9168	4439	126
56021	PLS	1989	7771	491	13728	4167	1772
50005	SIS	1989	11659	340	14256	2631	1641
50006	SIS	1989	2303	227	9456	469	346
50012	SIS	1989	1923	64	5448	1846	896
50026	SIS	1989	6148	35	6000	2565	223
50038	SIS	1989	2114	82	4896	1080	292
50049	SIS	1989	1123	152	5640	970	81
50050	SIS	1989	1407	63	7200	852	261
50058	SIS	1989	1154	40	7992	388	193
50207	SIS	1989	1171	202	7200	749	1060
50212	SIS	1989	762	107	3840	532	283
50303	SIS	1989	2163	228	14880	883	615
50304	SIS	1989	803	39	4176	249	204
50305	SIS	1989	1109	41	2976	499	187
50418	SIS	1989	12192	245	13032	2078	1123
52510	SIS	1989	2297	150	11856	1199	313
52512	SIS	1989	4219	170	24000	1664	413
52517	SIS	1989	4869	75	3912	1133	566
52529	SIS	1989	1594	203	7560	706	422
52562	SIS	1989	24126	713	37368	4215	2293
53759	SIS	1989	1319	9	3600	831	647

54001	SIS	1989	978	3	4200	55	66
54003	SIS	1989	1193	210	12600	656	267
54005	SIS	1989	4321	427	17280	2370	1331
56001	SIS	1989	23989	206	14352	2841	4850
56002	SIS	1989	2364	33	10368	257	539
56008	SIS	1989	10248	290	14880	11371	1678
50201	ES	1990	524	112	3000	231	185
50204	ES	1990	963	278	17976	766	250
50208	ES	1990	3141	352	13656	952	497
50217	ES	1990	1421	112	10104	385	290
50218	ES	1990	1040	14	6600	713	17
50220	ES	1990	1872	72	4800	1129	281
50300	ES	1990	626	29	4920	250	136
50301	ES	1990	4960	620	29232	3094	1315
50302	ES	1990	3129	196	12624	1638	865
50316	ES	1990	1108	80	3120	293	72
50317	ES	1990	996	80	2544	420	202
50318	ES	1990	1696	123	2544	668	328
50319	ES	1990	1071	100	2496	423	52
50321	ES	1990	2290	206	6408	399	265
50322	ES	1990	4319	502	17592	997	499
50323	ES	1990	616	176	5592	378	67
50412	ES	1990	3668	26	4224	1103	210
50413	ES	1990	5915	131	7704	969	1652
52536	ES	1990	4221	127	4800	1653	823
52561	ES	1990	611	5	2400	350	214
52567	ES	1990	433	17	4800	226	199
52568	ES	1990	2515	26	2592	1061	134
55027	ES	1990	2268	66	3600	674	780
55038	ES	1990	6587	111	8976	365	838
55052	ES	1990	2748	118	3528	988	1254
55053	ES	1990	882	86	1992	362	554
56006	ES	1990	950	133	6096	400	275
56020	ES	1990	5079	300	12144	3521	1920
50021	IS	1990	3956	120	7968	268	182
50039	IS	1990	5665	123	2352	1323	1460
50044	IS	1990	1648	57	1488	305	132
50047	IS	1990	184	9	3360	18	16
50056	IS	1990	2829	65	4368	190	462
50060	IS	1990	3619	44	816	490	1265
55004	IS	1990	2016	57	6000	769	514
55010	IS	1990	9247	445	7872	1432	726
55011	IS	1990	937	59	2400	210	273
55013	IS	1990	1237	53	3600	66	201
55014	IS	1990	1125	110	1368	458	469
55017	IS	1990	5255	301	3744	1095	943
55019	IS	1990	1121	106	9912	1431	403
55020	IS	1990	7154	267	4896	1442	598
55021	IS	1990	1529	142	4800	277	384
55026	IS	1990	2043	110	2400	302	304
55035	IS	1990	6620	1017	16128	799	919
55055	IS	1990	10029	746	8976	1834	3249
56011	IS	1990	2097	99	7632	622	702
50045	PLS	1990	1522	96	6000	447	555
52527	PLS	1990	640	91	5664	195	167
52538	PLS	1990	1111	22	4536	35	86
52541	PLS	1990	7037	115	3600	1382	534
52545	PLS	1990	3888	289	8616	991	889
52553	PLS	1990	1364	20	3720	423	272
52556	PLS	1990	3849	325	27288	1123	1276

52558	PLS	1990	3039	43	6072	663	458
52559	PLS	1990	1313	11	3648	97	77
52560	PLS	1990	2855	23	3384	391	209
52563	PLS	1990	2381	71	2400	692	562
52564	PLS	1990	6032	315	10032	1466	1093
52565	PLS	1990	1640	169	8208	1013	1244
52566	PLS	1990	1667	83	2832	750	300
52569	PLS	1990	1842	41	3312	190	214
53752	PLS	1990	1026	142	6696	623	379
53762	PLS	1990	8600	116	5904	4256	956
53766	PLS	1990	4877	352	13776	2239	798
54007	PLS	1990	1056	68	14832	559	220
55015	PLS	1990	4485	375	6312	1757	786
55018	PLS	1990	221	32	1344	76	96
56003	PLS	1990	3589	130	11784	1514	583
56004	PLS	1990	476	9	5520	167	170
56015	PLS	1990	2313	202	7608	627	571
56018	PLS	1990	3054	752	11136	1375	424
56019	PLS	1990	5379	134	8304	2380	192
56021	PLS	1990	6344	440	13728	2859	2038
50005	SIS	1990	10243	521	15144	2856	1847
50006	SIS	1990	2718	348	8304	409	347
50012	SIS	1990	2367	102	5616	2667	808
50026	SIS	1990	5306	54	6168	1849	173
50038	SIS	1990	2365	126	4464	695	401
50049	SIS	1990	630	233	3456	893	93
50050	SIS	1990	1477	97	6000	1097	281
50058	SIS	1990	1731	61	6096	228	201
50207	SIS	1990	1244	310	7200	475	908
50212	SIS	1990	2420	163	3264	608	223
50303	SIS	1990	2899	349	8568	721	694
50304	SIS	1990	695	60	3168	289	211
50305	SIS	1990	1934	62	3576	477	151
50418	SIS	1990	9657	380	14688	1274	1092
52510	SIS	1990	1985	229	12000	1183	283
52512	SIS	1990	7661	274	23280	1446	348
52517	SIS	1990	9365	115	5712	2976	595
52529	SIS	1990	1684	311	4968	659	487
52562	SIS	1990	11126	1092	27192	3446	3126
53759	SIS	1990	962	30	4392	754	118
54001	SIS	1990	526	4	3000	56	60
54003	SIS	1990	3477	322	9696	831	244
54005	SIS	1990	3402	641	17760	1630	1118
56001	SIS	1990	16520	318	11640	2490	4270
56002	SIS	1990	1535	51	10224	249	337
56008	SIS	1990	7516	447	14736	3265	1792
50201	ES	1991	1024	81	2736	248	161
50204	ES	1991	2137	202	17616	685	273
50208	ES	1991	3783	256	5592	1291	554
50217	ES	1991	1795	119	8688	398	267
50218	ES	1991	379	10	5040	444	15
50220	ES	1991	1098	52	4800	970	280
50300	ES	1991	365	21	4968	194	208
50301	ES	1991	11538	451	26400	2592	1263
50302	ES	1991	14543	143	5328	5091	1043
50316	ES	1991	1148	58	2328	207	48
50317	ES	1991	867	58	2712	295	154
50318	ES	1991	1677	89	2712	518	356
50319	ES	1991	1203	72	2856	381	56
50321	ES	1991	825	149	7776	316	40

50322	ES	1991	2106	365	13608	938	250
50323	ES	1991	755	128	5352	298	66
50412	ES	1991	3158	19	4632	906	211
50413	ES	1991	4594	95	7848	1100	1272
52536	ES	1991	3039	93	6144	1637	746
52561	ES	1991	706	3	2664	242	63
52567	ES	1991	646	13	4800	191	82
52568	ES	1991	711	19	3792	98	88
55027	ES	1991	4505	65	3168	1017	676
55038	ES	1991	3601	80	3552	815	769
55052	ES	1991	14715	145	5088	3248	1209
55053	ES	1991	5642	63	2400	919	566
56006	ES	1991	2997	97	8208	450	253
56020	ES	1991	4599	218	12264	3232	1850
50021	IS	1991	5253	128	7512	254	166
50039	IS	1991	9034	206	3600	1078	1453
50044	IS	1991	1806	61	1512	241	119
50047	IS	1991	336	10	3000	17	27
50056	IS	1991	4546	69	4296	272	480
50060	IS	1991	4116	47	816	614	779
55004	IS	1991	1903	61	5640	391	637
55010	IS	1991	9121	751	8064	1346	1019
55011	IS	1991	1138	63	2400	248	330
55013	IS	1991	1466	57	4800	105	401
55014	IS	1991	2282	117	1200	425	643
55017	IS	1991	4557	460	4512	1821	1069
55019	IS	1991	2208	390	7584	551	422
55020	IS	1991	4309	284	4512	1348	611
55021	IS	1991	2487	151	2400	204	349
55026	IS	1991	2111	117	1992	772	361
55035	IS	1991	4896	1083	8472	1259	862
55055	IS	1991	15237	801	5496	2320	3488
56011	IS	1991	3530	161	5808	324	1246
50045	PLS	1991	1587	120	5856	374	502
52527	PLS	1991	1312	113	6816	283	118
52538	PLS	1991	1079	27	3912	101	85
52541	PLS	1991	7636	144	4296	764	670
52545	PLS	1991	3751	362	10656	1085	1054
52553	PLS	1991	1231	60	2664	160	326
52556	PLS	1991	10375	420	36192	1388	1230
52558	PLS	1991	2153	54	4800	533	337
52559	PLS	1991	843	14	3288	118	115
52560	PLS	1991	2159	29	3336	210	194
52563	PLS	1991	2491	88	2520	669	480
52564	PLS	1991	5571	311	8664	1551	1925
52565	PLS	1991	3177	174	3600	1111	1043
52566	PLS	1991	2075	104	2928	299	346
52569	PLS	1991	4692	51	3360	474	252
53752	PLS	1991	2043	178	8400	596	293
53762	PLS	1991	7358	145	4128	4579	905
53766	PLS	1991	6220	440	13992	1985	1054
54007	PLS	1991	887	94	8544	522	202
55015	PLS	1991	5018	378	6048	1430	562
55018	PLS	1991	287	9	1320	48	93
56003	PLS	1991	2867	162	11688	1105	512
56004	PLS	1991	683	11	4632	104	120
56015	PLS	1991	2149	253	6792	571	562
56018	PLS	1991	2023	940	9504	965	476
56019	PLS	1991	5386	167	8808	2030	157
56021	PLS	1991	8532	550	12504	2524	1846

50005	SIS	1991	6687	840	9600	2458	1712
50006	SIS	1991	1940	359	8760	403	320
50012	SIS	1991	2099	125	4800	2137	646
50026	SIS	1991	8044	59	3600	2458	132
50038	SIS	1991	2266	130	3672	1075	333
50049	SIS	1991	1077	241	3552	699	95
50050	SIS	1991	1338	100	5496	715	42
50058	SIS	1991	1950	63	4248	436	237
50207	SIS	1991	1107	320	6000	491	911
50212	SIS	1991	831	169	2808	485	198
50303	SIS	1991	3368	361	9888	1363	582
50304	SIS	1991	646	62	3840	218	149
50305	SIS	1991	2121	65	5064	481	142
50418	SIS	1991	8299	314	12408	1947	1334
52510	SIS	1991	2418	237	10392	894	391
52512	SIS	1991	10243	283	17928	1210	516
52517	SIS	1991	8284	119	5208	3720	777
52529	SIS	1991	1853	322	5160	659	445
52562	SIS	1991	14762	1129	21600	4696	2430
53759	SIS	1991	615	31	3912	427	99
54001	SIS	1991	759	4	3600	20	50
54003	SIS	1991	2218	333	8064	510	255
54005	SIS	1991	4666	659	15120	1408	1069
56001	SIS	1991	18725	373	12504	1935	3581
56002	SIS	1991	1263	52	5328	180	380
56008	SIS	1991	8039	461	11640	2849	1575

Table 2 - Parametric Individual Levels of Technical Efficiency and Farm Ranking by Farming System

Farm Number	Farming System	Technical Efficiency			Ranking		
		Within	GLS	ML	Within	GLS	ML
50204	ES	12.1	17.2	24.9	1	2	2
50300	ES	14.4	17.1	24.2	2	1	1
50323	ES	15.6	21.3	30.5	3	3	3
50321	ES	19.1	25.5	35.7	4	6	6
50201	ES	20.1	24.9	35.0	5	5	5
50318	ES	21.6	23.2	33.1	6	4	4
50208	ES	22.1	27.6	39.1	7	8	8
50322	ES	23.9	32.4	45.4	8	13	13
50217	ES	24.0	31.1	43.1	9	11	11
52567	ES	24.1	27.0	37.0	10	7	7
50317	ES	26.6	30.4	42.4	11	9	9
50220	ES	27.5	30.7	42.6	12	10	10
50218	ES	27.6	39.4	53.0	13	16	16
50301	ES	28.6	34.3	48.0	14	14	14
50319	ES	30.4	44.1	60.6	15	18	18
52561	ES	31.1	32.0	43.3	16	12	12
50316	ES	34.2	46.5	63.3	17	19	19
56020	ES	36.9	37.0	51.5	18	15	15
50302	ES	37.7	40.1	55.4	19	17	17
56006	ES	41.4	49.4	66.7	20	21	21
52568	ES	51.0	57.2	74.7	21	23	22
55053	ES	51.0	48.5	66.0	22	20	20
52536	ES	54.3	57.0	75.2	23	22	23
50412	ES	55.5	61.0	77.9	24	26	26
55027	ES	56.8	58.2	76.1	25	24	24
55038	ES	60.5	62.4	79.4	26	27	27
50413	ES	60.8	59.7	77.4	27	25	25
55052	ES	77.8	74.2	87.2	28	28	28
55019	IS	19.6	22.8	32.1	1	1	1
55011	IS	28.3	32.3	44.4	2	2	2
55004	IS	29.8	32.8	45.1	3	3	3
50047	IS	31.8	49.2	64.2	4	5	4
55013	IS	44.2	57.0	74.3	5	11	9
55035	IS	45.3	57.2	76.4	6	12	12
56011	IS	46.8	51.7	69.2	7	6	6
55017	IS	47.6	48.5	67.0	8	4	5
55021	IS	49.0	55.6	74.2	9	8	8
50044	IS	52.0	59.1	77.2	10	13	13
55026	IS	53.2	56.6	75.3	11	10	10
55014	IS	53.2	54.9	73.6	12	7	7
55055	IS	58.2	55.8	75.3	13	9	11
55010	IS	66.0	75.1	88.0	14	14	15
50056	IS	71.7	75.8	87.3	15	15	14
50021	IS	73.2	97.4	92.7	16	19	19
55020	IS	79.4	85.3	90.9	17	18	18
50060	IS	88.7	77.4	88.4	18	16	16
50039	IS	92.1	80.6	89.4	19	17	17
53752	PLS	17.2	20.6	29.4	1	1	1
56018	PLS	17.7	22.9	33.3	2	2	2
54007	PLS	19.0	24.3	34.0	3	3	3
56004	PLS	23.6	27.6	37.4	4	5	5
50045	PLS	23.7	26.5	37.2	5	4	4
55018	PLS	24.6	29.0	39.7	6	6	6
52527	PLS	25.4	34.0	47.0	7	8	8

56015	PLS	26.6	31.8	44.5	8	7	7
56003	PLS	32.1	38.0	52.4	9	9	9

Table 2 - Parametric Individual Levels of Technical Efficiency and Farm Ranking by Farming System (Cont.)

56021	PLS	36.2	39.0	54.4	10	10	10
53766	PLS	36.7	43.0	59.2	11	13	13
55015	PLS	37.7	41.4	58.0	12	11	12
52553	PLS	39.2	44.4	59.6	13	14	14
52565	PLS	41.6	41.8	57.6	14	12	11
52545	PLS	42.4	46.8	64.2	15	15	15
52538	PLS	43.9	60.8	77.2	16	20	19
52556	PLS	43.9	53.0	70.7	17	16	16
56019	PLS	51.4	65.9	83.2	18	23	23
52564	PLS	53.4	55.7	74.5	19	17	17
52559	PLS	53.6	63.9	79.5	20	22	21
52563	PLS	55.7	56.5	74.9	21	18	18
52566	PLS	56.5	62.4	80.1	22	21	22
53762	PLS	60.2	58.3	77.3	23	19	20
52558	PLS	69.7	75.3	87.2	24	24	24
52560	PLS	73.8	82.0	89.3	25	25	25
52541	PLS	82.8	84.2	90.5	26	26	26
52569	PLS	86.3	98.2	92.8	27	27	27
50049	SIS	17.6	22.9	33.1	1	2	2
50207	SIS	17.6	19.7	28.5	2	1	1
52510	SIS	21.0	25.6	36.2	3	3	3
50212	SIS	23.7	27.7	39.0	4	6	6
54005	SIS	24.5	27.3	38.5	5	5	5
50304	SIS	25.2	29.9	41.3	6	7	7
53759	SIS	25.3	27.2	37.6	7	4	4
50006	SIS	26.2	34.4	47.8	8	9	9
50050	SIS	27.4	34.7	48.0	9	10	10
50303	SIS	29.8	36.2	50.2	10	11	11
52529	SIS	30.5	37.3	51.8	11	12	12
50012	SIS	31.5	32.7	45.5	12	8	8
54003	SIS	33.4	43.0	59.1	13	14	15
56008	SIS	34.8	38.2	53.2	14	13	13
50305	SIS	35.9	43.0	58.4	15	15	14
50038	SIS	38.1	43.6	59.9	16	16	16
50058	SIS	39.3	48.6	64.9	17	19	18
56002	SIS	40.0	47.0	62.4	18	17	17
50005	SIS	44.3	47.4	65.3	19	18	19
52512	SIS	46.0	58.1	76.2	20	21	21
52562	SIS	46.1	50.6	69.3	21	20	20
52517	SIS	64.2	65.2	82.3	22	22	22
54001	SIS	65.9	84.6	89.1	23	25	24
50418	SIS	66.6	72.7	86.5	24	23	23
50026	SIS	71.7	82.3	89.8	25	24	25
56001	SIS	100.0	100.0	93.2	26	26	26

Table 3 - Nonparametric Individual Levels of Technical Efficiency and Comparison between Ranking of Farms for Within and OTE

Farm Number	Farming System	Technical Efficiency					Ranking	
		OTE	PTE	SCE	COE	RTS	OTE	Within
50300	ES	19.5	60.8	32.0	100.0	IRS	1	2
50321	ES	26.9	37.6	78.1	91.7	IRS	2	4
50204	ES	28.1	100.0	88.2	31.9	IRS	3	1

50318	ES	28.8	73.0	42.8	92.2	IRS	4	6
50323	ES	30.2	37.6	81.3	98.8	IRS	5	3
50201	ES	31.5	59.9	56.0	93.8	IRS	6	5
50217	ES	35.0	43.7	80.8	99.0	IRS	7	9
50208	ES	35.6	38.5	93.7	98.6	IRS	8	7
50220	ES	36.0	57.1	63.1	100.0	IRS	9	12
50322	ES	39.5	50.4	95.3	82.3	IRS	10	8
52567	ES	39.7	82.0	50.5	95.7	IRS	11	10
50301	ES	41.7	100.0	66.9	62.3	DRS	12	14
50317	ES	42.2	64.0	65.9	100.0	IRS	13	11
56020	ES	43.5	44.0	98.9	100.0	DRS	14	18
50302	ES	55.2	55.6	99.3	100.0	DRS	15	19
56006	ES	62.6	64.9	96.8	99.7	IRS	16	20
50316	ES	70.4	100.0	70.4	100.0	IRS	17	17
55027	ES	70.8	77.2	91.7	100.0	IRS	18	25
52536	ES	74.4	75.2	98.9	100.0	DRS	19	23
50413	ES	77.2	100.0	99.7	77.4	IRS	20	27
55038	ES	78.4	100.0	95.4	82.2	DRS	21	26
55053	ES	78.8	100.0	78.8	100.0	IRS	22	22
50319	ES	81.1	100.0	81.1	100.0	IRS	23	15
50218	ES	85.8	100.0	85.8	100.0	IRS	24	13
52568	ES	90.2	99.2	91.0	99.9	IRS	25	21
50412	ES	97.4	100.0	98.6	98.8	IRS	26	24
52561	ES	100.0	100.0	100.0	100.0	CRS	28	16
55052	ES	100.0	100.0	100.0	100.0	CRS	27	28
55019	IS	24.1	34.2	70.5	100.0	IRS	1	1
55004	IS	36.2	50.9	71.2	99.8	IRS	2	3
55011	IS	41.0	75.6	54.9	98.7	IRS	3	2
56011	IS	59.9	60.9	99.6	98.7	DRS	4	7
55013	IS	67.9	92.7	79.9	91.6	IRS	5	5
55026	IS	69.5	91.1	76.9	99.2	IRS	6	11
50044	IS	70.3	100.0	70.3	100.0	IRS	7	10
55021	IS	71.0	97.2	85.1	85.9	IRS	8	9
55055	IS	72.3	100.0	72.3	100.0	DRS	9	13
55017	IS	73.5	100.0	88.5	83.0	IRS	10	8
55035	IS	74.0	100.0	78.4	94.4	DRS	11	6
55014	IS	75.9	100.0	75.9	100.0	IRS	12	12
50060	IS	84.8	100.0	98.1	86.4	IRS	13	18
55010	IS	85.9	100.0	93.6	91.8	DRS	14	14
50047	IS	90.0	100.0	90.0	100.0	IRS	15	4
50021	IS	100.0	100.0	100.0	100.0	CRS	19	16
50039	IS	100.0	100.0	100.0	100.0	CRS	16	19
50056	IS	100.0	100.0	100.0	100.0	CRS	18	15
55020	IS	100.0	100.0	100.0	100.0	CRS	17	17
53752	PLS	22.1	31.9	71.3	97.3	IRS	1	1
54007	PLS	28.9	35.5	81.4	100.0	IRS	2	3
50045	PLS	30.1	42.7	70.7	99.8	IRS	3	5
56018	PLS	33.0	100.0	89.9	36.7	IRS	4	2
56015	PLS	38.8	53.6	84.4	85.8	IRS	5	8
56004	PLS	39.7	74.0	57.1	94.0	IRS	6	4
56021	PLS	40.3	44.8	90.5	99.5	DRS	7	10
52527	PLS	42.1	62.4	71.6	94.2	IRS	8	7
55018	PLS	42.9	100.0	42.9	100.0	IRS	9	6

Table 3 - Nonparametric Individual Levels of Technical Efficiency and Comparison of Ranking of Farms between Within and OTE (Cont.)

56003	PLS	46.3	46.7	99.2	100.0	IRS	10	9
55015	PLS	48.3	79.5	88.5	68.7	IRS	11	12
52553	PLS	49.6	86.4	57.5	99.9	IRS	12	13
52565	PLS	55.4	57.0	97.5	99.6	IRS	13	14
52545	PLS	59.7	62.1	98.3	97.7	DRS	14	15
52556	PLS	61.8	100.0	78.0	79.2	DRS	15	17
53766	PLS	62.5	79.3	83.5	94.3	DRS	16	11
52564	PLS	64.6	64.6	100.0	100.0	IRS	17	19
52563	PLS	73.9	91.0	81.2	100.0	IRS	18	21
52566	PLS	76.5	81.4	94.0	100.0	IRS	19	22
52559	PLS	87.6	100.0	87.6	100.0	IRS	20	20
52538	PLS	88.5	95.6	97.6	94.8	IRS	21	16
52541	PLS	100.0	100.0	100.0	100.0	CRS	23	26
52558	PLS	100.0	100.0	100.0	100.0	CRS	27	24
52560	PLS	100.0	100.0	100.0	100.0	CRS	22	25
52569	PLS	100.0	100.0	100.0	100.0	CRS	24	27
53762	PLS	100.0	100.0	100.0	100.0	CRS	26	23
56019	PLS	100.0	100.0	100.0	100.0	CRS	25	18
50207	SIS	27.2	39.3	81.6	84.9	IRS	1	2
54005	SIS	27.6	28.7	99.8	96.3	DRS	2	5
52510	SIS	30.4	34.8	87.4	100.0	IRS	3	3
50304	SIS	35.2	66.5	52.9	100.0	IRS	4	6
50006	SIS	36.7	47.5	89.3	86.4	IRS	5	8
50212	SIS	38.1	49.3	77.2	100.0	IRS	6	4
50049	SIS	40.0	100.0	63.8	62.8	IRS	7	1
56008	SIS	40.5	43.2	94.0	99.8	DRS	8	14
50050	SIS	43.2	55.1	78.3	100.0	IRS	9	9
50303	SIS	44.8	46.6	98.4	97.6	IRS	10	10
52529	SIS	46.5	58.1	92.7	86.4	IRS	11	11
53759	SIS	47.0	69.6	67.6	100.0	IRS	12	7
50012	SIS	50.3	100.0	72.0	69.8	DRS	13	12
50005	SIS	50.9	52.6	97.5	99.4	DRS	14	19
52562	SIS	52.8	100.0	58.5	90.2	DRS	15	21
54003	SIS	56.9	64.5	93.7	94.2	IRS	16	13
50058	SIS	57.2	63.2	90.6	100.0	IRS	17	17
50038	SIS	58.3	67.3	86.7	100.0	IRS	18	16
50305	SIS	58.7	70.4	83.4	100.0	IRS	19	15
56002	SIS	63.1	100.0	96.5	65.4	DRS	20	18
52512	SIS	68.2	100.0	79.3	85.9	DRS	21	20
50418	SIS	73.8	100.0	76.4	96.6	DRS	22	24
52517	SIS	89.9	90.9	98.9	100.0	IRS	23	22
50026	SIS	100.0	100.0	100.0	100.0	CRS	25	25
54001	SIS	100.0	100.0	100.0	100.0	CRS	26	23
56001	SIS	100.0	100.0	100.0	100.0	CRS	24	26

APPENDIX III

GROWTH MODEL - MATHEMATICAL FORMULATION

The following equations specify the production process of one farm for one time period:

Maximize: Disposable Income (Short Term)

Net Present Value of Disposable Income + Terminal Net worth (Long Term)

Subject to: Production Capacity for Land, Labour, Variable Inputs and Durable Resources

$$\sum_{j=1}^{n} \beta_{ij} C_j + \sum_{j=1}^{n} \alpha_{ij} A_J \leq B_i$$

where: Durable Resource Availability

$$B_i = \sum_{j=1}^{n} \varphi_{ij} DRPP_j + \sum_{j=1}^{n} \gamma_{ij} I_j - \sum_{j=1}^{n} \mu_{ij} D_j - \sum_{j=1}^{n} \rho_{ij} O_j + \sum_{j=1}^{n} \delta_{ij} H_j$$

$$+ \sum_{j=1}^{n} \varepsilon_{ij} R_j$$

where: Land Set-Aside Requirements

$$\sum_{j=1}^{r} \frac{1}{(1 - sar_j)} C_j + \sum_{j=r+1}^{n} C_j \leq L_i$$

Subject to: Crops Response to Input

$$\sum_{j=1}^{n} \beta_{ijk} C_{jk} - \sum_{j=1}^{n} \lambda_{ij} BI_j \leq 0$$

With a Minimum Supply of Input at Planting

$$MR_{ij} C_{jo} - \lambda_{ij} BI_j \leq 0$$

Where: Area Cropped and Output Produced

$$- C_j 0 + \sum_{k=1}^{s} C_{jk} \leq 0$$

$$- {}_{ij} C_{jo} - \sum_{k=1}^{s} {}_{ijk} C_{jk} + \sum_{j=1}^{n} \eta_{ij} SL_j \leq 0$$

Subject to: Herd Composition - Females

$$\alpha_{ij} A_{jf} - HPP_{jf} - \sum_{j=1}^{n} \lambda_{ij} BI_{jf} - \sum_{j=1}^{n} \eta_{ij} SL_{j} \leq 0$$

Subject to: Herd Composition - Males

$$\alpha_{ij} A_{jm} - HPP_{jm} - \sum_{j=1}^{n} \lambda_{ij} BI_{jm} - \sum_{j=1}^{n} \eta_{ij} SL_{j} \leq 0$$

Where: The Number of Males

$$mrf_{ij} A_{jf} - \alpha_{ij} A_{jm} \leq 0$$

Subject to: Animals Born

$$- pr_{ij} A_{jf} + \alpha_{ij} A_{jb} \leq 0$$

Subject to: Animals Fatten

$$(-1 + mr_{ij}) A_{jb} + \alpha_{ij} A_{js} + \sum_{j=1}^{n} \eta_{ij} Sl_{j} \leq 0$$

Subject to: Herd Substitution

$$(rs_{ij} + mr_{ij}) A_{jf/m} - \sum_{j=1}^{n} \alpha_{ij} A_{js}$$

Subject to: Cull Selling

$$- rs_{ij} A_{jf/m} + \sum_{j=1}^{n} \eta_{ij} Sl_{j}$$

Subject to: Animal Feed Requirements - Energy

$$- \sum_{j=1}^{n} {}_{ij} C_{J} + \sum_{j=1}^{n} \alpha_{ij} A_{j} - \sum_{j=1}^{n} \lambda_{ij} BI_{j} \leq 0$$

Subject to: Animal Feed Requirements - Dry Matter

$$+ \sum_{j=1}^{n} {}_{ij} C_{j} - \sum_{j=1}^{n} \alpha_{ij} A_{j} + \sum_{j=1}^{n} \lambda_{ij} BI_{j} \leq 0$$

Subject to: Investment Capacity

$$\sum_{j=1}^{n} \gamma_{ij} I_{j} - \sum_{j=1}^{n} \tau_{ij} BLT_{j} - \sum_{j=1}^{n} \sigma_{ij} SUI_{j} - INPP + \sum_{j=1}^{n} \tau_{ij} DLT_{j} \leq 0$$

where: Investment Subsidy

$$SUI_J = \sum_{j=1}^{n} sr_J \; DR_J$$

where: Long Term Borrowing Capacity

$$\sum_{j=1}^{n} \tau_{ij} \; BLT_j + \sum_{j=1}^{n} \tau_{ij} \; BLTPP_j - \sum_{i=1}^{p} \sum_{j=1}^{n} \omega_{ij} \; NA_j + \sum_{j=1}^{n} \pi_{ij} \; PRPP_j \leq 0$$

where: Total Net Assets

$$\sum_{i=1}^{p} \sum_{j=1}^{n} \omega_{ij} \; NA_j = \sum_{i=1}^{p} \sum_{j=1}^{n} \varphi_{ij} \left(1 - \frac{au_{ij}}{al_{ij}}\right) DR_j$$

where: Total Durable Resources Assets

$$\sum_{i=1}^{p} \sum_{j=1}^{n} \varphi_{ij} \; DR_j = \sum_{i=1}^{p} \sum_{j=1}^{n} \varphi_{ij} \; DRPP_j + \sum_{i=1}^{p} \sum_{j=1}^{n} \gamma_{ij} \; I_j - \sum_{i=1}^{p} \sum_{j=1}^{n} \mu_{ij} \; D_j$$

$$\sum_{i=1}^{p} \sum_{j=1}^{n} \rho_{ij} \; O_j$$

Subject to: Tax Rates

$$TR_{ij} \leq MI_j$$

$$TI = \sum_{j=1}^{n} TR_j$$

Subject to: Funds Flow

$$+\sum_{j=1}^{n} gc_j C_j + \sum_{j=1}^{n} gc_j A_j + \sum_{j=1}^{n} p_j BI_j + \sum_{j=1}^{n} p_j H_j + \sum_{j=1}^{n} p_j R_j$$

$$+\sum_{j=1}^{n} dc_j DR_j + \sum_{j=1}^{n} lr_j BLT_j + \sum_{j=1}^{n} lr_j BLTPP_j - \sum_{j=1}^{n} dr_j DLT_j$$

$$-\sum_{j=1}^{n} p_j SL_j - \sum_{j=1}^{n} p_j D_j - \sum_{j=1}^{n} SU_j + \sum_{j=1}^{n} (1 + lr_j) STL_j$$

$$-\sum_{j=1}^{n} (1 + dr) STD_j + \sum_{j=1}^{n} r_j TR_j + FE + RCM \leq 0$$

where: Direct Payments

$$SU_J = \sum_{j=1}^{n} s_j C_j + \sum_{j=1}^{n} ss_j CAS_j + \sum_{j=1}^{n} s_j A_j + \sum_{j=1}^{n} s_j BI_j$$

and

$$CAS_J = \frac{rsa_j}{(1 - rsa)} C_j$$

Disposable Income is given by the following equation

$$-RCM - \sum_{j=1}^{n} dc_j DR_j + \sum_{j=1}^{n} \frac{1}{lp_j} BLT_j + \sum_{j=1}^{n} \frac{1}{lp_j} BLTPP_j + DI \leq 0$$

and Income to Next Period is

$$DI(-1 + mpc) - \sum_{j=1}^{n} \tau_{ij} DLT_j + INP \leq 0$$

VARIABLES

C_j - Crop Activities;
C_{jo} - Crop Activity at the Response level 0;
C_{jk} - Crop Activity at the Response level k;
A_j - Livestock Activities;
A_{jb} - Livestock Born Activity;
A_{jc} - Livestock Cull Activity;
A_{jf} - Livestock Female Activity;

A_{jm} - Livestock Male Activity;
A_{js} - Livestock Replacement Activity;
L_j - Land Availability;
HPP_{jj} - Livestock Herd from Previous Period;
BI_j - Buying Input Activities
H_j - Hiring Activities
R_j - Renting Activities
SL_j - Selling Activities
I_j - Investment Activities, takes only Integer Values;
SU_j - Subsidy Activities;
SUI_j - Subsidy Activities to Investments;
D_j - Disinvestment Activities;
O_j - Obsolescence Activities;
DR_j - Value of Durable Resources;
$DRPP_j$ - Durable Resources from Previous Period, takes only 0 or 1 values;
NA_j - Net Assets;
BLT_j - Borrow Long Term;
$BLTPP_j$ - Borrow Long Term Previous Period;
BST_j - Borrow Short Term;
DLT_j - Deposit Long Term;
DST_j - Deposit Short Term;
$PRPP_j$ - Principal Repaid Trough Previous Period;
TR_j - Tax Rate Class;
MI_j - Maximum Income for Class Rate;
TI - Taxable Income;
CAS_j - Crop Area Set-Aside;
RCM - Returns to Capital and Management;
DI - Disposable Income;
FE - Fixed Expenditures;
INP - Income to Next Period;
INPP - Income from Previous Period;

COEFFICIENTS

β_{ij} - Input Requirements by Crop Activities;
β_{ijk} - Coefficient of Decision Crop Variable j at Response Level K;
mri_{ij} - Minimum Requirement of Input i at Planting;
α_{ij} - Input Requirement for Livestock Activities;
pr_{ij} - Productivity Rate of Livestock Activities;
mr_{ij} - Mortality Rate;
mrf_{ij} - Male Requirements per Female;
rs_{ij} - Rate of Replacement;
λ_{ij} - Input Coefficient for Buying Inputs;
δ_{ij} - Input Coefficient for Hiring Activities;
ε_{ij} - Input Coefficient for Renting Activities;
η_{ij} - Input Coefficient for Selling Activities;
γ_{ij} - Input Coefficient for Investment Activities;
σ_{ij} - Input Coeffficient for Subsidy Activities;
sr_j - Subsidy Rate to Investments;
s_j - Direct Payments;
ss_j - Set-Aside Subsidy;
μ_{ij} - Input Coeficient for Disinvestment Activities;
ρ_{ij} - Input Coefficient for Obsolescence Activities;

$\_{ij}$ - Input Coefficient for Value of Durable Resources Activity;
ω_{ij} - Input coefficient for Net Assets Activity;
al - Asset Life (Years);
au - Asset Use (Years);
τ_{ij} - Input Coefficient of Borrow Long Term Activity;
lr - Loan Interest Rate;
dr - Deposit Interest Rate;
π_{ij} - Input Coefficient for Principal Repaid in Previous Period Activity;
lp - Loan Period;
r_j - Tax Rate;
dc_j - Depreciation coefficient;
gc_j - General Costs;
rsa_j - Rate of Set-Aside;
mpc - Marginal Propensity to Consume;
p_j - Price;

SUBSCRIPTS

j=1,...,r,...,n - Activities;
i=1,...,p - Input Constraint;
k=1,...,s - Number of Segments of the Response Function;
f = female;
m=male;