Yield risk in wheat production: A policy study for the Alentejo of Portugal

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YIELD RISK IN WHEAT PRODUCTION:
A POLICY STUDY FOR THE ALENTEJO OF PORTUGAL.

by

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ABSTRACT

This study attempts to determine whether or not Portuguese wheat price policies have resulted in a stabilization of the wheat price and/or the stabilization of income for wheat growers in the Alentejo region. It was found that these policies have contributed to a stabilization of price rather than a stabilization of income. It was also found that the income variability caused by yield variability was greater for the Alentejo farmers than that for the country as a whole. Weather uncertainties measured by rainfall were found to be a major source of that variability in both area and yield equations. Therefore, it was concluded that rainfall is significant in explaining variations in wheat supply and cannot be eliminated from the model specification. Finally, this study looked at a policy that would stabilize output returns to Alentejo farmers since high yield variability will continue to constrain farmers' willingness to invest in wheat production. An insurance program may be the policy to implement in this region since yield risks are the predominant source of income variability. However, the cost of financing an agricultural insurance scheme as well as the delineation of homogeneous areas are crucial determinants to the success of an all-risk insurance program.

CHAPTER I

INTRODUCTION

1.1 Introductory remarks

The Portuguese wheat sector has been protected since the end of the last century. However, with the Wheat Campaign, which began in 1929 by the then new Salazar government, protection acquired greater significance and scope. According to Josling and Tangermann (pg. 41), "the policies that Portugal has evolved to regulate and influence agricultural markets [were] introduced by Salazar in the late 1920s and survived until the Revolution of April 25, 1974".

The wheat price policy initiated by Salazar attempted to satisfy both consumers (through an adequate supply of cheap bread at a fixed price) and producers (through the support of the producer prices of wheat). The intervention price provided farmers with a minimum price for products such as wheat, barley, and oats. Farmers could sell their products at higher than guaranteed prices if market conditions resulted in higher prices. Government purchase was the mechanism used to maintain guaranteed prices. Producer prices were announced at the planting time and set according to production costs. These prices were generally set above CIF (cost, insurance, and freight) import prices to encourage production. Institutions were needed to implement price policy. The National Federation of Wheat Producers (FNPT) was established in 1933, and through 1963 maintained a monopoly over wheat marketing.

In addition to the Wheat Campaign, farmers were also provided with subsidies for bringing new lands into production and for fertilizers and selected seeds. Other policies were also undertaken to stimulate production and to assure national self-sufficiency. These included public investments in electricity, roads, irrigation projects and extension services, and preferential credit to stimulate private investment activities.

The immediate response to the Campaign incentives was an increase in production, particularly in the Alentejo. Increased output came not only from crop area expansion into marginal land but also from increased fertilizer application which led to higher yields. Consequently, the prominence of wheat in the Alentejo increased and dependence upon imports decreased. As Cecílio, Salgueiro, Mira, and Sanders (1982) point out, "in the initial years of the program, bumper crops in 1932, 1934, and 1935 enabled the practical elimination of imports until 1938 and the Forties".

By 1960, in spite of the continuation of subsidy policies that kept prices for wheat above world prices and credit subsidies for capital investments, production had begun to stagnate. Increases in domestic industrial employment opportunities, the African wars, and the explosion of the emigration to industrialized Europe absorbed much agricultural labor. As a result, labor costs increased significantly. Since wheat prices were more or less stable and labor costs were rising, "the net effect was falling revenues for Southern farms, which were then confronted with the task of transforming their operations through mechanization" (Avillez, Finan, and Josling, 1988). Meanwhile, population growth, income growth from emigrant remittances, and increases in rural wages caused demand for wheat to increase. Because these increases were not compensated by equal increases in wheat production, imports increased.

In 1974, a revolution overthrew the previous regime and changed many institutions. The revolution introduced a Land Reform that started with the occupation of the Southern "latifúndios" by landless workers. By 1976, a comprehensive Land Reform was in place. After that, wheat production declined substantially, in both yield and area. These decreases in wheat production are believed to be in part the result of the management, organization, and legal problems of the collective farms and production cooperatives. Producer prices were below world prices until 1978, (Josling and Tangermann). After that, the degree of protection relative to world prices increased for wheat and other cereals. Also, input subsidies for wheat continued. Because of the input substitution caused by continued increases in rural wages, these policies became expensive. The continuation of the fixed prices above the world market levels and the large subsidies aggravated the public deficit. Partly in response to this problem, input subsidies were eliminated in 1983. However, high producer prices for cereals were maintained.

Since Portugal's accession to the European Community (EC) in January 1986, price policy for agricultural products has been dictated by the Common Agricultural Policy (CAP), despite some Portuguese autonomy during the transition stage. Output price policies have become largely exogenous. Input subsidy policies are prohibited because they are contrary to the competition regulations in the EC. According to Josling and Tangermann, "except for feed ingredients covered by the CAP, imported inputs will come in without government price control, subject only to the EC's Common Customs Tariff (CCT) on Third-Country Trade and to the arrangements for the transition period". Finally, EPAC, an organization established after the 1974 Revolution to manage trade in the cereals sector, has given an expanded role for the private sector in wheat marketing.

1.2 Problem Statement

Being the leading wheat-producing region, the Alentejo region will be the focus of this research. From 1970 to 1977, this region produced 69.7% of the national total wheat production and, from 1980 to 1984, the same region produced 75.1% of the same total. The Alentejo can be characterized as a "rolling" plain that is divided by three rivers that form small valleys with alluvial soils. Limitations of water and poor soil quality constrain Alentejo agriculture. Very poor soils account for approximately 73% of total arable land of that region. Variability in annual yields is pronounced because of the weather: excessive rain or winter drought can severely affect wheat production, and these conditions occur frequently (Fox, 1987).

This study explores whether or not Portuguese wheat price policies have permitted a stabilization of the wheat price or a stabilization of income for wheat farmers, especially in the Alentejo. By definition, total revenue is equal to price multiplied by quantity. For a given percentage increase in price, total revenue can increase, decrease or to be equal depending on the magnitude of the corresponding change in quantity. As Tomek and Robinson (1981) point out, "the question is answered by the magnitude of the price-elasticity-of-demand coefficient". Suppose that there are not shifts in the demand. It is possible that the increase in price will have no effect on total revenue if its increase is equi-proportional to the decrease in quantity. But, if price is fixed by governmental intervention like it was in the Portuguese wheat sector, a different result occurs. This case is analysed in figure 1.

Suppose that the price for wheat in period t was set to be equal to $\overline{P}_t$ and that the planned wheat supply for the same period of time is S_e. Assuming that the realized wheat supply for that period of time was S_t, the reduction in the quantity supplied from q^s_e to q^s_t will reduce the total revenue for wheat farmers in the same proportion.

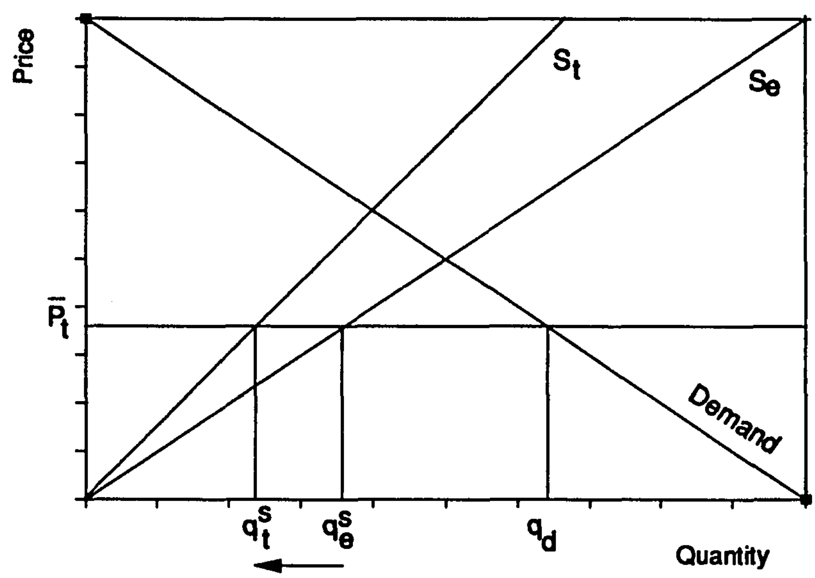

FIGURE 1: Supply relationships and price intervention policy in the Portuguese wheat sector.

Therefore, it is hypothesized that the Portuguese wheat price policies have permitted a stabilization of price rather than a stabilization of income. Because of this orientation of policy, income variability for the Alentejo is expected to be more significant than for the rest of the country. Because weather uncertainties are believed to be a major source of income variability in the Alentejo, a wheat supply model will be estimated in which planted area and yield will be functions of prices and rainfall. It is hypothesized that the agronomic variable, rainfall, cannot be omitted from the specification of the supply model. Finally, decreases in planted area and in production are expected to occur in the poorer soils of the Alentejo where the production of wheat is highly unprofitable (Fox, 1987). Since EC-price policies will do little to reduce income variability, high yield variability will continue to constrain farmers' willingness to invest in production. To overcome the fact that "high risk remains a problem even for the more profitable dryland crop and livestock systems" (Fox, 1987), the Portuguese decision makers do have the autonomy to implement a crop or a multiple-crop insurance program. A policy that has a positive impact on wheat production is one that would stabilize output returns to farmers, and the thesis provides an evaluation of a wheat insurance program.

1.3 Objectives and General Procedure

This study has three major objectives. The first objective is to estimate the variance of total revenue per hectare to determine if Portuguese wheat price policies have stabilized the wheat price. To accomplish this objective, estimates of the variance of total income per hectare will be computed using secondary data from the Portuguese National Institute of Statistics (INE). Assuming that total income for wheat farmers comes from wheat production and that production costs are not risky, the variance of the logarithm of income can be estimated. Total revenue per hectare is a function of price and quantity. The variance of the logarithm of total value is equal to

$$\mathrm{Var}(\log R) = \mathrm{Var}(\log P) + \mathrm{Var}(\log Y) + 2\,\mathrm{Cov}(\log P, \log Y) \tag{1}$$

Dividing the right-hand side of equation (1) by the sum of the first two right-hand side terms, the impact of price and yield variations on the variation of total revenue per hectare can be estimated (Burt and Finley, 1979).

$$\frac{\text{Var}(\log P) + \text{Var}(\log Y) + 2\text{Cov}(\log P, \log Y)}{\text{Var}(\log P) + \text{Var}(\log Y)} = R_P + R_Y + R_{PY} \tag{2}$$

The impacts of farm price policies can be characterized as preventing price variability or income variability, if "world" wheat prices are used and compared with the results induced by the domestic prices. A proxy for "world" wheat prices needs to be specified such that it would represent the prices that wheat farmers would have received in the absence of the direct price intervention.

A second objective of this research is to estimate wheat supply response to price changes and rainfall in order to understand the dynamics of wheat supply over time. Tests for statistical significance of the independent variables will be conducted. To accomplish this objective, equations will be estimated using multiple regression analysis of time series data for the period 1965-1984. Separate area and yield response equations will be developed under the assumption that planted area is dependent on output and input prices and on the prices of the competing crops, while yield is more dependent on non-economic factors, such as weather. Therefore, two behavioral equations should be estimated. The Nerlovian model will be used in the formulation of the planted area equation.

A final objective is to estimate the expected costs of a hypothetical wheat insurance program that provides varying degrees of protection against yield losses. To accomplish this objective, several assumptions need to be introduced. The hypothetical "guaranteed" price for wheat will be assumed to be the EC-price. This is the price that farmers would have received if Portugal were in the EC since 1965. A major difficulty with this analysis is that it will compare an actual situation to one that did not happen. Nevertheless, this simulation allows the expected costs of a wheat insurance program in the Alentejo to be roughly estimated. Program costs will be assessed under alternative assumptions of subsidized and non-subsidized premia.

CHAPTER II

PRICE STABILIZATION VS INCOME STABILIZATION

2.1 Previous Work

This chapter considers whether Portuguese wheat price policies have contributed to a stabilization of the wheat price and/or a stabilization of income for wheat farmers, particularly in the Alentejo, over the period 1965-84. Assuming that total income for wheat farmers comes from wheat production and that production costs are not risky, there are two possible ways for partitioning the variance of income per hectare. The first method has been suggested by Burt and Finley (1968), based on the Taylor's series expansion. They propose to estimate the variance of the total value "as the conventional asymptotic approximation to the variance of a product, obtained by linearizing the product about the mean point". Their method ignores the higher order interactions. The variance of the total value can be expressed as

$$\mathrm{Var(TV)} \approx \bar{Y}^2\mathrm{Var}(P) + \bar{P}^2\mathrm{Var}(Y) + 2\overline{PY}\mathrm{Cov}(P,Y) \qquad (3)$$

In spite of the comments of Goldberger (1970) about the possible inaccuracy of the proposed method, Burt and Finley (1970) reply that "the error is relatively small if the individual means are large relative to their respective variance".

The second method uses logarithmic values of the variables and has the advantage that it is exact rather than an approximation. Also, the variance of the logarithm of total value per hectare is monotonically related to variance of the total value. Hence, the variance of income per hectare will be analyzed using logarithms. The variance of the logarithm of total value is equal to

$$\mathrm{Var}(\log TV) = \mathrm{Var}(\log P) + \mathrm{Var}(\log Y) + 2\mathrm{Cov}(\log P, \log Y), \tag{1}$$

Dividing the right-hand side of equation (1) by the sum of the first two right-hand side terms, gives

$$\frac{\mathrm{Var}(\log P) + \mathrm{Var}(\log Y) + 2\mathrm{Cov}(\log P, log Y)}{\mathrm{Var}(\log P) + \mathrm{Var}(\log Y)} = R_P + R_Y + R_{PY}, \tag{2}$$

where R_p and R_y are the direct effects of price and yield respectively and sum to unity, and R_{py} is the interaction term which can take either sign.

Equation (2) will be used to analyze the impact of price and yield variations on total value per hectare during the period 1965-84. Furthermore, if a proxy variable for world wheat prices is used instead of the average wheat prices actually received by farmers, the R_p, R_y, and R_{py} are recalculated and the impacts of wheat price policies can be characterized as preventing price or income variability. The "world" wheat price, defined by Avillez, Finan, and Josling in 1988, will be used as a proxy for the actual wheat prices that farmers would have received in the absence of direct price intervention. These estimations were made under the assumption that the wheat price would be close to the world market price, CIF Lisbon, adjusted for transportation costs from the producing centers to the milling areas.

2.2 Empirical Results

The above procedure was used to decompose revenue variations into direct effects and the interaction term. This decomposition was done for the Nation as a whole and for the Alentejo region. Annual time series data from 1965 to 1984 were used. The secondary data used for the decomposition come from "Estatísticas Agrícolas", Portuguese National Institute of Statistics (INE), and from the World Bank, 1988. The data from the World Bank were derived from INE, which implies consistency among data. The "world" wheat prices in this study were derived from the World Bank Comparative Studies (1988) but expressed as a simple national average instead of a weighted average as shown in the mentioned reference. For the estimation of the total variance for the nation and for the Alentejo, equation (1) was used; that is, by definition the variance of the total revenue per hectare is equal to the variance of the product between price and yield. For the estimation of the relative magnitude of price and yield variations on total revenue per hectare, equation (2) was used.

Estimated data from tables 23 and 24 in Appendix C were used to calculate the covariance between the log of the real wheat price and the log of the yield. Tables 1 and 2 show the total wheat revenue per hectare in the Alentejo and in the Nation, respectively. These tables specify the variances of total income from wheat production. Decompositions of the variance of total income into direct and indirect effects are shown in tables 3 and 4.

From table 3, it can be seen that yield variation is about twice as important as price variation in the Alentejo while yield and price variations are about equally important in the nation as a whole. More than 67% of the variability in the Alentejo total value per hectare is explained by yield fluctuations. The variance of the national total value of wheat produced per hectare is about 70% of the variance of the total value of wheat produced per hectare in the Alentejo region. The main reasons for these results are mentioned in page 23.

TABLE 1: TOTAL INCOME PER HA FROM WHEAT PRODUCTION IN THE ALENTEJO, 1965-1984.[a]

	Wheat Price (esc/kg) [1]	"World" Price (esc/kg) [2]	Average Yield (kg/ha) [3]	Total Income (esc/ha) [1]*[3]	Total Income (esc/ha) [2]*[3]
1965	2.95	1.73	1060.3	3132.33	1835.05
1966	3.01	1.94	576.0	1732.00	1120.00
1967	2.91	1.96	1206.3	3505.66	2358.65
1968	2.78	1.69	1331.8	3707.84	2253.73
1969	2.63	1.50	766.3	2013.78	1146.21
1970	2.55	1.71	894.0	2277.91	1530.53
1971	2.71	1.38	1364.3	3695.73	1875.84
1972	2.59	1.70	1234.3	3201.20	2094.50
1973	2.30	2.71	1281.3	2940.47	3476.46
1974	2.09	2.87	1235.3	2577.70	3539.34
1975	1.97	2.33	1394.0	2749.63	3242.01
1976	1.62	1.83	1283.3	2076.64	2349.33
1977	1.81	1.37	871.3	1580.60	1196.34
1978	1.80	1.23	655.0	1160.68	794.59
1979	1.76	0.99	936.3	1621.43	909.71
1980	2.21	1.53	1253.3	2765.70	1919.04
1981	2.06	1.74	967.8	1993.78	1680.14
1982	2.14	1.45	1180.3	2530.16	1707.34
1983	2.33	1.45	991.3	2312.32	1439.11
1984	2.56	1.37	1653.0	4148.55	2268.58
			Var	622586.60	598573.92

(a) Rounded data.
Note: The nominal and the "world" wheat prices were deflated by the Wholesale Price Index (Lisbon), (1963=100).

TABLE 2: TOTAL INCOME PER HA FROM WHEAT PRODUCTION IN THE NATION, 1965-84.[(a)]

	Wheat Price (esc/kg) [1]	"World" Price (esc/kg) [2]	Average Yield (kg/ha) [3]	Total Income (esc/ha) [1]*[3]	Total Income (esc/ha) [2]*[3]
1965	3.06	1.73	983	3005.7	1701.4
1966	3.07	1.94	596	1832.2	1158.9
1967	2.96	1.96	1087	3222.2	2125.5
1968	2.84	1.69	1218	3456.2	2061.3
1969	2.74	1.50	802	2200.5	1199.7
1970	2.66	1.71	897	2382.4	1535.7
1971	2.70	1.38	1263	3404.2	1736.6
1972	2.70	1.70	1235	3329.9	2094.9
1973	2.43	2.71	1232	2989.7	3342.8
1974	2.11	2.87	1156	2443.8	3312.3
1975	2.12	2.33	1301	2757.2	3025.7
1976	1.90	1.83	1289	2449.1	2359.9
1977	1.67	1.37	868	1448.4	1191.9
1978	1.56	1.23	732	1141.3	900.0
1979	1.51	.99	881	1330.0	870.2
1980	1.99	1.53	1225	2439.9	1875.8
1981	1.94	1.74	927	1800.1	1609.4
1982	1.93	1.45	1202	2317.9	1738.8
1983	1.97	1.45	988	1949.1	1434.4
1984	2.12	1.37	1595	3374.7	2188.9
Var				497455.98	493360.13

(a) Rounded data.
Note: Nominal and "World" wheat prices were deflated by the Wholesale Price Index (Lisbon), (1963=100).

TABLE 3: DECOMPOSITION OF THE VARIANCE OF TOTAL REVENUE PER HA USING THE REAL WHEAT PRICES RECEIVED BY FARMERS: 1965-84.

	Direct R_p (a)	Effects R_y (a)	Linear Interaction R_{py} (a)	Total Variance (Esc/ha) (b)
Nation	.475	.525	.008	497455.9
Alentejo	.325	.675	.024	622586.6

Source: Study results.
(a) Using equation (2).
(b) Using Var(TV)= Var(P×Y).

- Despite the positive covariance between the yield per hectare and the real wheat price per kilo for the nation and for the Alentejo, the covariance for the Alentejo is greater than that for the nation. That is, price and yield interactions have tended to increase the variance in total value per hectare more for the Alentejo than for the nation. The interaction term tended to increase the total variance by 3980 esc/ha (=.008 × 497455.9) for the nation as compared to 14942 esc/ha (=.024 × 622586.6) for the Alentejo.

- The variance of the logarithm of the national yield per hectare is smaller than the variance of the logarithm of the yield per hectare in the Alentejo, (Tables 23 and 24 in the Appendix C). This indicates that the wheat production in other regions is less risky because of more stable weather patterns.

Table 4 shows the effect of using "world" wheat prices as a proxy for the average real wheat prices that farmers would have received in the absence of price policies. This table shows that for the nation the price variability becomes slightly greater: 265921.1 esc/ha

(=.539×493360.13) against 236291.6 esc/ha (=.475×497455.98). Thus, if "world" wheat prices were used, price variability would have been more important than yield variability to explain income variability.

TABLE 4: DECOMPOSITION OF THE VARIANCE OF TOTAL REVENUE PER HA, USING "WORLD" AND "ACTUAL" WHEAT PRICES; 1965-84.

	Direct R_p	Effects R_y	Linear Interaction	Total Variance
Nation (a)	.475	.525	.008	497455.98
(b)	.539	.461	.225	493360.13
Alentejo (a)	.325	.675	.024	622586.60
(b)	.472	.528	.267	598573.92

Source: Study results.
(a) Using the actual real wheat prices received by farmers.
(b) Using the "World" real wheat prices.

If the F distribution is used in order to compare the magnitude of these variances, the results suggest that the values for those total variances are not different from one another for 19 degrees of freedom at the 95% confidence interval. However, it can be said that the direct impacts of the wheat price policy have tended to stabilize prices and increase yield risk. In sum, wheat price policies followed in Portugal over the sample period seem to have been directed toward price stabilization rather than toward income stabilization.

Overall, the results in this section provide some support for the effectiveness of price stabilization policy as a component of income stabilization and for the existence of yield risk in the production of wheat in the Alentejo. Yield variability is twice as important as price variability in the Alentejo. Thus, eliminating price instability still leaves substantial revenue variability.

However, the estimation of the variance of the total value per hectare followed in this study has assumed that only a single crop was grown. Consequently, the estimated variance does not represent the "actual" values when several crops contribute to farm income. In the case of the multicrop farm, it is necessary to take account of the covariance between the returns of different crops. Letting j subscript be the j^{th} crop, the variance of total farm revenue is,

$$\mathrm{Var}(R) = \sum_{j} \mathrm{Var}(R_j) + \sum_{i \neq j} \sum_{j} \mathrm{Cov}(R_i, R_j), \tag{4}$$

For example, if barley is complementary with wheat in the Alentejo crop rotation, then the estimation of the variance of total income is underestimated not only due to its own variability but also due to a hypothesized positive covariance between the returns from these two activities.

CHAPTER III

DYNAMICS OF WHEAT SUPPLY

The dynamics of wheat supply in terms of economic and non-economic variables are addressed in this chapter. Chapter II concluded that the major factor in revenue variability was yield-variability, especially for the Alentejo. Because weather uncertainties in the Alentejo are hypothesized to be a major source of the estimated yield-variability for the winter wheat sector, this chapter attempts to determine the supply response to variations in price and non-price factors such as rainfall.

3.1 Previous Work

The most significant contribution to the literature on time-series supply analyses has been the work of Nerlove. His basic supply model for an annual crop includes coefficients of expectation and adjustment that reflect the "responses of expectations to observed prices and observed areas under cultivation to changes in equilibrium areas" (Nerlove, 1979). The inclusion of dynamic elements is accomplished in two different ways. First, the dynamic element in the basic models is introduced by assuming that producers are moving toward a long-run equilibrium position. Second, the dynamic element is introduced through a description of expectations formation such that expected prices are a function of last period's observed and expected prices. That is,

$$A_t - A_{t-1} \;=\; \rho(A_t^* - A_{t-1}), \tag{5}$$

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*), \quad (6)$$

$$A_t^* = a_0 + a_1 P_t^* + a_2 Z_t + u_t, \quad (7)$$

where A_t is the actual planted area in time t; P_t is the actual unit price of the crop in t; A^*_t is the desired planted area in t; P^*_t is the expected price in t; Z_t contains other observed variables; u_t is the random disturbance term in t; ρ and β are the coefficients of adjustment and expectation, respectively. The statistical problems of estimating this models, particularly those of identifying the relevant observed exogenous variables and of serially correlated disturbances, are well-known (Nerlove, 1979).

Modifications of the Nerlovian models have been proposed for applications to staple food crop production in developing countries. Some of the earliest studies are those of Krishna (1963, 1965) for rice and wheat in the Punjab region and Behrman (1966, 1968a) for rice and other crops in Thailand. Both studies emphasize the need to include the income elasticity of demand within the farm household. Because of lack of data, it was not possible to follow this procedure in this study.

Concerning the relationship of rainfall to supply-response, Lahirl and Roy (1985) point out that "rainfall, which is a crucial variable in the determination of acreage and yield of crops in developing countries, has been treated somewhat cursorily". They suggest that rainfall should be included in this type of research in a non-linear relationship to account for the detrimental impact of droughts as well as floods. Therefore, the optimum amount of rainfall needed for a specific season can be estimated from the structure of the model. The normal curve used captures that "too much rainfall is as bad as little rainfall". Rainfall will be positively related to yield and area up to some optimal amount R^* after which it reduces yield or area. Consider the yield relationship,

$$\text{Yield} = e^{-\beta(RWS - RWS^*)^2}, \qquad \beta > 0, \tag{8}$$

where RWS^* is the optimum growing season rainfall and RWS is the average amount of rainfall for the growing season. Taking the logarithm of both sides gives:

$$\text{Log(Yield)} = -\beta\, RWS^2 + 2\beta\, RWS^*\, RWS - \beta\, RWS^{*2}, \tag{9}$$

with unknown parameter β and RWS^*.

A similar formulation applies to the area equation. However, due to multicollinearity between RWS_t and RWS_t^2 (the correlation degree between these terms is about 0.99), it was decided to opt for another specification because the gain resulting from reducing the variances of the retained variables will offset the loss resulting from an increase in bias. The problem is that a high degree of multicollinearity results in large variances for the estimated coefficients. This implies that the confidence interval for a parameter will be relatively wide. Therefore, even if the corresponding variable has an important effect on the dependent variable, multicollinearity may make it quite difficult to estimate the effect of that variable. Therefore, the linear specification between area or yield and rainfall will be preferred.

3.2 Modeling Wheat Supply Response

A wheat supply model will be estimated for planted area and for yield for the Alentejo during the 1965-1984 time-period. Economic theory is used as a guide to the specification but no rigid a priori hypotheses are imposed. The model will be formulated so that a family of hypotheses can be included. However, this methodology is limited by the available degrees of freedom. A double-log functional form will be used. It is assumed that adjustment occurs but technological and/or institutional constraints permit only a fraction of the planned adjustments to be realized during the short-run. In the area equation it is also assumed that current planted area devoted to wheat is dictated by an average of current and past real wheat prices. According to Pindyck and Rubinfield (1981), "when constructing models, it is important to recognize that some amount of time usually lapses between the movement of the independent variables and the response of the dependent variable." For time-series models, a significant time period time may be needed to adjust the final impact of a change in a given policy variable. So, under the assumption that the full effects of a change in the real price on the planted area are gradually felt, a one-time increase in real price may result in observed increases in planted area over two, three, or more years.

The wheat sector in the Alentejo remains rain-dependent so that the exclusion of rainfall from the model would lead to a misspecification problem. The effect of rainfall in the area and yield equations is included in a linear fashion to avoid collinearity which would occur with the additional inclusion of quadratic terms. Average rainfall during the growing season is included in the yield equation. Average rainfall during the sowing season is included in the area equation because the development of the plant is influenced by the quantity of rainfall in this season and also because the lack or the excess of rainfall during this season can reduce the initially planted area.

The relevant months for rainfall during the planting and growing time were dictated by agronomic information and the availability of quarterly data. Therefore, the average amounts of rainfall (in mm) during Autumn (September, October, and November) and Winter and Spring (from December to May) for Agricultural Stations in the Alentejo were considered to correspond to the water availability for the planting and growing periods, respectively. The optimum amount of rainfall needed by the plant for the area and yield equations will be estimated according to the water needed by the plant as suggested by an F.A.O. study (Irrigation and Drainage papers numbers 24 and 33).

Another assumption was required about the variable to use to represent fertilizer. According to Firmino (1979), farmers commonly use a pre-emergence mixture of fertilizers, 18-36-0 (NH_4, P_2O_5, K_2O) at sowing time, on the good soils in the Alentejo. During the growing period, ammonium nitrate (26%) is the most used post-emergence fertilizer. Hence, the prices of the components were aggregated into a price index of the selected fertilizers.

Commodity prices were deflated by the Portuguese (Lisbon) Wholesale Price Index (World Bank Comparative Studies, 1988) as a proxy for the Agricultural Price Index. Therefore, all the prices are expressed in real terms with 1963 prices serving as the base year.

3.2.1 Area equation

It is assumed that the partial adjustment formulation reflects the effects of technological and institutional constraints that do not permit full adjustment to the desired position within one period. This formulation reflects the crop rotation system and was estimated using different lags before a final specification was chosen. According to Firmino (1979), while in the good soils of the Alentejo, wheat is typically rotated with fallow land during the Summer, in the other soils, the rotation system is wheat-barley or oats-fallow land (1 or 2 years). Equation (1) specifies the desired total cultivable area devoted to wheat.

$$\log(A_t^*) = a_0 + a_1 \log(ARPW_t) + a_2 \log(ARPB_t) + a_3 \log(RPF1_t) + $$
$$+ a_4 RA_t + \varepsilon_t, \tag{10}$$

where:

A^*_t is the desired planted area for that period.

$ARPW_t$ is the lagged moving average of the wheat price received by farmers in time t deflated by the Portuguese Wholesale Price Index (WPI) for the same period.

$ARPB_t$ is the lagged moving average of the barley price received by farmers in time t deflated by the same deflator for the same period.

$RPF1_t$ is the average prices paid by farmers for pre-emergent fertilizer used in period t, deflated by WPI for the same period.

RA_t is the average of rainfall in Autumn of year t, which is the average rainfall during the sowing period in mm.

ε_t is the t^{th} disturbance term.

Following Nerlove, farmers' actual planted area is assumed to be a function of the desired area devoted to wheat.

$$\log(A_t) - \log(A_{t-i}) = \sigma (\log(A_t^*) - \log(A_{t-i})), \tag{11}$$

where σ is the coefficient of adjustment and i is the lag structure that best fits the data.

3.2.2 Yield equation

It will be assumed that the yield for year t is determined as:

$$Log(Y_t) = \delta_0 + \delta_1 \log(RPF2_t) + \delta_2 RWS_t + \delta_3 T_t + \mu_t, \quad (12)$$

where:

$RPF2_t$	is the average price that farmers paid for post-emergence fertilizer at the growing period, deflated by WPI for the same period.
RWS_t	is the average rainfall (in mm) in the growing period of year t, which is assumed to be the average Winter and Spring rainfall.
T_t	is the time-trend variable in period t.
μ_t	is the t^{th} error term.

3.3 Empirical Results

3.3.1 Area equation

The reduced form of equation (11) was estimated by OLS. Under the assumption that the full effects of a change in the real wheat price on the planted area are gradually felt, current planted area is dictated by a lagged moving average of current and past real wheat prices. Several models using different moving average lengths were estimated. A three-period moving average real wheat price provided the best fit of the model. Also, a two-period adjustment lag turned out to be the most significant for the lagged endogenous variable. Because the data for the corresponding rainfall were not published for 1970 for all Stations, it was assumed that the value of the average rainfall in Alentejo for that year was equal to the average value of the Autumn rainfall over the entire period. The estimated results are the following:

$$\log(\hat{A}_t) = 3.005 + .278 \log(ARPW_t) + .359 \log(ARPB_t) + \\ + .103 \log(RPF1_t) - .00115\, RA_t + .372 \log(A_{t-2}) \quad (13)$$

These results show that wheat and barley are complementary crops. Barley is complementary with wheat because it usually follows wheat in the rotation. Typically, the expected returns per hectare from one of the crops in the rotation is greater than from the other, but the secondary crop is the next best source of income that is compatible with the soil structure and fertility. However, if the price of barley was to increase substantially because of a policy change, it could substitute for wheat as a primary crop and the rotation would be altered. These results also show a positive sign for the log of the real price that farmers paid for the pre-emergent fertilizer that was not expected.

Before analysing the significance of the estimated parameters or interpreting the coefficient of determination, the symmetric correlation matrix shown in Table 5 will be examined.

The correlation among the independent variables may be the cause for the unexpected positive sign for the coefficient on the log of the real price of fertilizer ($RPF1_t$). Due to this correlation, the log of the real price of barley ($ARPB_t$) and the log of the real price index of fertilizer ($RPF1_t$) were omitted from the initial model. With these omissions, the estimation results become

$$\log(\hat{A}_t) = \underset{(3.157)}{2.902} + \underset{(2.637)}{0.564} \log(ARPW_t) - \underset{(-3.134)}{0.0012} RA_t + \underset{(2.552)}{0.438} \log(A_{t-2})$$

$$R^2 = 0.714 \quad \overline{R^2} = 0.653 \quad h = -0.998 \qquad (14)$$

where the t-statistics are given in parentheses.

TABLE 5: CORRELATION MATRIX FOR THE AREA EQUATION (LOGARITHMIC).

Log of:	A_t	ARPW	ARPB	$RPF1_t$	A_{t-2}
A_t	1	.6233	.6168	.5754	.5933
ARPW		1	.7177	.7322	.4415
ARPB			1	.3865	.5269
$RPF1_t$				1	.3575
A_{t-2}					1

When a lagged endogenous variable is present in the chosen specification, it is expected that the value of the disturbance term in one period will not be independent of its value in another. The interdependence among successive values of the disturbance term will affect the variance of the estimators, which will in turn generate erroneous t ratios. As a result, hypothesis tests of the estimated parameters in the model will be not valid.

Therefore, the next step is to test if the estimated model suffers from this problem. When lagged endogenous variables are present, the Durbin Watson statistic (DW) is no longer useful and the Durbin h statistic was used. It is concluded that the null hypothesis of no serial correlation cannot be rejected and therefore the autocorrelation does not appear to be an econometric problem. Hypotheses testing can proceed and some conclusions can be drawn.

Several variables are significant in explaining area planted to wheat. The parameters found to be different from zero at the 5% level of significance are the logarithm of the real output price, the rainfall, and the lagged endogenous variable. More than 70% of the variability in the log of the planted area is explained by the independent variables considered in the model.

A negative relationship between the log of area planted and rainfall was expected because the average amount of rainfall during the planting time (165.17 mm) was greater than the estimated optimum amount (of about 60mm for Beja and Évora stations) recommended by the F.A.O. (Irrigation and Drainage Papers n^{os} 24 and 33). The Blaney-Criddle method was used due to the fact that only temperature data were available. From the regression results, a unit increase in rainfall in the Alentejo area diminished the planted area by 0.12%, if the other things remain constant.

It is possible to measure the effect of the adjusted output price on the planted area while holding barley and oat prices constant. Due to the correlation among the mentioned prices of the three outputs, the log of the real wheat price can be determined directly by the log of the real barley price and indirectly by the log of the real oat price because the log of the real price of barley is highly correlated with the log of real price of oats (0.9). The estimated results are the following:

$$\log(\hat{A}_t) = 2.340 + 0.389\ \text{Ehat}_t - 0.0013\ \text{RA}_t + 0.618\ \log(A_{t-2})$$
$$(2.268) \qquad (1.209) \qquad (-2.812) \qquad (3.435)$$

$$R^2 = 0.613 \qquad \overline{R^2} = 0.53 \qquad h = 1.121 \qquad (15)$$

where the t-statistics are given in parentheses. In equation (15) Ehat_t is given by:

$$\text{Ehat}_t = \log(\text{ARPW}_t) - \log(\text{AR}\hat{\text{P}}\text{W}_t)$$

Ehat_t removes the influence of the log of the real price of barley, directly, and the log of the real price of oats, indirectly;

$$\log(\text{AR}\hat{\text{P}}\text{W}_t) = \hat{a}_0 + \hat{a}_1 \log(\text{ARPB}_t)$$

This equation models the policy common to cereal prices. Notice that the estimated parameter associated with $\log(\text{ARPB}_t)$ is 0.899 and its t-value is 4.123.

The estimated parameter of 0.389 on Ehat_t represents the effect of the log of the real wheat price on the log of the planted area, while holding the log of the real price of barley (which is significantly correlated with the log of price of oats) constant. In this specification, the correlation between the log of the real wheat prices and the log of the real barley prices has been removed and, therefore, the estimated parameter represents mostly the isolated effect of the log of the real wheat price on the log of the planted area. Therefore, it seems that this estimated value (0.389) is the best estimate of the short-run elasticity. However, the estimated value is not significantly different from zero at the 5% level of significance. The short-run wheat supply is highly inelastic with respect to price and the long-run elasticity is estimated to be about 1. The output price is no longer significant at the 5% significance level in explaining variations in the planted area since the t-statistic associated with its estimated parameter (1.209) is less than the critical value (2.1451). However, if the 30%

level of significance is chosen, the output price becomes significant in explaining variations in the planted area. The adjustment model is still a significant specification since the lagged endogenous variable has an estimated coefficient of 0.618 and a t-value of 3.435. The rainfall is also significant in explaining variations in the area equation; its t-value is -2.812. Figure 2 shows the relationship between area and rainfall for the period under analysis.

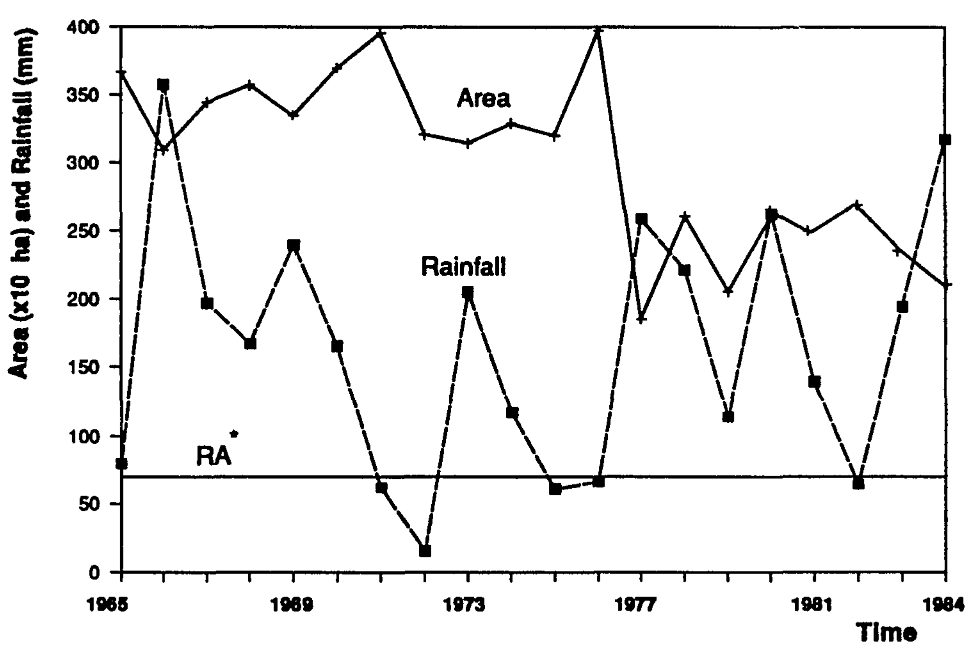

FIGURE 2: Alentejo area and rainfall from 1965 to 1984.

It suggests that a dummy variable might explain the significant decreases in the planted area devoted to wheat after 1975. This shift could represent the effect of the Land Reform that occurred after the revolution. If it is assigned a value of zero until 1975 and a value of one after 1975, then the effect of that qualitative variable on the planted area devoted to wheat could be measured. However, such a variable is correlated with the log of the lagged endogeneous variable (-0.61) and with the adjusted log of the lagged moving averages of the real wheat prices after holding the log of the real barley prices constant (-0.37). Because it is belived that this variable is important in explaining area variations devoted to wheat after 1975, its omission would yield biased and inconsistent estimators. Therefore, it was decided to include that dummy variable in the specified equation in spite of the multicollinearity problem. The more related is that dummy variable to the other regressors, the more serious is the multicollinearity.

If D_t is added to equation (15), the following results are obtained:

$$\log(\hat{A}_t) = \underset{(1.291)}{3.792} + \underset{(0.332)}{0.153}\ Ehat_t - \underset{(0.0005)}{0.0009}\ RA_t$$

$$+ \underset{(0.223)}{0.372}\ \log(A_{t-2}) - \underset{(0.105)}{0.178} D_t$$

$$R^2 = 0.684 \qquad \overline{R^2} = 0.59 \qquad F(3,14) = 7.019$$

where the standard deviations are given in parentheses.

It is concluded that the inclusion of D_t to the equation (15) creates multicollinearity resulting in large variances on the estimated parameters. However, the F statistics allow us to test the hypothesis that none of the explanatory variables help to explain the variation of area planted about its mean. Because the value of the F statistics is significantly different from zero for 3 and 14 degrees of freedom at a 5% significance level, it is concluded that the explanatory variables in the last equation are significant in explaining the variations of the area devoted to wheat.

3.3.2 Yield equation

Equation (12) was estimated by OLS. Again, because the values for the corresponding rainfall for each of the stations in Alentejo were not published in 1970, it was assumed that the average value for the corresponding rainfall in Alentejo in that year was equal to the average value of Winter and Spring rainfall over the historical period. The estimated results are:

$$\log(\hat{Y}_t) = -26.375 - 0.0018 \;\; RWS_t + 0.01672 \;\; Time_t + 0.2367 \;\; \log(RPF2_t)$$

Once again, before conducting regression analyses, a correlation matrix was estimated in order to determine the degree of correlation among the potential explanatory variables, because the positive sign associated with the $\log(RPF2_t)$ was not expected.

TABLE 6: CORRELATION MATRIX FOR THE YIELD EQUATION.

	$Log(Y_t)$	$Log(RPF2_t)$	$Time_t$	RWS_t
$Log(Y_t)$	1	.0458	.1981	-.5301
$Log(RPF2_t)$		1	-.8182	-.0739
$Time_t$			1	-.2043
RWS_t				1

Because $Time_t$ is negatively and strongly correlated with the log of the real price index for fertilizer ($RPF2_t$), it was decided to drop the latter independent variable. The results are the following:

$$\log(\hat{Y}_t) = \underset{(-0.514)}{-1.02} - \underset{(-2.446)}{0.0021} \;\; RWS_t + \underset{(0.448)}{0.0042} \;\; Time_t$$

The estimated parameter associated with time is not significantly different from zero at a 95% or a 70% level of confidence. Thus, significant technical innovations do not appear to have existed and the time-trend as a proxy for technological changes appears not to be a relevant variable.

The log of the planted area seems to influence yield per hectare, but, because their correlation is extremely low (0.16), it was decided not to include it. Hence, a reduction in the wheat area does not imply a significant increase in wheat yield. Finally, the only significant variable in explaining yields is rainfall. It is assumed that the average Winter and Spring rainfall is the relevant rainfall for the growing period because the plant is most sensitive to a water deficit during the flowering stage. Because of the difficulty of isolating the effects of the assumed relevant variables from each other, the coefficient of determination is low (0.47). Figure 3 shows the yield and rainfall paths through time.

This figure suggests that from 1971 to 1976 something happened because, in these years, yields had been higher and more or less stable. It was found that the effects of Autumn rainfall on yields cannot be omitted from the specified model. Theoretically, if it rains "too much" or "too little" during the planting time, the expected yields will be lower.

If Autumn rainfall is included in the yield equation, the regression estimation results are:

$$\log(\hat{Y}_t) = \underset{(41.30)}{7.577} - \underset{(-2.644)}{0.00206}\ RWS_t - \underset{(-1.95)}{0.00105}\ RA_t$$

$$R^2 = 0.412 \qquad \overline{R^2} = 0.343 \tag{16}$$

where the t-statistics are in parentheses.

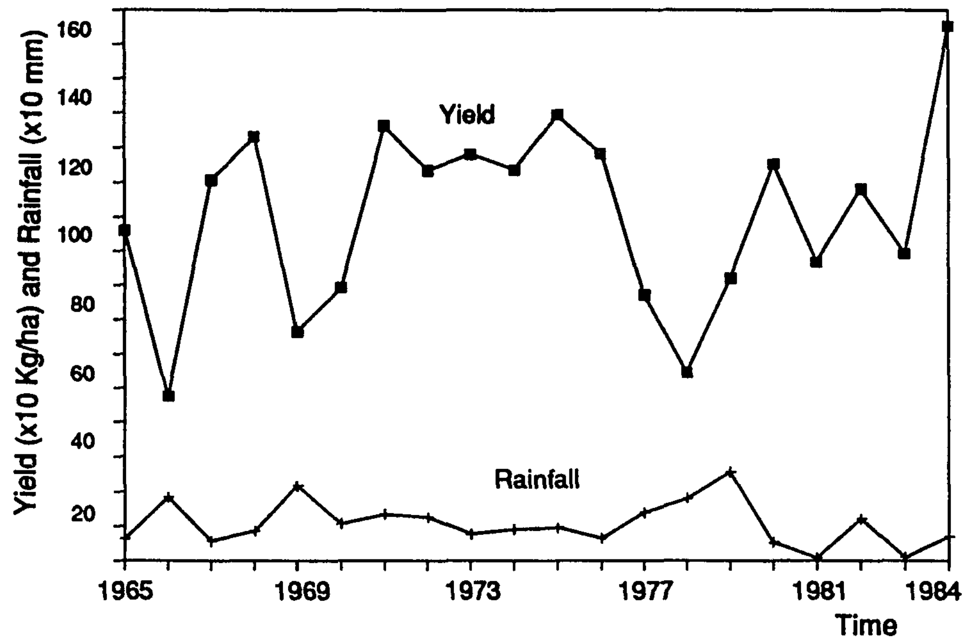

FIGURE 3: Alentejo yield and rainfall from 1965 to 1984.

It is concluded that Autumn rainfall is significant in explaining yields at the 10% significance level. Winter and Spring rainfall is a significant variable in explaining variations in the observed yield/ha even at the 5% significance level. Therefore, a linear specification between the log of the yield and rainfall was found to work quite well. These results suggest that the average rainfall during the planting and growing times diminished the yield per hectare. The estimated optimum amount of rainfall recommended by F.A.O. studies for the Winter season, which coincides with the tillering and dormancy stages of the plant, was found to be about 60 mm, far below the average rainfall during the same season (254.3); thus, an excess of rainfall occurred during this period. But, the estimated optimum amount of rainfall for the Spring season, which coincides with the head development and flowering stages of the plant, was found to be about 250 mm which is far above the average of rain felt in the same season (161.6); thus, a deficit of rainfall occurred during this period.

3.4 Summary

This chapter addressed the dynamics of the wheat supply in the Alentejo from 1965 to 1984. One of the findings was that wheat and barley are complementary crops, a result that was expected from the crop rotations used in type C soils. The lagged endogenous variable in the area equation generally explains this rotation.

Technological innovations, if measured by a trend in the yield per hectare, were not significant in the yield equation. These results support to some extent the idea that the Portuguese intervention in factor and commodity markets could have motivated farmers to maintain traditional crop rotations.

As hypothesized, rainfall was relevant in explaining variations in both the planted area and yield per hectare. A linear specification between rainfall and yield or area works quite well in both models. Therefore, rainfall variability may contribute to income variability in the Alentejo. Figures 4 and 5, respectively, show the actual and predicted deviations in $\log(A_t)$ and the actual and predicted deviations in $\log(Y_t)$.

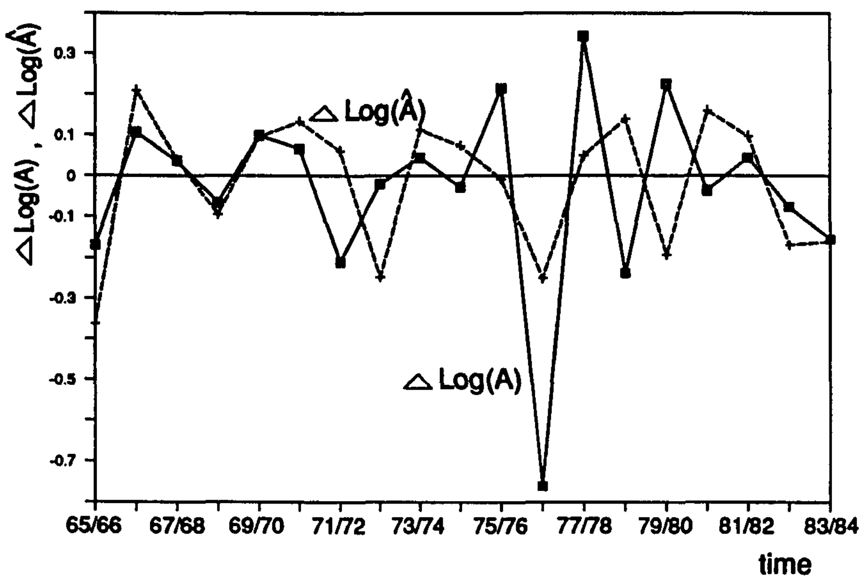

FIGURE 4: Actual and predicted deviations in the Alentejo planted area due to the deviations in the "Autumn rainfall".

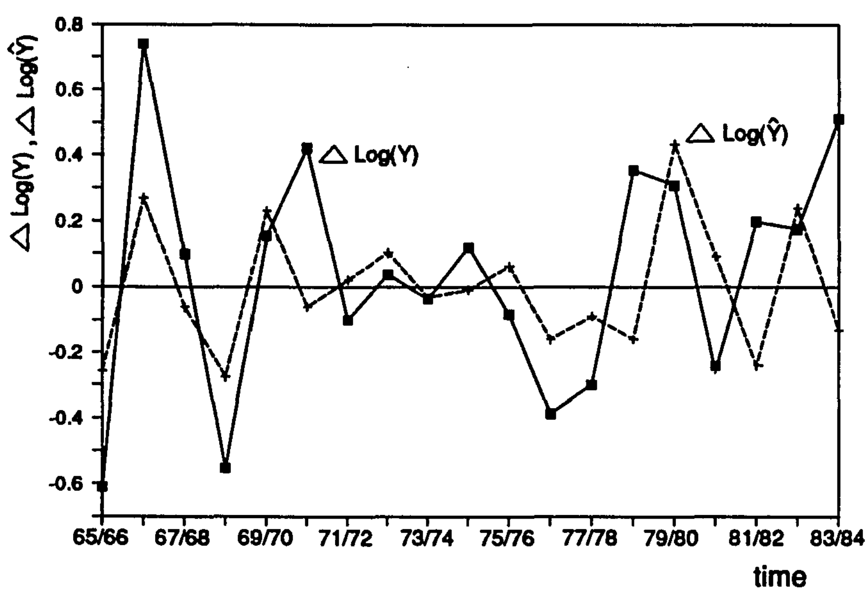

FIGURE 5: Actual and predicted deviations in the Alentejo yield due to the deviations in the "Winter and Spring rainfall".

The results when compared with the estimation of the optimum amount of water for the wheat production suggest that it rains too much in the earlier stages of the plant growth (establishment, tillering and dormancy) which coincides with Autumn rainfall and Winter rainfall when the plant does not need too much water, and there is a deficit of rain during the critical flowering stage which coincides with the Spring rainfall, when the plant needs more water.

Hence, besides the adoption of potential new crop and livestock technologies and/or the implementation of an irrigation system, a crop insurance program is suggested as a mean of decreasing this risk in this region. Fox argues, in pp.105- 106, that "it is unlikely, however, that irrigation will provide the solution to declining profits in the Alentejo [in the EC]. Even if improved technologies could increase yields and profits substantially, the potential irrigable area is very small relative to the vast area of cultivated land."

CHAPTER IV

CROP INSURANCE

Chapter II showed that yield variability was identified as the major factor in income variability for the Alentejo. In Chapter III, rainfall was identified as relevant in explaining variations in area and yield per hectare. Deviations from the optimum amounts of rainfall for each of the specified seasons appear to be a major factor in income variability. This chapter discusses the implementation of a policy that could stabilize output returns to farmers. An evaluation of the possibilities for a wheat insurance program is provided and the expected costs of such program in the Alentejo are estimated.

4.1 Previous Work

Pricing institutions unquestionably influence price behavior. One problem of price analysis is to separate the influences of economic factors from institutional effects. Telser (1957) attempted to assess the effect of the United States support program for cotton prices on price stability. He estimated the price behavior that would have existed in the 1933-53 period without price supports. He concluded that the support program reduced price instability for cotton, but he admitted that the major difficulty of his research was that what actually happened was being compared with what did not in fact happen. Similarly, in this study, the expected effects of a hypothetical insurance program on income variability will be estimated as if the output price policies were been implemented by the EC.

Siamwalla and Valdés (1986) argue that subsidies can be justified at least during the initial phase of an insurance implementation. They say that "until the insurance program reaches a critical size, it may also be difficult to adequately spread its risks or to build up the necessary reserves to survive a run of bad years". Subsidized insurance will be discussed in detail in the next section. Afterwards, a hypothetical non-subsidized and subsidized premium will be estimated as well as total government costs and subsidies for the sample period. Finally, the cost will be estimated for the implementation of a wheat insurance program under different scenarios and for different degrees of protection against yield losses.

4.2 Theoretical Considerations

The presence of high yield risk in the Alentejo continues to constrain farmers' willingness to invest. According to Hazell, Pomareda, and Valdés, "problems associated with risks in agriculture are one of the reasons that many governments intervene directly in agricultural product and factor markets." Portuguese wheat farmers face a variety of risks, such as weather uncertainty in the Alentejo, that make their incomes variable. These risks are of interest to policy-makers because fluctuations in farm incomes result in welfare losses for the rural community if farmers are risk averse. If farmers are risk averse, they will supply smaller quantities of agricultural products and expect reduced average farm incomes than they would if risk were neutral. The purpose of a crop insurance is to stabilize income which in turn ensures enough income each year to pay debts and meet essential living costs (Hazell, Bassoco, and Arcia, 1986). If this goal is achieved at a lower cost than the costs imposed by risk aversion, farmers may seek higher average profits.

4.2.1 Demand for insurance

Insurance is expected to reduce income risks for typically risk-averse farmers by reducing the variability of the returns for that activity or by increasing the level of income common in "bad" years. Hazell, Bassoco, and Arcia point out that a good insurance program for a single crop should reduce the variance of income and, in the case of multicrop farms, "[it] should reduce the positive covariances and increase the absolute value of the negative ones".

$$\mathrm{Var}(R) \;=\; \sum_{j} \mathrm{Var}(R_j) \;+\; \sum_{i \neq j} \sum_{j} \mathrm{Cov}(R_i, R_j) \qquad (4)$$

where, j is the j^{th} crop.

Knowing that yield risks are the primary source of fluctuations in wheat farmers' incomes, the Portuguese government could intervene in the wheat sector by providing an all-risk insurance program. In general, farmers in developed and developing countries have been unwilling to pay the full cost of all-risk crop insurance and, thus, most of the all-risk programs remain public sector schemes.

Ahsan (1985) argues that "insurance may not be provided by private markets if the cost of information needed to formulate a coherent probability distribution is very high" because the incidence of random events in agriculture may not be independent. And, sometimes, even with a public program, it may take a very long time to select a "viable" normal yield which could be used for indemnity and premium calculations.

Moreover, the insurers will be exposed to a certain degree of "moral hazard" and "adverse selection". The first problem arises when farmers become less aggressive about avoiding damages because of the temptation to rely on insurance compensation. That is, "moral hazard problems occur because the insured can take actions which affect the probability of losses and cannot be observed by the insurer", Nelson and Loehman (1987). A common solution to this problem is "coinsurance" in which part of the risk is borne by the insured.

A second problem arises when the contracts for farmers who face different risks are written with the same premiums and indemnities, since the insurer cannot easily determine the risks that they are insuring against. When insurance is voluntary as is common with private insurance, if the insurer offers a single policy that would be strongly subscribed by the higher risk groups, the firm can expect losses. According to Nelson and Loehman (1987) "adverse selection is avoided if insurance contracts are based on perfect information about each individual's risk". In practice, compulsory insurance is a solution to the adverse selection problem. Increased administrative costs can be minimized if homogeneous areas rather than individual farmers are used as the basis for normal yield estimation. Since compulsory insurance would encourage moral hazard, a progressive premium structure could be adopted. That is, premiums would increase progressively to the amount of coverage wanted and indemnities would also increase progressively to the amount offered, based on the shortfall in yield.

Because of these costs, private firms will have little or no incentive to provide this type of insurance, and only the public sector may offer it. Furthermore, substantial externalities are associated with agricultural risks because the incidence of crop failure will affect not only farmers and their creditors directly, but also a vast cross section of society. These reasons may prompt governments to provide crop insurance.

4.2.2 Insurance and public policy

The welfare economics of crop yield-insurance must be addressed to understand the issues of government-subsidized crop insurance. Following Siamwalla and Valdés, suppose that a non-subsidized insurance is introduced and that commodity demand is not perfectly elastic.

The insurance will reduce the production risks for which farmers need to be compensated. When farmers diversify their production into other safe crops with some reduction in their average return, that reduction is also added in the risk undertaken by farmers. Suppose that, in figure 6, the initial supply is S_0; then, the new supply will be S_1 because insurance will reduce the farmers' risk and there will be a fall in price from P_0 to P_1, shown in figure 3. The reduction in cost (AC) will be an incentive for farmers to subscribe to insurance without any subsidy. The drop in price will benefit either consumers (by capturing an extra-surplus) or producers (by capturing the cost savings). The net welfare gain for producers may be positive or negative - but, in this case will be P_1DO less P_0AO. Consumers will gain P_0ADP_1. For society as a whole the net welfare gains will be positive, represented by the area OAD, and the amount of the gain will depend on the magnitude of the shift of the crop supply. These gains will result from the adoption of insurance and their magnitude depends on the relevant demand as well as on the supply elasticities. As the authors argue, "since the insurance premiums paid are included in S_1, the welfare gain depicted by the area OAD measures the social value of the introduction of insurance net of its full cost", if a constant cost function for insurance is assumed over the relevant range.

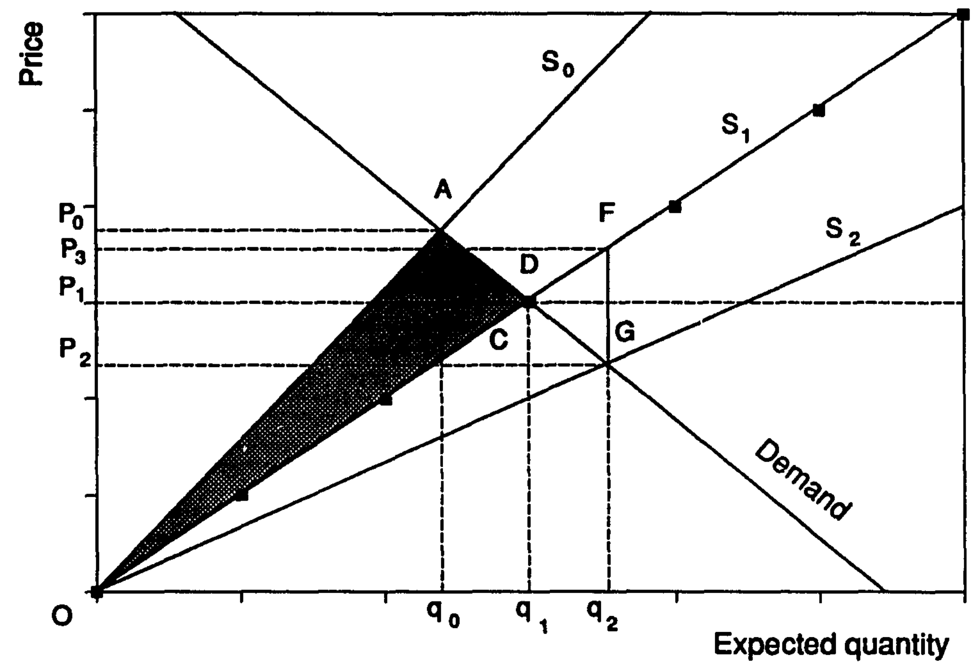

FIGURE 6: The general case of welfare gains to consumers and producers

With a subsidy there will be a further supply shift to S_2 which will induce a shift in production from q_1 to q_2 and a further drop in price. The gain in consumers' and producers' surpluses will be ODG which is always less than the subsidy cost P_2P_3FG as Siamwalla and Valdés proved. According to these authors, ODG and the cost of subsidy can be expressed by:

$$\text{ODG} = 1/2P_1q_1 + P_1(q_2 - q_1) - 1/2P_2q_2 - 1/2(P_1 - P_2)(q_2 - q_1)$$

$$\text{ODG} = 1/2P_1q_2 - 1/2P_2q_1 \qquad (18)$$

While

$$P_2P_3\text{FG} = (P_3 - P_2)q_2 \qquad (19)$$

If the supply function, P, is equal to, P= kq, where k is the slope coefficient, then, $P_1= k_1q_1$, $P_2= k_2q_2$, and $P_3= k_1q_2$. Substituting into the above expression and taking the net social gain as the difference of the above two expressions, equation (20) is obtained:

$$ODG - P_2P_3FG = (k_1 - k_2)(1/2q_1q_2 - q_2^2) \qquad (20)$$

Since $k_1>k_2$, and $q_1<q_2$, the net social gain is always negative. There will be a net social loss regardless of the level of subsidy given.

If demand is perfectly elastic as is the case with Portugal as a member in the EC, farmers will capture all the benefits from the insurance. If a subsidy is given, there will be a further leakage of benefits to farmers. Figure 6 shows this particular case.

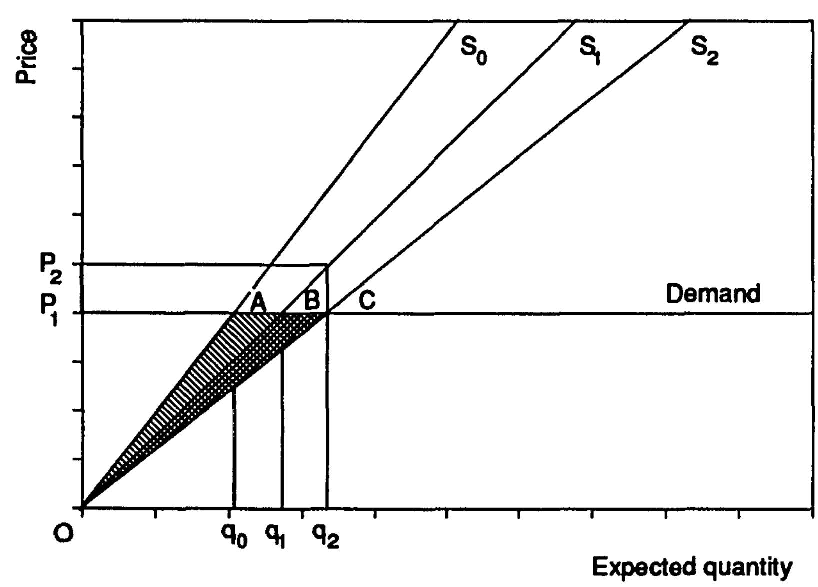

FIGURE 7: The case of welfare gains to producers in the presence of a perfectly elastic demand.

Suppose that the initial supply is S_0; then, with insurance the new supply will be S_1 since insurance will reduce the farmers' risk. But, this shift will benefit only producers since demand is perfectly elastic. The net welfare gains to producers will be equal to the net welfare gains to society as a whole, which in this case, it will be OAB. With a subsidy, supply will shift from S_1 to S_2. The net welfare gains for producers will be OBC. The cost of subsidy will be P_2P_1DC. And the net welfare gains for society as a whole will be equal to OBC-P_2P_1DC.

$$OBC = 1/2P_1q_2 - 1/2P_1q_1 \tag{21}$$

$$P_2P_1DC = 3/2P_1q_2 - 1/2P_1q_1 - P_2q_2 \tag{22}$$

Again, if $P_1=k_1q_1$ and $P_2=k_2$ and if $k_1>k_2$ and $q_1<q_2$, then the net welfare gains to society will be equal to:

$$OBC - P_2P_1DC = -1/2\ (k_1q_1^2 + 2k_2q_2^2 - 3k_1q_1q_2)$$

Note that $(aq_1 - bq_2)^2 = a^2q_1^2 + b^2q_2^2 - 2abq_1q_2$. Thus, $a = \sqrt{k_1}$ and $b = \sqrt{2k_2}$. Hence,

$$(\sqrt{k_1}\,q_1 - \sqrt{2k_2}\,q_2)^2 \quad = k_1q_1^2 + 2k_2q_2^2 - 2\sqrt{2k_1k_2}\,q_1q_2$$

Then,

$$OBC - P_2P_1DC = -\frac{1}{2}\left[(\sqrt{k_1}\,q_1 - \sqrt{2k_2}\,q_2)^2 + (2\sqrt{2k_2k_1} - 3k_1)q_1q_2\right] \tag{23}$$

Because the first term in brackets is always positive and the second term in brakets is negative, the net welfare gains for society as a whole can be either positive or negative.

Therefore, nothing can be said a priori about the expected sign of the net social gains from a subsidized insurance plan. The expected sign of the net social gains must be determined for each case.

In sum, Siamwalla and Valdés argue that in the general case subsidies can be justified only during the initial phase of an insurance program. Subsidies can also be socially justified for small-scale farmers, those who are more vulnerable and unable to pay the full price of insurance. Subsidies might also be desired if the public wants to support the income of wheat growers as a compensation for the consequence of the accession of Portugal to the EC.

Therefore, farmers should be eligible for a premium subsidy at least in the early years of the implementation of a crop insurance. If the implementation of a subsidized wheat insurance program in Alentejo results in negative net social gains, inefficiencies in allocating resources are expected. Socially inefficient systems of producing wheat in the poor soils are going to be subsidized. For simplification, an estimation of the costs of a hypothetical wheat insurance program will be measured on the basis of a non-subsidized and a subsidized premium to be applied to the Alentejo region.

4.3 Expected Costs of a Wheat Insurance

According to Ahsan, the option of homogeneous areas rather than individual farms as the basic unit of insurance coverage solve one of the major problems of an insurance plan. The area should be as small as possible in order to account for deviations of the actual yields from the Alentejo average but yet as large as possible in order to reduce the administrative costs and the information costs for weather, soil, and crop yield data. The greater the agroclimatic homogeneity of the delineated area, the lower should be the coefficient of variation in yields defined as the ratio of the standard deviation to the mean of the distribution. If such an approach is chosen, "a detailed inspection of an individual farm is not required as indemnities are based on the year to year fluctuations in area average output", Ahsan (1985). However, a drawback of the homogeneous area plan is that some proportion of farmers can obtain an average yield that is different from the average in the specified area in a given year. It is believed that the positive and negative deviations would offset each other in the long run.

For simplification, the estimation in this study will consider Alentejo as one homogeneous area. Also, several other assumptions need to be introduced. The hypothetical "guaranteed " wheat price for the 1965-1984 period will be assumed to be the EC prices for wheat. Because Portugal has been a member of the EC since 1986, and because the EC maintains a output price policy to control price risks, it makes sense to orient the analysis toward EC prices. The EC prices for wheat were calculated using CAP prices expressed in units of account (U.A.) up to 1979. After that time, they were expressed in terms of European Currency Units, (ECUs). A fixed relationship was used according with the "CAP Monitor", (AgraEurope (London), Ltd, (21.1.1989)), in order to facilitate the changeover between the two financial units. Then, the EC prices were expressed in ECUs/U.S. dollars. A nominal exchange rate expressed in esc/U.S. dollars, which came from the World Bank Comparative Studies, 1988, was used to convert prices to esc/kg. Finally, the Portuguese Wholesale price index (Lisbon) which came from the World Bank Comparative Studies, 1988, converted to a 1980 base year, was used to obtain real prices. It will be assumed that the hypothetical wheat insurance program provides multiple-risk coverage against yield risks.

4.3.1 Empirical model: Revenue Insurance Calculations

To simulate the effects of insurance on income variability, a new set of revenue deviations must be estimated corresponding to what the economic variables would have been if the crop had been insured. Deviations of the new crop revenue series, which differ from the original series in those years in which indemnities would have been paid, will be calculated. Both revenue series are based on the real EC prices expressed in Esc/kg and yields expressed in kg/ha.

The first scenario assumes that an indemnity was paid when the actual yield is less than 85 percent of the normal (mean) yield. The assumption is that a natural disaster occurred whenever the yield was less than 85% of the mean yield. The indemnity payment is calculated as the difference between actual revenue and mean revenue. The premium is calculated as the total indemnity divided by the number of years of the time series. Table 7 shows these insurance calculations.

The mean of the uninsured revenue series for the Alentejo region is 13675.664 esc/ha and the revenue deviation is calculated around this mean. Indemnities would have been paid in years 1966, 1969, 1970, 1977, 1978, and 1979. Notice that the insurance scheme would have reduced the standard deviation by 972.6 esc/ha. If it is assumed that payments occurred whenever the actual yield was less than 90 (or less than 80) percent of the mean yield, the total indemnities that would have been paid to farmers increase (decrease) when compared with the previous results, as shown in table 25 in Appendix D.

These simple calculations show that wheat insurance is able to reduce income variability, since it reduces the variability of returns for that activity and increases the level of income realized in "bad" years. Therefore, wheat insurance will partially compensate the losses associated with weather uncertainties in the Alentejo. In reducing income variability, the insurance agency seeks to reduce risk by spreading risk among farmers and to spread risk over time by accumulating reserves.

TABLE 7: INSURANCE CALCULATIONS FOR THE ALENTEJO, 1965-1984.(a)

		Uninsured Series		Insured Series		
	Average Yield (kg/ha)	Revenue (Esc/ha)	Revenue Deviations	Revenue (Esc/ha)	Revenue Deviations	Indemnity
1965	1060.3	17603.4	3927.7	17603.4	2824.9	
*1966	576.0	9209.2	-4466.5	13675.7	-1102.8	4466.5
1967	1206.3	18590.8	4915.1	18590.8	3812.4	
1968	1331.8	19647.9	5972.2	19647.9	4869.4	
*1969	766.3	10931.1	-2744.6	13675.7	-1102.8	2744.6
*1970	894.0	12597.4	-1078.3	13675.7	-1102.8	1078.3
1971	1364.3	19456.9	5781.2	19456.9	4678.4	
1972	1234.8	17678.2	4002.5	17678.2	2899.8	
1973	1281.3	16734.6	3059.0	16734.6	1956.2	
1974	1235.3	13599.5	-76.2	13599.5	-1179.0	
1975	1394.0	15443.5	1767.8	15443.5	665.1	
1976	1283.3	13352.5	-323.2	13352.4	-1426.0	
*1977	871.3	9326.5	-4349.2	13675.7	-1102.8	4349.2
*1978	646.3	6889.9	-6785.8	13675.7	-1102.8	6785.8
*1979	921.0	11044.7	-2630.9	13675.7	-1102.8	2630.9
1980	1253.3	15266.2	1590.5	15266.2	487.8	
1981	967.8	10064.8	-3610.9	10064.8	-4713.7	
1982	1180.3	11389.5	-2286.1	11389.5	-3388.9	
1983	991.3	10002.8	-3672.9	10002.8	-4775.6	
1984	1653.0	14684.2	1008.5	14684.2	-94.3	
Mean	1105.6	13675.7		14778.4		
Std Dev		3695.4		2722.8		
Total						22055.3

(a) The EC-prices were used from table 8 in appendix B.
Source: Study results.
*: year in which indemnities would have been paid.

Ideally, agricultural insurance would eliminate income variability and cause farmers to behave as if they were risk neutral. But, this ideal situation will be impossible to operate with zero transaction costs. In practice, agricultural insurance has been costly both to tranfer risk from farmers to governments or to other insurers and to motivate farmers to buy insurance.

4.3.2 Cost Estimations under different Scenarios

Costs are estimated by calculating the total losses whenever the actual yield was less than the corresponding sum insured. The losses correspond to the difference between the sum insured and the actual yield for the years in which actual yield was below the hypothesized sum insured. Table 8 provides the results of that estimation.

An initial reserve is required to face possible initial yield losses and it is assumed equal to 1/9 of the single premium. The single premium is considered equal to the yield losses to be indemnified, that is less than 80% of the normal yield. The initial reserve and the single premium constitute the basic premium. Moreover, it is assumed that government costs are 40% of the full premium (Ahsan, pg 36).

For the years for which the average yield is less than the sum insured, the total losses to be indemnified are equal to 963.66 kg/ha for the first case (85% of the mean yield), 1326.62 kg/ha for the second case (90% of the mean yield), and 678.02 kg/ha for the third case (80% of the mean yield). Table 9 shows the calculations of the hypothetical full premiums under different cases.

TABLE 8: TOTAL LOSSES TO BE INDEMNIFIED IN ALENTEJO, 1965-84.

	.85MY-Y_t (kg/ha)	.9MY-Y_t (kg/ha)	.8MY-Y_t (kg/ha)
1966	363.76	419.04	308.48
1969	173.46	228.74	118.18
1970	45.76	101.04	13.18
1977	68.46	123.74	238.18
1978	293.46	348.74	x
1979	18.76	74.04	x
1981	x	27.24	x
1983	x	4.04	x
Total	963.66	1326.62	678.02

Source: Study results.
x: Year in which indemnities would have not been paid.
Note: MY is the mean yield and Y_t is the actual yield per hectare.

TABLE 9: CALCULATIONS FOR A HYPOTHETICAL FULL PREMIUM IN THE ALENTEJO UNDER DIFFERENTS CASES.

	CASE I	CASE II	CASE III
(1) Basic Premium:	1070.73	1474.02	753.36
Single Premium	963.66	1326.62	678.02
Initial Reserve	107.17	147.40	75.34
(2) Administrative Costs	713.82	982.68	502.24
(3) Full Premium (kg/ha)	1784.55	2456.70	1255.60
(10^3esc/year)	343520.1	472782.8	241703.6

Source: Study results.

The next step is to estimate the total government costs under different scenarios of subsidizing insurance. Four scenarios are assumed to correspond to the hypothetical situations of subsidizing 100%, 50%, 25%, and 0% of the single premium, respectively. Table 10 shows these calculations.

How expensive is the provision of insurance under each scenario and under each case? The government costs under each scenario are expressed relative to the total direct subsidies given to the wheat farmers as a consequence of the output price policy. These total direct subsidies were estimated as being equal to the difference between the real producer prices and the real "world" prices for wheat farmers presented in Chapter II. Table 11 shows the calculations.

TABLE 10: TOTAL GOVERNMENT COSTS FOR THE ALENTEJO UNDER DIFFERENT INSURANCE SUBSIDIZATION SCENARIOS.(a)

	CASE I (85%MY)	CASE II (90%MY)	CASE III (80%MY)
SCENARIO I (100% sp)	343471.94	472859.75	241703.55
SCENARIO II (50% sp)	250701.51	345173.34	176453.41
SCENARIO III (25% sp)	204332.65	281339.81	143791.29
SCENARIO IV (0% sp)	158015.76	217506.25	111166.70

Source: Study results.
(a) 10^3 esc/year.
Note: sp is the single premium

TABLE 11: HYPOTHETICAL TOTAL GOVERNMENT COST IN THE ALENTEJO AS A FRACTION OF THE TOTAL DIRECT SUBSIDIES.

	CASE I	CASE II	CASE III
SCENARIO I	0.29	0.40	0.21
SCENARIO II	0.21	0.29	0.15
SCENARIO III	0.17	0.24	0.12
SCENARIO IV	0.13	0.18	0.09

Source: Study results.

Even in the most expensive situation, case II and scenario I, the total government costs of implementing an insurance plan in Alentejo would represent an additional cost of 40% of the total direct subsidies given in this region from 1965 to 1984. To subsidize 50% of the single premium for which the sum insured is 85% of the mean yield (or to subsidize 100%), has the same cost as to subsidize 100% of the single premium for which the sum insured is 80% of the mean yield (or to subsidize 50% of the single premium for which the sum insured is 90% of the mean insured). Finally, note that the least expensive case of subsidizing insurance that was considered (case III, scenario III), the estimated total government costs would only be 12% of the direct subsidies given during that period. Therefore, the implementation of an insurance plan does not seem to be as expensive for some cases as one would expect before conducting this analysis.

4.4 Summary

A wheat insurance plan can be viable for the wheat sector in Alentejo because it reduces income variability. If efficient resource allocation is the dominant goal of policy-makers, the non-subsidized premium appears to be the most attractive policy. Truong and Josling (1983) argue that "subsidies can also be used selectively to provide incentives for expansion of economically efficient activities [and, therefore,] an acceptable subsidy policy will reflect both income support and economic efficiency objectives". In that case, subsidized insurance is suggested, since the subsidies given to economically efficient systems would provide both income support and further incentives to expand those systems. But, subsidies given to inefficient systems would support producer income at an economic cost, since those incentives would lead to resource misallocation. In this case, a subsidized premium can be viewed as a policy that transfers income to wheat farmers. An evaluation of a national crop insurance is needed if it is desired to implement such a policy on a larger scale. Several difficulties are expected. Although the need for crop insurance is readily acknowledged, its implementation presents basic difficulties such as lack of disaggregated long-term data on crop yields and losses, the variety of agricultural practices, and the problems of moral hazard.

CHAPTER V

CONCLUSION

This chapter summarizes the major findings of this study from each of the four chapters. The results are briefly reviewed and recommendations for further research are discussed.

5.1 Summary of Major Findings

This thesis had several sequentially-related objectives. The first objective was to determine if the Portuguese wheat price policy has permitted a stabilization of the wheat price or/and a stabilization of income, especially in the Alentejo. It was found that the wheat price policy followed in Portugal over the period studied has focused on a price stabilization rather than income stabilization. Yield variability was found to be substantial, especially in the Alentejo where it was twice as important as price variability.

The second objective was to determine the cause of such yield variability. Several regressions were done for area and yield equations. It was found that the agronomic variable, rainfall, is one of the relevant variables in explaining variations in both area planted and yield per hectare. In both equations, rainfall had a negative effect. It was therefore concluded that rainfall variations were one of the major causes of yield variation.

Third, an all-risk insurance policy was considered as the policy that could stabilize income to farmers because "price risks are effectively controlled by Portuguese and EC policies, but yield risks continue to limit farmers' willingness to invest" (Fox, 1987).

Insurance reduces the variability of income and increases the level of income realized in bad years but the costs for its implementation cannot be ignored. The delineation of "homogeneous areas", the basic unit levels to determine the average yield, are crucial to the success of an insurance plan.

The costs of an insurance program were estimated under the assumption that Portugal was in the EC since 1965 and a wheat insurance plan had been used. It was found that an insurance plan can be viable for the wheat farmers in the Alentejo because it stabilizes their income and it increases their average income. If government subsidies are used to finance part of the full premium of such program, this policy will work as an income transfer to the wheat farmers. One problem of such an action is that it may provide private incentives to inefficient wheat production.

In summary, it is well-known that the effects of Portuguese price alignments with the EC prices are expected to reduce farm profitability of the traditional crops in the Alentejo over the transition period. New technologies analyzed by Serrão (1988) will reduce but not eliminate the decrease in farm incomes from adoption of EC prices. Farmers will need to make significant investments and new crops will also be subject to the weather uncertainties in this region, a major cause for their income variability. An insurance plan is recommended because it would reduce such variability and at the same time would increase the cash-flow needs for farmers to adopt new technologies.

5.2 Recommendations for further research

If crop insurance is a viable policy option, further research needs to be done to delineate "homogeneous areas" as the first step to identify the appropriate premium rates for each area. For that exercise, more disaggregated data are needed. This study could also be expanded to evaluate a multiple-crop insurance on the basis of improving the adoption of new crops that could be rotated in the better soils with wheat. Furthermore, an evaluation of a national crop insurance program could be done if it is not desired to favor one agricultural region more than another.

APPENDIX A

QUANTITY DATA

TABLE 12: WHEAT: TOTAL PLANTED AREA FOR THE ALENTEJO BY DISTRICT, 1965-84. (1000 ha)

	Beja	Évora	Portalegre	Setúbal	Total Alentejo (a)	Total Nation
1965	190.3	84.3	64.8	27.1	366.5	628.0
1966	166.4	75.5	43.9	23.8	309.6	523.1
1967	178.4	89.8	50.9	25.6	344.7	591.6
1968	179.4	91.7	55.0	31.5	357.6	619.9
1969	171.0	92.0	48.3	24.0	335.3	574.1
1970	183.0	105.1	57.3	25.0	370.4	607.9
1971	194.8	112.5	62.9	25.7	395.9	634.5
1972	147.9	94.0	59.0	20.0	320.9	495.0
1973	140.9	98.5	56.2	19.1	314.7	480.0
1974	146.3	108.9	55.2	18.5	328.9	466.8
1975	143.8	97.5	58.0	21.0	320.3	466.0
1976	173.3	131.3	64.5	28.0	397.1	534.5
1977	90.6	55.8	27.8	11.2	185.4	260.4
1978	124.1	81.9	40.3	14.3	260.6	354.9
1979	110.1	52.6	32.5	10.2	205.4	281.3
1980	124.0	73.4	48.1	11.8	257.3	350.7
1981	117.5	72.1	47.5	11.3	248.4	339.8
1982	123.4	77.2	46.6	12.3	259.5	353.1
1983	105.7	70.1	47.5	17.4	240.7	330.9
1984	97.1	55.4	39.7	14.0	206.2	291.8

(a) Author's calculations.
Source: Estatísticas Agrícolas, I.N.E.
Note: Rounded data

TABLE 13: NATIONAL AND ALENTEJO AVERAGE WHEAT YIELD

BY DISTRICT, 1965-84. (kg/ha)

	Beja	Évora	Portalegre	Setúbal	Alentejo Average (a)	National Average
1965	978.0	1197.0	985.0	1081.0	1060.3	983.0
1966	614.0	614.0	431.0	645.0	576.0	596.0
1967	1069.0	1237.0	1325.0	1194.0	1206.3	1087.0
1968	1288.0	1417.0	1389.0	1233.0	1331.8	1218.0
1969	716.0	729.0	917.0	703.0	766.3	802.0
1970	935.0	880.0	953.0	808.0	894.0	897.0
1971	1339.0	1299.0	1482.0	1337.0	1364.3	1263.0
1972	1326.0	1088.0	1176.0	1349.0	1234.8	1235.0
1973	1536.0	1189.0	1204.0	1196.0	1281.3	1232.0
1974	1208.0	1195.0	1402.0	1136.0	1235.3	1156.0
1975	1462.0	1390.0	1512.0	1212.0	1394.0	1301.0
1976	1384.0	1256.0	1511.0	982.0	1283.3	1289.0
1977	893.0	901.0	957.0	734.0	871.3	868.0
1978	750.0	590.0	728.0	517.0	646.3	732.0
1979	834.0	1038.0	1073.0	739.0	921.0	881.0
1980	1263.0	1314.0	1299.0	1137.0	1253.3	1225.0
1981	558.0	1157.0	1134.0	1022.0	967.8	927.0
1982	1414.0	1136.0	1045.0	1126.0	1180.3	1202.0
1983	826.0	1153.0	1293.0	693.0	991.3	988.0
1984	1797.0	1822.0	1791.0	1202.0	1653.0	1595.0

(a) Author's calculations.
Source: Estatísticas Agrícolas, INE.
Note: Rounded data.

TABLE 14: AVERAGE AUTUMN RAINFALL IN SOME ALENTEJO STATIONS, 1965-84. (mm)

	Évora	Beja	Portalegre	Setúbal	Elvas
1965	84.0	84.1	97.7	68.9	72.9
1966	394.7	338.0	431.8	414.2	311.6
1967	207.1	130.0	335.0	222.7	175.3
1968	116.0	225.7	184.6	143.0	160.5
1969	249.4	211.5	347.0	290.4	196.6
1970	x	x	x	x	x
1971	43.9	43.4	89.4	90.7	52.0
1972	14.8	34.3	18.5	15.5	8.5
1973	216.1	189.3	223.0	223.0	193.0
1974	85.6	155.0	204.5	174.3	75.8
1975	66.1	71.4	88.5	42.8	56.3
1976	64.8	59.7	104.6	84.5	56.5
1977	221.4	250.7	408.4	268.4	211.1
1978	188.9	226.1	305.8	279.2	171.7
1979	153.2	94.3	184.9	79.2	93.9
1980	242.9	229.6	335.8	281.0	272.7
1981	151.6	107.9	189.1	180.1	95.3
1982	70.0	47.3	100.6	73.4	x
1983	160.6	158.0	264.4	185.1	x
1984	292.5	260.9	438.0	441.1	312.0

TABLE 14: (Continued)

	Alcácer do Sal	Santiago do Cacém	Amareleja	Average Rain (a)
1965	53.5	90.4	84.0	79.4
1966	307.5	375.0	289.9	357.8
1967	165.7	219.0	119.3	196.8
1968	121.1	209.8	174.9	167.0
1969	242.7	x	139.1	239.5
1970	x	x	x	x
1971	51.8	75.0	50.9	62.1
1972	12.2	11.4	7.0	15.3
1973	179.9	240.0	172.8	204.6
1974	91.5	69.3	81.4	117.2
1975	52.3	x	46.6	60.6
1976	77.3	x	18.2	66.5
1977	200.5	x	251.2	258.8
1978	191.2	x	185.0	221.1
1979	81.2	x	110.0	113.9
1980	x	x	212.2	262.4
1981	145.0	x	108.0	139.6
1982	43.0	x	50.7	64.2
1983	171.9	x	225.2	194.2
1984	278.1	x	198.1	317.2

(x) Not published.
(a) Author's calculations
Source: Estatísticas Agrícolas, INE.

TABLE 15: AVERAGE WINTER RAINFALL IN SOME ALENTEJO STATIONS, 1965-84. (mm)

	Évora	Beja	Portalegre	Setúbal	Elvas
1965	217.7	168.6	274.4	242.1	178.0
1966	464.8	349.4	598.2	394.8	364.4
1967	178.0	150.6	286.7	176.7	170.1
1968	222.7	151.0	247.3	248.1	168.6
1969	365.7	402.9	381.9	408.7	336.7
1970	x	x	x	x	x
1971	250.2	189.2	218.3	199.1	198.3
1972	326.7	293.9	410.9	434.6	260.4
1973	228.8	198.0	381.9	381.5	210.4
1974	245.8	190.9	321.1	274.1	170.7
1975	157.2	175.4	220.9	243.2	106.8
1976	177.3	210.8	233.5	195.9	146.3
1977	455.0	442.4	671.0	418.3	337.5
1978	433.5	306.4	503.3	472.3	357.7
1979	514.5	452.2	814.5	647.5	493.3
1980	97.2	115.6	221.6	191.2	92.7
1981	35.0	24.8	53.9	53.5	34.8
1982	311.4	302.4	491.6	440.5	x
1983	83.1	53.3	106.5	88.5	x
1984	141.8	133.9	207.6	59.5	102.7

TABLE 15: (Continued)

	Alcácer do Sal	Santiago do Cacém	Amareleja	Average Rain
1965	164.5	237.0	157.2	204.9
1966	338.1	468.5	336.7	414.4
1967	160.3	244.0	114.5	185.1
1968	181.2	180.8	156.3	194.5
1969	342.9	369.2	284.3	361.5
1970	x	x	x	x
1971	175.0	242.6	154.7	203.4
1972	298.2	332.9	225.6	322.9
1973	295.9	258.9	119.1	259.3
1974	245.1	278.8	138.7	233.2
1975	148.7	x	98.2	164.3
1976	172.5	x	149.7	183.7
1977	383.4	x	413.4	445.9
1978	325.0	x	246.2	377.8
1979	515.5	x	427.2	552.1
1980	99.3	x	87.5	129.3
1981	x	x	22.5	37.4
1982	334.5	x	230.2	351.8
1983	71.1	x	60.2	77.1
1984	163.5	x	124.9	133.4

(a) Author's calculations.
(x) Not published.
Source: Estatísticas Agrícolas, INE.

TABLE 16: AVERAGE SPRING RAINFALL IN SOME ALENTEJO STATIONS, 1965-84.(mm)

	Évora	Beja	Portalegre	Setúbal	Elvas
1965	107.9	119.7	177.3	136.2	123.6
1966	189.2	115.8	303.1	167.8	166.0
1967	136.0	117.4	170.9	141.7	130.8
1968	168.9	128.4	216.3	212.4	181.0
1969	325.5	209.8	420.2	297.9	282.6
1970	x	x	x	x	x
1971	283.1	217.2	343.3	255.9	210.5
1972	115.5	117.0	168.5	128.7	108.3
1973	100.5	94.1	148.3	148.3	124.5
1974	133.8	135.7	189.4	122.8	138.2
1975	236.1	253.3	320.9	202.6	204.0
1976	133.4	171.3	189.0	107.8	138.5
1977	40.5	32.7	58.2	38.1	29.4
1978	197.5	177.6	277.5	182.0	157.6
1979	151.2	160.6	214.8	153.7	140.4
1980	132.9	205.6	269.6	188.6	129.9
1981	181.1	118.4	245.1	238.6	177.2
1982	93.4	106.0	89.0	89.7	x
1983	128.6	103.4	193.9	x	x
1984	218.1	235.9	280.7	159.4	177.2

TABLE 16: (CONTINUED)

	Alcácer do Sal	Santiago do Cacém	Amareleja	Average Rain
1965	97.2	143.6	81.4	123.4
1966	131.2	85.4	78.1	154.6
1967	112.7	117.5	116.2	130.4
1968	193.1	212.0	123.8	179.5
1969	204.8	215.0	212.3	271.0
1970	x	x	x	x
1971	296.8	308.7	228.8	268.0
1972	149.6	146.5	92.1	128.3
1973	61.8	77.1	114.3	108.6
1974	140.4	171.1	169.0	150.1
1975	194.5	x	170.3	226.0
1976	124.1	x	168.3	147.5
1977	25.2	x	20.2	34.9
1978	131.2	x	182.8	186.6
1979	129.8	x	178.2	161.2
1980	93.3	x	130.7	176.2
1981	x144.4	x	125.4	181.0
1982	240.4	x	80.3	92.0
1983	108.2	x	x	142.6
1984	74.4	x	156.2	209.7

(a) Author's calculations.
(x) Not published.
Source: Estatísticas Agrícolas, INE.

APPENDIX B

PRICE DATA

TABLE 17: WHEAT: AVERAGE PRICES RECEIVED BY FARMERS BY DISTRICT, 1965-84. (Esc/kg)

	Beja	Évora	Portalegre	Setúbal	Alentejo Average (a)	National Average
1965	3.04	3.07	3.14	3.04	3.073	3.180
1966	3.23	3.26	3.29	3.21	3.248	3.320
1967	3.22	3.26	3.33	3.21	3.255	3.320
1968	3.25	3.26	3.31	3.21	3.258	3.320
1969	3.14	3.17	3.26	3.15	3.180	3.320
1970	3.17	3.19	3.25	3.13	3.185	3.320
1971	3.47	3.48	3.49	3.43	3.468	3.450
1972	3.53	3.49	3.49	3.49	3.500	3.640
1973	3.47	3.42	3.42	3.42	3.443	3.640
1974	3.99	4.03	4.08	4.01	4.028	4.080
1975	4.26	4.35	4.36	4.23	4.300	4.620
1976	4.23	4.20	4.17	4.23	4.208	4.940
1977	6.10	6.12	6.13	5.96	6.078	5.590
1978	7.75	8.06	8.45	7.35	7.903	6.860
1979	10.08	10.12	10.45	9.56	10.053	8.620
1980	13.50	13.29	14.33	12.55	13.418	12.110
1981	14.89	15.28	16.17	14.56	15.225	14.350
1982	19.28	18.71	19.93	17.54	18.865	16.970
1983	25.51	25.92	27.88	23.33	25.660	21.700
1984	34.94	34.94	39.94	34.94	36.190	30.510

(a) Author's calculations.
Source: Estatísticas Agrícolas, INE.
Note: Rounded data

TABLE 18: BARLEY: AVERAGE PRICES RECEIVED BY FARMERS BY DISTRICT, 1965-84. (Esc/kg)

	Beja	Évora	Portalegre	Setúbal	Alentejo Average (a)
1965	2.42	2.85	2.75	2.48	2.625
1966	2.52	2.85	2.83	2.63	2.708
1967	2.73	2.78	2.90	2.98	2.848
1968	2.18	2.12	2.11	2.16	2.143
1969	2.47	2.53	2.30	2.49	2.448
1970	2.64	2.61	2.42	2.71	2.595
1971	2.61	2.53	2.55	2.67	2.590
1972	2.42	2.40	2.40	2.57	2.448
1973	2.80	2.58	2.90	2.87	2.788
1974	3.86	3.29	3.88	3.64	3.668
1975	3.55	3.89	3.96	3.87	3.818
1976	3.57	3.84	3.82	3.92	3.788
1977	6.84	5.56	5.68	6.50	6.145
1978	9.78	8.28	8.13	10.08	9.068
1979	9.10	9.00	7.86	11.42	9.345
1980	8.90	x	8.11	10.0	9.003
1981	12.03	13.55	11.36	10.50	11.860
1982	13.46	14.00	13.78	11.00	13.060
1983	16.00	x	17.24	x	16.620
1984	23.00	29.90	22.95	x	25.283

(a) Author's calculations.
(x) Not published.
Source: Estatísticas Agrícolas, INE.
Note: Rounded data.

TABLE 19: OATS: AVERAGE PRICES RECEIVED BY FARMERS

BY DISTRICT, 1965-84. (Esc/kg)

	Beja	Évora	Setúbal	Portalegre	Alentejo Average (a)
1965	2.38	2.65	2.67	2.48	2.545
1966	2.61	2.76	2.76	2.59	2.680
1967	3.22	2.97	2.84	3.33	3.090
1968	1.87	1.85	1.95	1.90	1.893
1969	2.10	2.04	1.95	2.070	2.040
1970	2.33	2.39	2.18	2.27	2.293
1971	2.30	2.42	2.40	2.30	2.355
1972	2.01	2.10	2.21	2.19	2.128
1973	2.25	2.27	2.44	2.43	2.348
1974	2.96	2.75	3.34	3.06	3.028
1975	2.93	3.35	3.23	3.14	3.163
1976	3.00	3.23	3.16	3.50	3.223
1977	6.37	5.56	5.80	6.13	5.965
1978	10.50	9.75	11.13	9.68	10.265
1979	9.54	10.00	8.92	11.77	10.058
1980	8.13	x	8.46	9.00	8.530
1981	10.89	9.10	10.38	9.00	9.843
1982	11.32	12.00	12.19	11.00	11.628
1983	14.88	x	15.13	x	15.005
1984	24.00	25.50	24.07	x	24.523

(a) Author's calculations.
(x) Not published.
Source: Estatísticas Agrícolas, INE.
Note: Rounded data.

TABLE 20: EC-PRICES FOR WHEAT THAT ALENTEJO FARMERS WOULD HAVE RECEIVED, 1965-84. (Esc/kg) (a)

	Price (UA/ton) [1]	ECUs/Dollar [2]	Price (US$/ton) [3]=[1]/[2]	Nominal Exchange Rate (esc/dollar) [4]
1965	98.75	1.00	98.75	28.75
1966	98.75	1.00	98.75	28.75
1967	98.75	1.00	98.75	28.75
1968	98.75	1.00	98.75	28.75
1969	98.75	1.00	98.75	28.75
1970	98.75	0.98	100.77	28.75
1971	100.72	0.95	106.02	28.32
1972	104.75	0.89	117.70	27.01
1973	105.80	0.81	130.62	24.67
1974	115.53	0.84	137.54	25.41
1975	125.93	0.81	155.47	25.55
1976	131.00	0.89	147.19	30.23
1977	135.59	0.88	154.08	38.28
1978	136.96	0.78	175.59	43.94
1979	168.06	0.73	230.22	38.92
1980	175.20	0.72	243.33	50.06
1981	184.84	0.90	205.38	61.55
1982	179.27	1.02	175.75	79.47
1982	184.58	1.12	164.80	110.78
1984	182.73	1.27	143.88	146.39

TABLE 20: (Continued)

	Nominal EC-Price (esc/kg) [5]=[3]*[4]	Wholesale Price Index (1963=100) [6]	Real EC-Price (esc/kg) (1963=1) [7]	Real EC-Price (esc/kg) (1980=1) [8]
1965	2.84	104	2.73	16.60
1966	2.84	108	2.63	15.99
1967	2.84	112	2.53	15.41
1968	2.84	117	2.43	14.75
1969	2.84	121	2.35	14.27
1970	2.90	125	2.32	14.09
1971	3.00	128	2.35	14.26
1972	3.18	135	2.35	14.32
1973	3.22	150	2.15	13.06
1974	3.49	193	1.81	11.01
1975	3.97	218	1.82	11.08
1976	4.45	260	1.71	10.41
1977	5.90	335	1.76	10.70
1978	7.72	440	1.75	10.66
1979	11.26	571	1.97	11.99
1980	12.18	608	2.00	12.18
1981	12.64	739	1.71	10.40
1982	13.97	880	1.59	9.65
1982	18.26	1100	1.66	10.09
1984	21.06	1442	1.46	8.88

(a) Rounded data.

Source: [1], [2], and [3] from "CAPMonitor", AgraEurope (London),Ltd, 1989.
[4] and [6] from the World Bank Comparative Studies, 1988.

TABLE 21: PRICES PAID BY FARMERS FOR SELECTED PREEMERGENT FERTILIZERS IN THE ALENTEJO, 1965-84. (Esc/kg)

	Calcium Nitrate		Superphosphate		Total
	(15.5% N)	(N)	(18%P_2O_5)	(P_2O_5)	(18-36-0) (a)
1965	10.36	66.839	5.27	29.278	22.57
1966	10.43	67.29	5.27	29.278	22.65
1967	10.43	67.29	5.27	29.278	22.65
1968	10.43	67.29	5.27	29.278	22.65
1969	10.43	67.29	5.27	29.278	22.65
1970	10.43	67.29	5.27	29.278	22.65
1971	9.72	62.71	4.95	27.500	21.19
1972	9.72	62.71	4.95	27.500	21.19
1973	9.23	59.548	4.94	27.444	20.60
1974	11.10	71.613	6.03	33.500	24.95
1975	16.39	105.742	11.67	64.833	42.37
1976	16.39	105.742	11.67	64.833	42.37
1977	14.77	95.29	10.50	58.333	38.15
1978	15.39	99.29	12.09	67.167	42.05
1979	20.38	131.484	14.50	80.556	52.67
1980	21.89	141.226	15.55	86.389	56.52
1981	30.60	197.419	21.90	121.667	79.34
1982	46.28	298.581	50.08	278.722	154.08
1983	72.02	464.645	59.08	328.222	201.80
1984	95.03	613.097	58.00	322.222	226.36

(a) Author's calculations.
Source: Estatísticas Agrícolas, INE.

TABLE 22: PRICES PAID BY FARMERS FOR SELECTED POST-EMERGENT FERTILIZERS IN THE ALENTEJO, 1965-84. (Esc/kg)

	Amonium Nitrate (26% N)	Total (a) (N)
1965	8.30	31.92
1966	8.30	31.92
1967	8.30	31.92
1968	8.30	31.92
1969	8.30	31.92
1970	8.30	31.92
1971	7.63	29.35
1972	7.63	29.35
1973	7.43	28.58
1974	8.93	34.35
1975	12.96	49.85
1976	12.96	49.85
1977	11.67	44.88
1978	12.14	46.69
1979	16.08	61.85
1980	16.76	64.46
1981	23.05	88.65
1982	33.05	130.73
1983	55.55	213.65
1984	58.00	223.03

(a) Author's calculations.
Source: Estatísticas Agrícolas, INE.

APPENDIX C

VARIANCE CALCULATIONS

TABLE 23: VARIANCE OF THE LOG OF TOTAL REVENUE PER HA FROM WHEAT PRODUCTION IN THE ALENTEJO, 1965-84.

	log(RP)	log(Y)	log(RP)log(Y)	log(WRP)log(Y)
1965	0.4705	3.0241	1.4233	0.7199
1966	0.4781	2.7604	1.3198	0.7944
1967	0.4633	3.0814	1.4277	0.9005
1968	0.4447	3.1244	1.3894	0.7120
1969	0.4196	2.8844	1.2104	0.5079
1970	0.4062	2.9513	1.1988	0.6876
1971	0.4328	3.1349	1.3568	0.4385
1972	0.4137	3.0916	1.2791	0.7125
1973	0.3608	3.1076	1.1212	1.3455
1974	0.3195	3.0918	0.9877	1.4157
1975	0.2950	3.1443	0.9276	1.1551
1976	0.2091	3.1083	0.6498	0.8158
1977	0.2587	2.9401	0.7606	0.4020
1978	0.2543	2.8104	0.7147	0.2527
1979	0.2456	2.9643	0.7281	-.0129
1980	0.3438	3.0980	1.0650	0.5722
1981	0.3139	2.9858	0.9373	0.7182
1982	0.3312	3.0720	1.0174	0.4957
1983	0.3679	2.9962	1.1022	0.4835
1984	0.3996	3.2183	1.2861	0.4400
Sum	7.2283	60.5910	21.9031	13.5454
Var	0.0063	0.01310		

Source: Author's calculations.

TABLE 24: VARIANCE OF THE LOG OF TOTAL REVENUE PER HA FROM WHEAT PRODUCTION IN THE NATION, 1965-84.

	log(RP) (a)	log(WRP) (b)	log(Y)	log(RP) x log(Y)	log(WRP) x log(Y)
1965	0.4854	0.2383	2.9926	1.4526	0.7129
1966	0.4877	0.2888	2.7752	1.3535	0.8015
1967	0.4719	0.2912	3.0362	1.4329	0.8842
1968	0.4530	0.2285	3.0856	1.3977	0.7050
1969	0.4384	0.1749	2.9042	1.2731	0.5079
1970	0.4242	0.2335	2.9528	1.2527	0.6895
1971	0.4306	0.1383	3.1014	1.3355	0.4289
1972	0.4308	0.2295	3.0917	1.3318	0.7095
1973	0.3850	0.4335	3.0906	1.1899	1.3398
1974	0.3251	0.4572	3.0630	0.9958	1.4003
1975	0.3262	0.3666	3.1143	1.0158	1.1415
1976	0.2788	0.2626	3.1103	0.8670	0.8169
1977	0.2224	0.1377	2.9385	0.6534	0.4047
1978	0.1929	0.0897	2.8645	0.5525	0.2571
1979	0.1789	0.2601	2.9450	0.5268	0.7659
1980	0.2992	0.1850	3.0881	0.9241	0.5714
1981	0.2882	0.2396	2.9671	0.8551	0.7109
1982	0.2852	0.1603	3.0799	0.8784	0.4938
1983	0.2951	0.1619	2.9948	0.8837	0.4849
1984	0.3255	0.1375	3.2028	1.0424	0.4403
Sum	7.0243	4.4493	60.3985	21.2145	13.4854
Var	0.0091	0.0117	0.01002		

(a) Real wheat prices received by farmers for the sample period.
(b) Real "world" wheat prices.
Source: Author's calculations.
Note: Rounded values.

APPENDIX D

INSURANCE CALCULATIONS

TABLE 25: INSURANCE CALCULATIONS FOR THE ALENTEJO, 1965-84.

(90% AND 80% OF THE MEAN YIELD)

			Uninsured	Insured	Series	
	Average Yield (kg/ha)	EC-price (1980=1) (esc/kg)	Series Revenue (esc/ha)	Revenue (90%) (esc/ha)	Indemnity (90%) (esc/ha)	Indemnity (80%) (esc/ha)
1965	1060.3	16.60	17603.41	17603.41		
1966	576.0	15.99	9209.17	13675.66	4466.49	4466.49
1967	1206.3	15.41	18590.79	18590.79		
1968	1331.8	14.75	19647.86	19647.87		
1969	766.3	14.27	10931.09	13675.66	2744.57	2744.57
1970	894.0	14.09	12597.37	13675.66	1078.29	
1971	1364.3	14.26	19456.87	19456.87		
1972	1234.8	14.32	17678.18	17678.18		
1973	1281.3	13.06	16734.62	16734.63		
1974	1235.3	11.01	13599.45	13599.45		
1975	1394.0	11.08	15443.47	15443.47		
1976	1283.3	10.41	13352.45	13352.45		
1977	871.3	10.70	9326.49	13675.66	4349.17	4349.17
1978	646.3	10.66	6889.86	13675.66	6785.80	6785.80
1979	921.0	11.99	11044.73	13675.66	2630.94	
1980	1253.3	12.18	15266.17	15266.17		
1981	967.8	10.40	10064.77	13675.66	3610.90	
1982	1180.3	9.65	11389.52	11389.52		
1983	991.0	10.09	10002.81	13675.66	3672.85	
1984	1653.0	8.88	14684.16	14684.16		
Mean	1105.6		13675.66	15142.61		
Sum					29339.00	18346.03
Standard deviation			3695.39	2269.61		

Source: Author's calculations.

TABLE 26: TOTAL DIRECT SUBSIDIES IN THE ALENTEJO ESTIMATED FROM THE ACTUAL WHEAT PRICES RECEIVED BY FARMERS, 1965-84.

	Subsidy (esc/kg) (1980=1)	Planted area (1000 ha)	Yield (kg/ha)	Total Subsidy (10^3esc)
1965	8.12	366.5	1060.25	3135921.89
1966	6.78	309.6	576.00	1229164.47
1967	6.28	344.7	1206.25	2553519.80
1968	7.05	357.6	1331.75	3323715.06
1969	7.55	335.3	766.25	1949520.97
1970	5.62	370.4	894.00	1906060.33
1971	8.05	395.9	1364.25	4346571.96
1972	6.14	320.9	1234.75	2409514.51
1973	-1.72	314.7	1281.25	-704796.88
1974	-4.53	328.9	1235.25	-1858349.85
1975	-1.25	320.3	1394.00	-561240.75
1976	.42	397.1	1283.25	214810.64
1977	1.98	185.4	871.25	290225.87
1978	2.01	260.6	646.25	337757.24
1979	3.17	205.4	921.00	600358.61
1980	2.8	257.3	1253.25	902891.43
1981	1.25	248.4	967.75	300733.69
1982	2.92	259.5	1180.25	897446.77
1983	3.17	240.7	991.25	755745.11
1984	4.52	206.3	1653.00	1541825.82
Total				23571396.69
(10^3/ year)				1178569.84

Sources: The nominal prices received by farmers and the planted area as well as the yield per ha came from Estatísticas Agrícolas, INE. The direct subsidy per unit was estimated as the difference between the real prices received by farmers and the real "world" prices that farmers would have received in the absence of the direct intervention.

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