AN ABSTRACT OF THE THESIS OF

ABDERREZAK BELAID for the degree of Doctor of Philisophy in Agricultural and Resource Economics presented on October 18, 1985.

Title: FARMERS' RISK ATTITUDES IN THE EASTERN HIGH PLATEAU REGION OF ALGERIA: AN APPLICATION OF THE EXPERIMENTAL APPROACH

Abstract approved: ______________________________
STANLEY F. MILLER

Farmers in the high plateau region of Algeria are assumed to exhibit risk averse behavior, particularly, due to highly variable weather conditions inducing income instability over time. This in turn directly affects their production behavior. The Eastern High Plateau (Setif) is not a homogeneous region. In the El-Eulma daira, for example, three different agroecological zones have been identified on the basis of climate, topography and soil quality. In addition, two distinct agricultural sectors (private and socialist) coexist side by side in each of the agroecological zones. This study constitutes an

attempt to measure farmers' risk attitudes in three communes (El-Eulma, Oum Ladjoul and Beni Fouda) which are representative of the three agroecological zones of the El-Eulma daira. Farmers' risk attitudes were measured through the experimental approach developed by Binswanger in India. The technique used consisted of presenting the subjects, i.e. the farmers, with a set of alternative prospects involving real money.

Based on the derived risk aversion coefficients, a series of tests was run to determine if farmers' risk attitudes are dependent on the zone and/or the sector. The effect of socioeconomic characteristics (age, schooling, number of working children, etc.) on partial risk aversion was analyzed.

Finally, the derived risk aversion coefficients were used in a risk programming model (MOTAD) to determine optimal farming plans for private as well as socialist sector farmers.

The experiment results indicate that regardless of the zone and the sector, farmers unanimously exhibit risk averse attitudes. At low payoff level, the distribution of risk preferences is more spread. A narrower distribution occurs at higher payoff levels (e.g. 200 DA scale). There was no evidence of significant difference among sites and between sectors. Also socioeconomic attributes correlate poorly with the estimated partial risk aversion coefficients.

In the socialist sector major discrepancies between the risk programming model solutions and actual activity levels occured. They were expected because of the specific structure of this sector. The inclusion of government cropping pattern recommendations in the constraint matrix indicates that government interventions have a different effect on socialist farmers' welfare of the three zones.

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by

Abderrezak Belaid

A THESIS
Submitted to
Oregon State University

in partial fulfillement of
the requirements for the
degree of

Doctor of Philosophy

Completed October 18, 1985

Commencement June 1986

APPROVED:

Professor of Agricultural and Resource Economics
in charge of major

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Dean of Graduate School

Date thesis is presented October 18, 1985

Typed by A. BELAID

ACKNOWLEDGEMENT

I wish to express my deep gratitude to Dr. Stanley Miller, my major professor for his guidance and support throughout the course of this research. I extend my special thanks to Drs. J. Edwards and W. Brown (Dept. of Ag. and Res. Economics), Dr. W. McCuistion (Dept. of Crop Science) and Dr. R. Towey (Dept. of Economics) for accepting to serve on my graduate committee and for their help and support.

Dr. Steven Buccola's help and suggestions in the early stages of this study are greatly appreciated. A special thanks is due to Dr. Bruce McCarl (Texas A&M) for taking the time to review the final draft, particularly the programming section.

My sincere thanks to the faculty, staff and fellow graduate students at the Ag. and Res. Economics Department for their support and friendship.

I am very grateful to CIMMYT (Mexico) for granting me a fellowship which enabled me to pursue my graduate studies. This research could not have been possible without CIMMYT financial support and the precious and invaluable help and support of Dr. George Varughese (CIMMYT) to whom I am extremly indebted.

Several colleagues at the "Institut de Developpement des Grandes Cultures" (Algeria) offered helpful suggestions and precious assistance during the long and often frustrating data collection process. In this regard, I wish to express my sincere thanks to the whole staff of the Experimental Station of Setif, particularly to its director and dear friend Hamid Oudina for his unconditional support (moral as well as logistics) in the course of my experiment.

I am very grateful to the Ministry of Agriculture of Algeria, particularly its General Secretary N. Kadra, and to Dr. L. Hachemi director of the "Institut de Developpement des Grandes Cultures" (the institute to which I belong) for giving me the opportunity to study at Oregon State University.

I am profoundly proud to dedicate this dissertation to the first graduating class (1973), best known as "Premiere Promotion", of the "Institut de Technology Agricole de Mostaganem" (Algeria) of which I am proud to be a member.

I am unable to find the right words for expressing my profound gratitude and indebtedness to my family in Algeria, particularly to my mother, for the help, the support and the understanding I benefited from for so many years and particularly during my long stay in the U.S. My dear wife Ouiza and my sweet son Hocine have demonstrated so much patience and understanding during the most crucial stages of my education. Their support and sacrifices were beyond anything any husband and father could ever hope

for. I will never be able to thank them enough for all they did for me. To them all I dedicate this dissertation.

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CHAPTER I

INTRODUCTION

Algeria relies heavily on semi-arid winter rainfall zones for its grain supply. Cereals occupy the bulk of crop acreage. Despite considerable efforts, cereal productivity remains very low.

Cereal production is not keeping pace with increasing demand resulting from a rapid growth in population and relative growth in income. The combination of these two factors makes Algeria highly dependent on imports for its grain consumption. Self-sufficiency in cereals is a high priority by the government.

Intensification has been identified as the best technical alternative for ultimately achieving the goal of self-sufficiency. It is a program aimed at increasing overall cereal production by substantially improving yield levels through the use of fertilizers, weed control, high yielding varieties, better cultural practices and crop rotations giving more emphasis to forages and livestock (thus, reducing fallow area). However, the relative complexity of the administered (by the Ministry of Agriculture) cropping patterns, particularly in the socialist sector; inadequate price and input distribution systems; and frequent disruption in the input supply hinder the process of closing the gap between actual and self-sufficiency levels of production.

Algerian agriculture is characterized by two major and structurally distinct sectors[1] (private and socialist sectors). These two sectors are highly regulated, particularly the socialist sector, by government intervention policies in the input (for both sectors) and output markets as well as forced cropping patterns (for the socialist sector and to a lesser extent for the private sector).

Risk of production often is not considered in government policies. The high plateau of Algeria (where most cereal production takes place) is characterized by relatively low and particularly erratic precipitations concentrated in the winter season and a high frequency of

[1]- A third sector (Agrarian Revolution Sector) covering about 10% of total agricultural area also exists. However, because of its relative newness (compared to the other two sectors) its impact on production is relatively lower.

late frosts and early sirocco[2]. This adverse environment (not to mention other potential problems such as uncertain input supply, for example) constitutes a major source of income instability. Thus, farmers whose very subsistence hinges solely on agricultural income are expected to be more sensitive to income variability than income level. Income levels are not high enough to permit capital accumulation to secure future consumption. Existing risk adjustment mechanisms are not very efficient and certainly not cost free.

Most economic studies on the effect of risk on subsistence farmers behavior, e.g., Moscardi and de Janvry, Walker, Binswanger, Young, Wiens, Jodha, and Sillers, to name only a few, conclude that "poor" farmers are willing to forego higher means for smaller variances of income. There also seems to be a virtual unanimity regarding the importance of risk aversion in determining farmers' technology adoption behavior. Thus, there may be a reluctance from the part of the farmers to adopt a new technology if its level of riskiness is (or if only felt) higher than the one currently used. It implies that programs aimed at developing (e.g., breeding) and recommending (e.g., extension) new cereal varieties, for

2- Hot wind originating from the Sahara desert and which can have devastating effects on cereal production, particularly when the cereals are at the milky stage of maturation. Its severity and frequency decreases from South to North.

example, on the sole criterion of higher yield potential will fall short of farmers' desires since yield stability may be given a higher weight than yield potential by risk averse farmers.

Individuals' aversion to risk may constitute an explanation of their observed economic behavior (Arrow). Thus, policies aimed at improving farmers' welfare should take into consideration their attitudes towards risk. This in turn points to the importance of generating reliable information about farmers' risk attitudes.

This study deals with the measurement of farmers' risk attitudes in the Eastern High Plateau of Algeria. To determine these risk attitudes, the author conducted an experiment using the experimental approach developed by Binswanger in India[3]. The experiment sample included farmers from three agroecological subareas representative of the high plateaus. The sample also included farmers from private as well as socialist sectors. The experiment consisted of offering the farmers a choice among seven alternatives whose outcome is determined after a toss of a coin. The experimental approach on which the experiment was built differs from classical methods of utility elicitation, e.g., von Neumann-Morgenstern technique and Ramsey technique, since real and substantial money payoffs

3- However, unlike Binswanger's, the experiment whose results are reported here used alternatives including gains as well as losses. The major differences between the two experiments are presented in chapter IV.

instead of hypothetical questions and/or trivial money payoffs are used. The experiment format was such that the subject could not increase the expected value of the payoff without increasing the variance between the "good" and "bad" outcomes. Subjects were presented with games whose scale of payoffs cover a range of prospects relevant (in terms of expected money value) to farmers farming decisions (for example, the highest outcome associated with the highest payoff scale was equivalent to the annual income of a tractor driver). Based on the choice they make, the subjects are classified according to the risk aversion level associated with each alternative.

The objectives of the experiment were (1) to investigate if risk aversion behavior varies among the three agroecological areas considered, (2) to investigate if farmers in the socialist sector exhibit significantly different attitudes toward risk from those in the private sector, and (3) to analyze the effects of farmers' socioeconomic characteristics on their level of risk aversion. Subsequently the derived risk coefficients at three payoff scales were included in a risk programming model in order to determine optimal acreage allocation plans given the constraint set and the level of risk aversion.

Organization of the dissertation.

Chapter II is a brief presentation of the research area. In this chapter an explanation of the organization and importance (areawise) of the three sectors of agriculture is provided.

Chapter III is a review of the literature dealing with the process of decision making under risk and uncertainty with an emphasis on the expected utility model and its major limitations. This chapter concludes with a description of the most common methods of utility elicitation and the different risk measures for classifying individuals according to their aversion to risk.

Chapter IV is a detailed description of the experiment used in this study. It also explains why a sequence including both gains and losses was prefered to that including only gains. The experiment format needed to be slightly adjusted before it could be applied to the socialist sector. Finally, the chapter discusses how two common criticisms associated with the experimental approach were overcome.

Chapter V presents the results of the experiment and their implications in accordance with the stated objectives. The distributions of risk preferences by scale of payoff are reported for each sub-sample. The impact of payoff scale on risk preferences is also analyzed. This chapter concludes with an attempt to relate farmers' (private farmers only) derived risk aversion coefficients with their personal attributes (age, schooling, income, etc).

Chapter VI constitutes an attempt to include the derived risk aversion coefficients in a risk programming model. It starts with a brief presentation of optimization techniques and mathematical risk programming models. The risk programming model used then is presented in details. Model activities and constraints for both sector are also explained. The empirical results obtained at the various risk aversion coefficients are discussed for all runs of the model.

Chapter VII summarizes the results of the experiment as well as the risk programming model. Potential policy implications are discussed. The chapter concludes with suggestions for further research based on the study's results.

CHAPTER II

DESCRIPTION OF THE RESEARCH AREA.

The field work was conducted on three communes of El-Eulma daira[4] located on the Eastern high plateau (Wilaya of Setif) of Algeria. El-Eulma can roughly be divided into two geographically distinct regions:

-A northern region associated with the Tellien Atlas (mountain range) and constiting of mountains and hills varying between 700 and 1500 meters of altitude.

-A second region formed by valleys in its center part and hills in the southern part varying between 900 and 1100 meters in altitude.

Three main agro-ecological zones have been identified on the basis of topography, soil type, rainfall and risk of sirocco and/or late frost: Northern, Central and Southern.

4 - Algerian administrative structure is as follows: Wilaya (state or department), Daira (county) and Commune (district of local government).

Table 1: Characteristics of the 3 agro-ecological zones of El-Eulma.

Zone	Northern	Central	Southern
Topography	uneven, mountains and hills mainly.	alluvial plains; plateaus.	mainly plateaus; mountains in extreme South.
Soil type	deep clayey and silty loam on hills, sandy clay on mountains.	33% of soils are deep silty-loam. 67% are silty with an average depth of 50 cm.	light text; sandy-loam to sandy; calcareous shell in some parts.
Rainfall	450 to 700 mm. frequent snow on tops.	350 to 450 mm but irregular.	350 mm on average; higher in the extreme South. Very irregular frequency.
Sirocco and Frost	risk of late frost low; spring sirocco not frequent.	risk of late frost high; high to average risk of spring sirocco; 10 to 20 days per year on average.	high risk of late frost; high risk of spring sirocco, up to 60 days per year.
Altitude	700 to 1200 m.	900 to 1100 m.	800 to 1000 m.

As one moves from north to south the characteristics used to distinguish the three zones (particularly rainfall, soil type and risk of late frost and/or sirocco) become less favorable.

There are three distinct agricultural sectors in El-Eulma: the self-managed sector, the agrarian revolution sector, and the private sector. They will be discussed in that order.

1- The self-managed sector consists of 25 farms[5] having an average cropping area between 1200 and 3500 hectares each. In it farms are highly mechanized (by Algerian standards) and regularly use inputs such as fertilizers and herbicides. This sector covers about 30% of the country's cultivable area. A voting assembly of permanent workers meet periodically to vote on production and financial policies (within a framework defined by the Ministry of Agriculture). A workers' council and a management committee oversee and implement the assembly's decisions. A president is elected among the management committee members. His duties consist of conducting the day-to-day operations of the farm. A director is

[5]- In 1981 there was a restructuring of the socialist sector within the country. The size of large farms was reduced in order to make them more manageable. In 1980 there were 17 socialist farms in El-Eulma, in 1984 as a result of the restructuring there were 25. Since the operation is not completed yet, data prior to the restructuring will be used in this dissertation.

appointed by the Ministry of Agriculture to provide technical assistance to the farm and to act as a liaison between the latter and the former. The right to the use of the land remains with the workers of the farms (i.e. the permanent workers) but the government retains ownership of the land.

The term self-managed is a misnomer since the government (through the Ministry of Agriculture) establishes effective control of this sector even though relatively more management autonomy has been granted to the management committee on technical and financial matters since 1975. It is usually referred to as the socialist sector[6]. The control of this sector allows the government to change cropping patterns to meet the country's needs. National as well as local production objectives defined by the government must be met by the farms of this sector. Technical assistance is provided by the government through the DAP (Direction de l'Agriculture et de la Peche: entity representing the Ministry of Agriculture at the state level) and the SDA (Secteur de Developpement Agricole: assistance service of the Ministry of Agriculture at the county level).

2- The agrarian revolution sector covers about 10% of the country's total cultivable area. The agrarian

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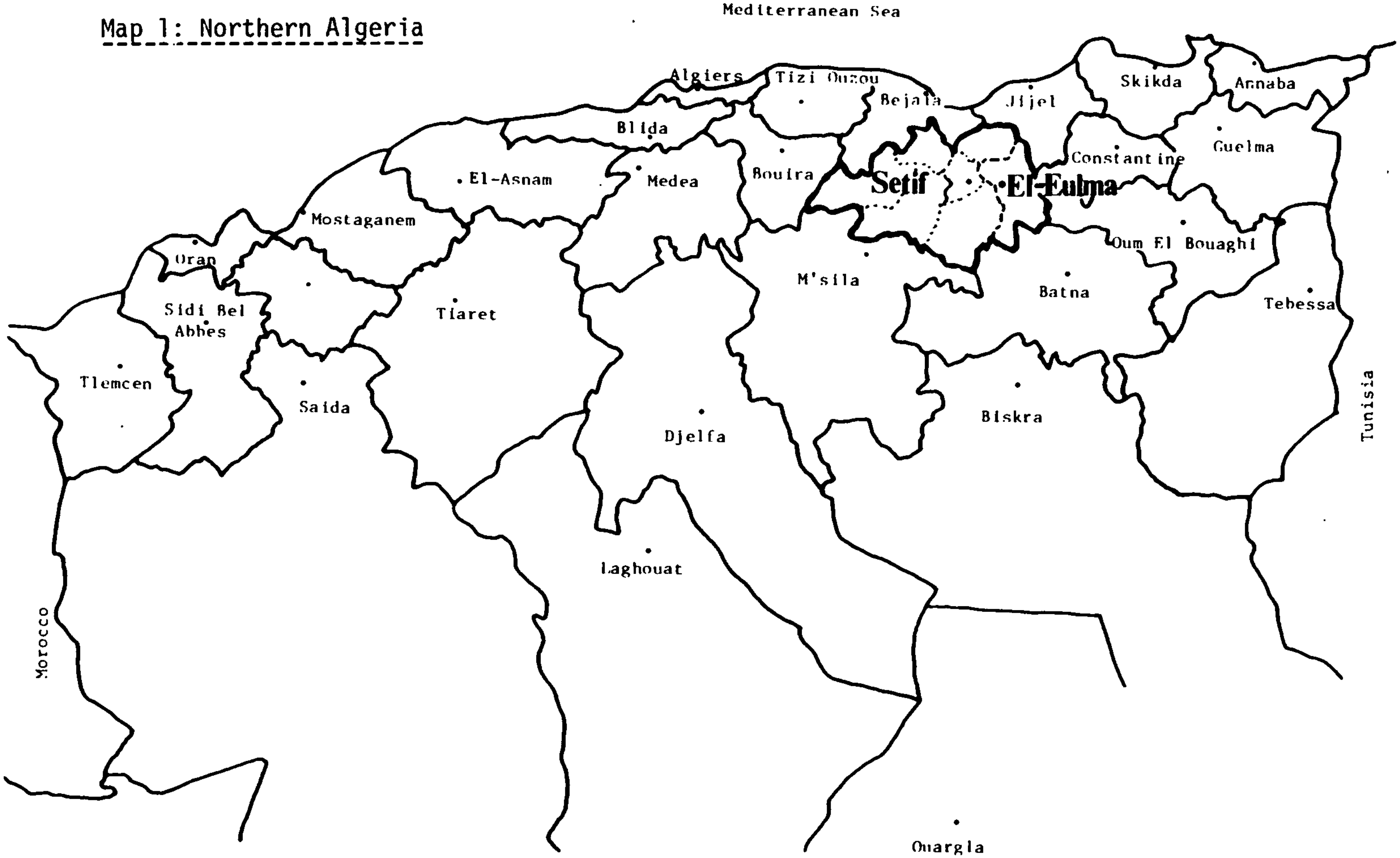
6- This term will be used to label this sector in this dissertation.

revolution program was to be implemented in three phases and calls for improving the economic, social and cultural welfare of the rural population. The nationalization and distribution of public lands (mainly communal land, land owned by religious foundations and land confiscated from absentee and/or large scale landlords) characterized the first two phases of the program which began in 1972. The last phase was aimed at nationalizing public pasture lands (non cultivable land mostly used for herding sheep and goats in the steppe area). The land nationalized was organized into units (cooperatives) for distribution to small farmers and landless workers of the private sector. The land remains state property. It cannot be sold, leased or mortgaged but can be inherited by the benificiary's heirs. The cooperatives of this sector agree to accept new cropping patterns designed by the Ministry of Agriculture , the DAP and SDA, according to national as well as local priorities.

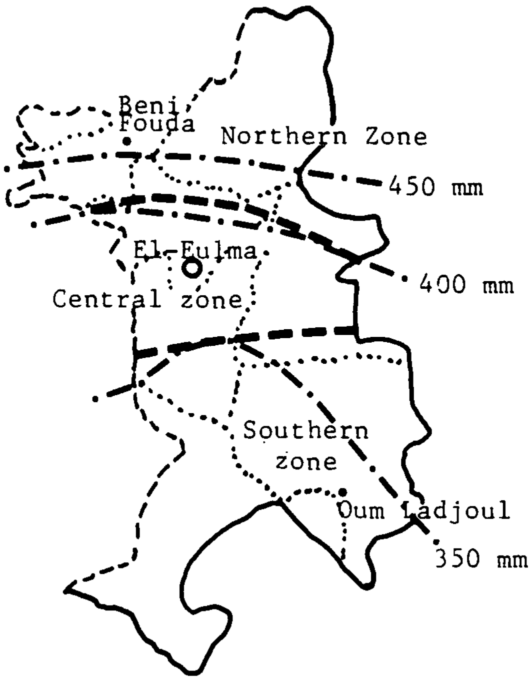
3- The remainder of the agricultural area is occupied by the private sector (60% of the agricultural area at the national level). The government has no direct control over this sector in terms of the cropping systems used and crops grown. This sector does benefits from the assistance of the DAP and of the DAD (Delegation de l'Agriculture de Daira: entity of the Ministry of Agriculture at the county level), however. Within the country more than half of the holdings of this sector are less than 5 hectares in size.

Nationwide, the cultivable area represents about 16% of the total agricultural area whereas rangelands occupy more than 80% (see table 2). Land distribution varies from region to region but the private sector predominates in the high plateau region. The percentage of non cultivable (i.e. rangelands and/or unproductive lands) land is very high in the private sector. As shown in table 3, the average percentage of cultivable area in El-Eulma is 94.09 and 46.29 in the socialist and private sectors respectively.



Map 1: Northern Algeria

Map 2: El-Eulma Daira.



Agroecological zone limits

Isohyetes

Wilaya limits

Daira limits

Commune limits

Table 2: General division of the land (Algeria).*

Category	Area (Hectares)	Percentage
Cereals for grains	3,228,770	7.60
Other annual crops	312,860	0.70
Sub-total	3,541,030	8.30
Fallow land	2,707,280	6.40
Vineyards	300,340	0.70
Orchards and vegetables	252,210	0.60
Pastures	34,480	----
Rangelands	34,345,380	80.80
Unproductive farmlands	1,268,670	3.20
Total area	42,449,390	100.00

Source: E.D. Carter, 1975. "The Potential for Increasing Cereal and Livestock Production in Algeria". CIMMYT.

*This is only the agricultural area. The total country area is about 240,000,000 hectares of which less than 20% is considered as agricultural land, i.e. cultivable land and/or rangelands.

Table 3: Land distribution by sector (in hectares): El Eulma 1979.

	Socialist Sector			Private sector		
Communes	Total area	Cropping area	%*	Total area	Cropping area	%*
El Eulma	5,368	5,306	98.85	18,328	8,159	44.52
Beni Fouda	2,919	2,789	95.55	26,191	5,142	19.63
Oum Ladjoul	7,823	7,062	90.27	17,385	13,752	79.10
Djemila	618	552	89.32	38,166	14,684	38.47
Bir El Arch	12,227	11,453	93.67	11,726	8,350	71.21
Bazer	1,561	1,495	95.77	26,041	8,460	32.49
Beida Bordj	2,845	2,725	95.78	21,956	10,762	49.02
Total	33,361	31,391	94.09	149,703	69,304	46.29

* Cropping area/Total area.

Source: "Hypothese de Fonctionnement du Secteur Socialiste de la Daira d'El Eulma." IGC, 1979.

On the other hand, table 4 shows that the bulk of livestock and poultry is held by the private sector.

Table 4: Livestock and poultry held by sector (El Eulma 1983).

Category	Soc.Sector (a)	%*	Priv.Sector (b)	%**	Total (c)
Cattle	754	2.35	31,277	97.65	32,031
Sheep	22,516	27.60	59,074	72.40	81,590
Poultry (eggs)	15,800	28.32	40,000	71.68	55,800
Poultry (meat)	-----	-----	167,700	100.00	167,700

* (a)/(c)

**(b)/(c)

Source: SDA El Eulma, 1983.

Field work was conducted on the communes of Beni-Fouda, El-Eulma and Oum Ladjoul in the northern, central and southern agro-ecological zones respectively. Several characteristics for the three communes are given in table 5.

Table 5: General characteristics of the three communes.

	B.Fouda	El-Eulma	O.Ladjoul
Area	300 Km^2	190 Km^2	265 Km^2
Population (1977 census)	8,604	49,946	10,807
-Inhabitants/Km^2	28.68	262.87	40.78
-Urban population	4,500	44,266	113
-% of urban population	52.30	88.63	1.05
Estimated population in 1983	9,602	66,055	13,149
-Inhabitants/Km^2	32.00	327.65	49.61
-Urban population	5,220	57,447	1,913
-% of urban population	54.36	86.97	14.55
Schooling			
-Elementary school			
-Number of schools	12	24	12
-Number of students	1,955	13,653	2,317
-Students/classroom	36	62	50
-Students/teacher	19.36	36.02	30.48
-% of female students	46.24	48.46	22.74
-Intermediate school			
-Number of schools	1	7	0
-Number of students	758	6,095	0
-Students/teacher	27	26	0
-% of female students	27.44	45.56	0
-High school			
-Number of lycees	0	3	0
-Number of students	0	2,839	0
-Students/teacher	0	18	0
-% of female students	0	36.81	0
-Schooling population*	2,987	2,3623	2,413
-Schooling ratio	90.83	95.16	96.02
-Female schooling ratio	79.54	65.97	66.21
Health			
-Number of doctors	2	14	4
-Inhabitants/doctor (1983)	4,801	4,717.21	3,287.25
-Number of dentists	1	9	0
-Inhabitants/dentist (1983)	9,602	7,339	-
-Hospitals	0	1	0

* Population in the 6 to 15 age bracket.

SOURCE: Sous-Direction des Statistiques et de l'Informatique Wilaya de Setif, 1984 (Modified).

In the three communes, cereals annualy occupy about 47% of the total cropping area, forages and dry legumes about 6% and the remaining (47%) area is fallow. The biannual rotation (cereals-fallow) is widely used in all three zones. However, as a result of the intensification program (1975), the fallow area has been reduced to approximately 35% of total cropping area by increasing the annual cropped forage area (particularly the vetch-oats association) and introducing dry legumes (lentils and chick peas) particularly in the northern and central zones. Tables 6 through 8 show the evolution of major crops (in the socialist sector) over a ten year period (1969-70 to 1978-79).

In the northern zone (table 6) durum wheat occupies most of the area devoted to cereals (70% on average for the 10-year period) whereas barley's share was less than 6% on average. For the 10-year period the bread wheat area was about 22% of cereals area. For the same period, cereals and fallow represented about 92% of the area cropped. From 1975-76 fallow area shrunk a bit from 50 to 30% of the cropping area. No high yielding durum wheat variety was used (in all three zones) since no improved variety tested (e.g. Polonicum, Jori) performed better than the local variety (M.Ben Bachir) in terms of yields and quality.

In the central zone (table 7), the cereal area, for the 10-year period, was relatively evenly distributed between durum and bread wheat. The area devoted to local bread wheat increased between 1975-76 and 1977-78 as a result of a decrease in durum acreage. The area devoted to wheat (durum and bread) decreased from 93.6% (from 1969-70 to 1973-74) to 79.4% (from 1974-75 to 1978-79) despite the decrease in fallow area. During the same period the barley and oats area increased substantially (though to a lesser extent for oats). These changes resulted from specific recommendations made by the OIRD[7] project to obtain spatial distribution of crops grown based on soil type, volume and frequency of precipitation, risk of sirocco and/or late frost and to reduce the fallow area in order to increase the barley, oats and forage areas. For the 10-year period bread wheat occupied more than 50% of the area devoted to cereals.

In the southern zone (table 8), the area devoted to durum is much lower than in the other zones. The area planted in barley, on the other hand, increased substantially after 1974-75 as a result of a reduction in the area devoted to durum (not suitable in this zone,

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7- Operations Integrees de Recherche Developpement: program aimed at diagnosing, testing and solving production problems with which farmers are confronted. This project was conducted by multidisciplinary teams in three pilot dairate (El-Eulma, Mahdia in the Wilaya of Tiaret and Hamam Bou Hadjar in the Wilaya of Sidi Bel Abbes) except in some micro-environments) and the fallow area.

Cereal yield generally decreases from north to south. Yield decreases more sharply for durum than bread wheat, which in turn decreases more rapidly than barley. However, durum yields are higher than bread wheat in the northern zone whereas the reverse occurs in the southern zone. These differences may partly be explained by the lower level of moisture available to plants in the southern zone, by shallower soils, and by higher sirocco risks. In the northern zone, the combination of higher rainfall and heavier soils explains the better results obtained by durum wheat. In all three zones barley is usually planted in poorer quality soils (barley yields could be much higher than wheat yield if barley were planted on soil of equivalent quality). During relatively "good" years average crop yields in all three zones are comparable, however, in "bad" years wheat yields are very low in the southern zone.

Given the official wheat prices and average yields obtained in each area, gross cereal income per hectare is generally higher in the north than the south. Northern farms benefit from a double advantage compared to farms in the other two zones: a more favorable environment and a higher price for the most suitable crop, i.e. durum wheat. Southern zone farms are the most disadvantaged.

Table 6: Cropped area in the Northern zone (in hectares).

Crops / Years	Durum	Bread wheat	Barley	cereals*	Fallow	Total**
1970	2,060	205	45	2,310	2,839	5,258
1971	2,345	170	40	2,555	2,629	"
1972	1,650	750	21	2,421	2,681	"
1973	1,350	930	0	2,280	2,681	"
1974	1,266	1,210	40	2,516	2,420	"
1975	1,740	420	14	2,194	2,680	"
1976	1,580	856	239	2,820	1,577	"
1977	2,000	380	228	2,788	1,682	"
1978	2,120	290	346	2,970	1,577	"
1979	2,000	400	426	3,036	1,636	"

* This is the sum of durum + bread wheat + barley areas.

** The differece between total area and the sum cereals + fallow is occupied by crops such as oats (grain), rainfed forages, legumes and fruit trees.

Source: "Hypotheses de Fonctionnement du Secteur Socialist de la daira d'El-Eulma". IGC. 1979. Modified.

Table 7: Cropped area in the Central zone (in hectares).

Crops / Years	Durum	Bread wheat	Barley	Cereals*	Fallow	Total**
1970	3,450	3,398	452	7,300	8,460	15,962
1971	3,345	3,480	500	7,315	8,460	"
1972	3,118	3,980	400	7,498	8,460	"
1973	2,680	3,896	420	6,996	8,620	"
1974	2,980	4,111	425	7,516	7,630	15898
1975	2,993	4,070	440	7,503	7,630	15707
1976	2,506	4,745	1,017	8,268	5,360	15099
1977	2,057	4,794	1,676	8,527	5,360	"
1978	2,140	4,337	1,985	8,462	4,581	"
1979	2,417	3,820	1,910	8,147	5,360	"

* This is the sum of durum + bread wheat + barley areas.

** The difference between total area and the sum cereals + fallow is occupied by crops such as oats (grain), rainfed forages, legumes and fruit trees.

Source: "Hypotheses de Fonctionnement du Secteur Socialist de la Daira d'El-Eulma". IGC. 1979. Modified.

Table 8: Cropped area in the Southern zone (in hectares).

Crops years	Durum	Bread wheat	Barley	Cereals*	Fallow	Total**
1970	1,120	2,910	1,256	5,286	4,854	10,484
1971	850	3,050	880	4,780	5,494	"
1972	1,250	3.070	856	5,176	5,095	"
1973	1,200	2,880	760	4,840	5,473	"
1974	1,250	2,582	929	4,761	5,029	10,058
1975	850	2,852	1.054	4,756	4,595	9,574
1976	550	3,060	1,950	5,560	3,137	9,506
1977	700	2,932	1,755	5,382	2,947	"
1978	700	2,610	1,960	5,270	3,422	"
1979	700	2,700	1,680	5,080	3,499	"

* This is the sum of durum + bread wheat + barley areas.

** The difference between total area and the sum cereals + fallow is occupied by crops such as oats (grain), rainfed forages, legumes and fruit trees.

Source: "Hypotheses de Fonctionnement du Secteur Socialiste de la Daira d'El-Eulma". IGC. 1979. Modified.

CHAPTER III

REVIEW OF THE THEORY OF DECISION MAKING UNDER RISK AND UNCERTAINTY

Decision making models (under uncertainty) are classified according to various behavioral criteria (Roumasset 1976, Anderson 1976). In this chapter three behavioral models are reviewed: utility based models, security based models and stochastic dominance models. Methods of utility elicitation and the different risk measures used to classify individuals in terms of their aversion to risk are given in the last section of this chapter.

3.1-UTILITY BASED MODELS.

The most widely used utility model is the expected utility model[8] developed by von Neumann and Morgenstern (1944). Bernoulli (1738) was the first to postulate the expected utility theorem (also known as the Bernoulli's principle) and to propose that people maximize expected utility rather than expected monetary value. Ramsey (1926) gave a proof of the theorem. Von Neumann and

8- Some paradoxes, however, have shed doubt as to the rationality of the model.

Morgenstern provided a complete and rigorous formulation and treatment of expected utility based on well defined axioms.

-ORDERING AND TRANSITIVITY: This axiom implies that if a decision maker is asked to choose between two risky prospects, X_1 and X_2, he either prefers X_1 to X_2 or X_2 to X_1 or is indifferent between them. If a third prospect X_3 is added to the choice set and that, for example, he prefers X_1 to X_2 or is indifferent between them, and that the same relation holds between X_2 and X_3, he will prefer X_1 to X_3 or will be indifferent between them. This axiom implies that all prospects are orderable and that preferences are transitive.

-CONTINUITY: If the decision maker prefers X_1 to X_2 to X_3, then there exists a subjective probability p ($0 < p < 1$) such that he is indifferent between taking a gamble with probability "p" of yielding X_1 and a probability ($1 - p$) of yielding X_3 and receiving X_2 with certainty.

-INDEPENDENCE: If X_1 is prefered to X_2, and X_3 is another prospect, then a choice offering X_1 and X_3 as outcomes will be prefered to a choice offering X_2 and X_3 as outcomes when the probability of X_1 and X_2 occuring is the same, i.e., $[pX_1 + (1-p)X_3] > [pX_2 + (1-p)X_3]$, where ">" means prefered to. The axiom implies that preference between X_1 and X_2 is independent of X_3.

The three axioms imply the existence of a utility function with the following properties:

1)- If $X_1 > X_2$ then $U(X_1) > U(X_2)$, conversely if $U(X_1) > U(X_2)$ then $X_1 > X_2$.

2)- If X is a risky prospect with a set of outcomes {x} occuring according to a probability distribution f(x), then $U(X) = E[U(X)]$, where "E" is the expectation factor. If f(x) is discrete then $E[U(X)] = \Sigma U(x)f(x)$, i.e., given $X[x_1,p;x_2,(1-p)]$, then $U(X) = E[U(X)] = pU(x_1) + (1-p)U(x_2)$. If f(x) is continuous, then $E[U(X)] = \int U(x)f(x)dx$. Thus, for a decision maker, who does not violate the above axioms, the utility of a risky prospect is represented by the expected utility of its outcomes. If faced with several risky prospects, the decision maker will select the one which maximizes expected utility.

3)- The utility function is unique up to an affine[9] transformation, i.e., any other utility function $U^* = aU + b$ $(a > 0)$ will serve as well as U. This implies that one is free to choose the origin and the unit of measurement of the utility scale.

Despite its wide use the expected utility model has been criticized on various grounds. Schoemaker (1982) indicated that "...from a measurement perspective NM[10] utility theory is cardinal in that its utility scale has

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9- A function is affine if $U[tX_1 + (1-t)X_2] = tU(X_1) + (1-t)U(X_2)$, i.e. an affine function is both convex and concave.

10- NM stands for von Neumann-Morgenstern.

interval properties. However, from a preference perspective, NM utility theory is ordinal in that it provides no more than ordinal ranking of lotteries." (p. 533). NM utility theory, however, is different from neoclassical cardinal utility and should not be considered as a measure of strength of preference under certainty[11].

Another confusing aspect deals with the notion of probability associated with the model. Probabilities fall in one of two major categories 1) objective or historical probabilities, and, 2) subjective or personal probabilities. The latter are usually referred to by f(p). This by no means implies that the f(p) transform indicates degree of belief. As a matter of fact such a transform may reflect probability preference and/or attitudes toward risk.

Some of the major variants of the utility based model are presented below.

[11]- Baumol (1977) has indicated that "...the N-M marginal utility of X therefore ends up as no more than the marginal rate of substitution between X and the probability of winning the prespecified prize (E) of the standard lottery ticket. This is surely not a cardinal measurement in the neoclassical sense." (p. 432).

$U = p_i X_i$	Expected monetary value.
$U = p_i U(X_i)$	NM expected utility[12].
$U = f(p_i) X_i$	Certainty equivalence theory. (Schneeweiss, 1974; Handa, 1977; de Finetti, 1937).
$V = f(p_i) v(X_i)$	Subjective expected utility. Psychologists' version (Edwards, 1955).
$U = f(p_i) U(X_i)$	Subjective expected utility. Economists' version. (Ramsey, 1931; Savage, 1954; Quiggin, 1980).
$V = w(p_i) v(X_i)$	Prospect theory. (Kahneman and Tversky, 1979).

Where X_i = monetary outcome; p_i = objective probabilities; f(.) = subjective probabilities; w(.) = decision weights; v(x) denotes an interval scaled utility measure constructed under certainty and U(x) denotes one constructed via lotteries (Schoemaker, 1982. p. 538, modified).

[12]- As presented here, the NM utility function is defined over ultimate wealth states and assumes linearity in the probabilities. The utility function suggested by Kahneman and Tversky, for example, is instead defined over changes in wealth with the assumption that the probabilities enter nonlinearly.

As originally outlined by von Neumann and Morgenstern, the expected utility model was essentially normative. However, throughout the literature, direct violations of its axioms have been reported by researchers who have tried to empirically test the model. Three such violations are presented and discussed below.

3.11-Violation of the independence axiom: the Allais' Paradox.

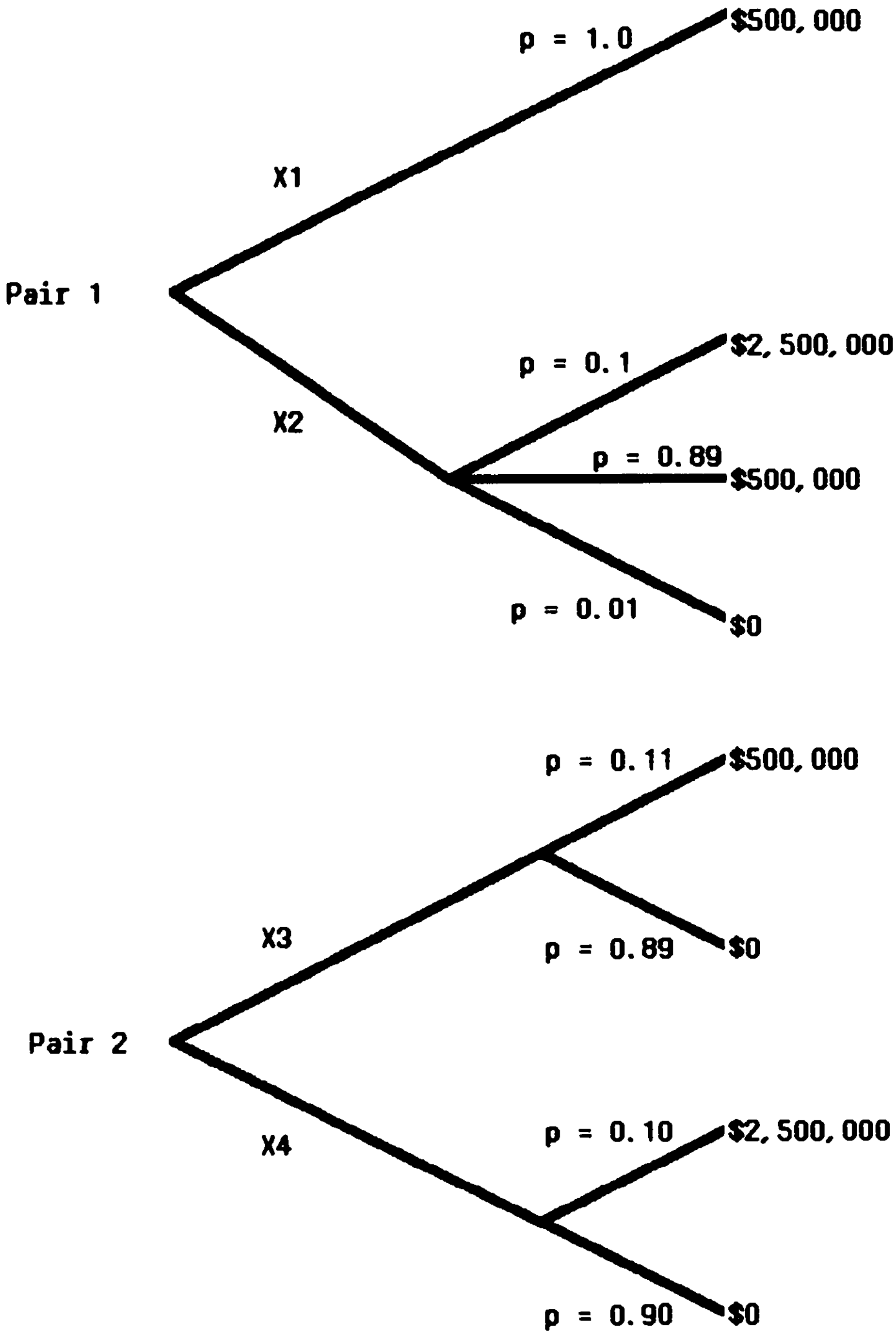
The most known example of the empirical violation of the independence axiom has been reported by Allais (1953) and is known as Allais' paradox. The paradox resulted from an experiment during which individuals were presented with two pairs of risky prospects (X_1, X_2 and X_3, X_4). The payoffs and probabilities associated with each pair[13] were as shown in figure 1. It was found that most individuals prefered X_1 to X_2 when presented with the first pair and X_4 to X_3 when presented with the second pair. The preference of X_1 over X_2 implies U($500,000) > 0.10U($2,500,00) + 0.89U($500,000) + 0.11U($0). Assuming U(0) = 0, the inequality implies 0.10U($2,500,000) < 0.11U($500,000). The preference of X_4 over X_3 implies 0.10U($2,500,000) > 0.11U($500,000) indicating inconsistency in preferences. Kahneman and Tversky

13- This version of the paradox is the one provided by Savage.

provided several examples of patterns of behavior violating the axiom.

The systematic violation of the independence axiom also has been mentioned in the field of psychology where a substantial amount of research on the validity of the expected utility principle has been conducted, e.g. Edwards (1961). Machina (1982, a) also has extensively addressed this issue, though from a different perspective than Kahneman and Tversky. He concluded that despite systematic empirical violations of the independence axiom, "...the implications and predictions of theoretical studies which use expected utility analysis typically will be valid, provided preferences are smooth." In other words, the independence axiom may be considered as an unnecessarily strong condition.

Figure 1: Representation of the Allais' Paradox



3.12- The asset integration hypothesis.

Traditionally, economists have expressed utility as a function of wealth. The assumption that the decision maker' behavior (under risky conditions) is traced out by a utility function defined in terms of final wealth has been labeled "asset integration hypothesis" (Kahneman and Tversky). This assumption implies that decision makers do not behave as if their utility directly depends on the immediate outcome of their decisions but rather on their ability to sustain, for example, a given level of consumption; i.e., wealth, per se, is not perceived to be affected by current decisions. A decision maker endowed with initial wealth W_0 and facing a risky prospect with certainty equivalent M, may have his utility function expressed as $U = U(W_0 + M) = U(W)$, where $W = W_0 + M$. According to the asset integration hypothesis, the decision maker will accept the risky prospect yielding X_1 with probability "p" and X_2 with probability (1-p) if and only if $U[p(W+X_1) + (1-p)(W+X_2)] > U(W)$. This implies that the prospect is acceptable (to the decision maker) if and only if the utility he derives from combining (or integrating) his assets with the outcomes of the prospect is higher than the utility he derives from his assets alone. In other words, the domain of the utility function is defined over final wealth rather than over gains and losses.

This hypothesis was challenged by Markowitz (1952) on grounds that the implied utility function, i.e., one defined over ultimate wealth, runs counter to observed behavior since, in general, regardless of their wealth level, individuals do buy insurance, i.e., accept to pay in order to avoid the risk, and lotteries, i.e., accept to pay in order to take the risk.

In rejecting the asset integration hypothesis, Markowitz postulated a utility function defined over gains and losses and which has convex and concave segments in both the positive and the negative regions, and where the middle inflection point is assumed to be at the "customary[14] level of wealth. A utility curve consistent with Markowitz specifications is shown in figure 2 where U(X) is monotonic and bounded[15].

Defining a utility function in terms of gains and losses does not imply that the function is independent of wealth. Kahneman and Tversky indicated that such a utility function "...should be treated as a function of

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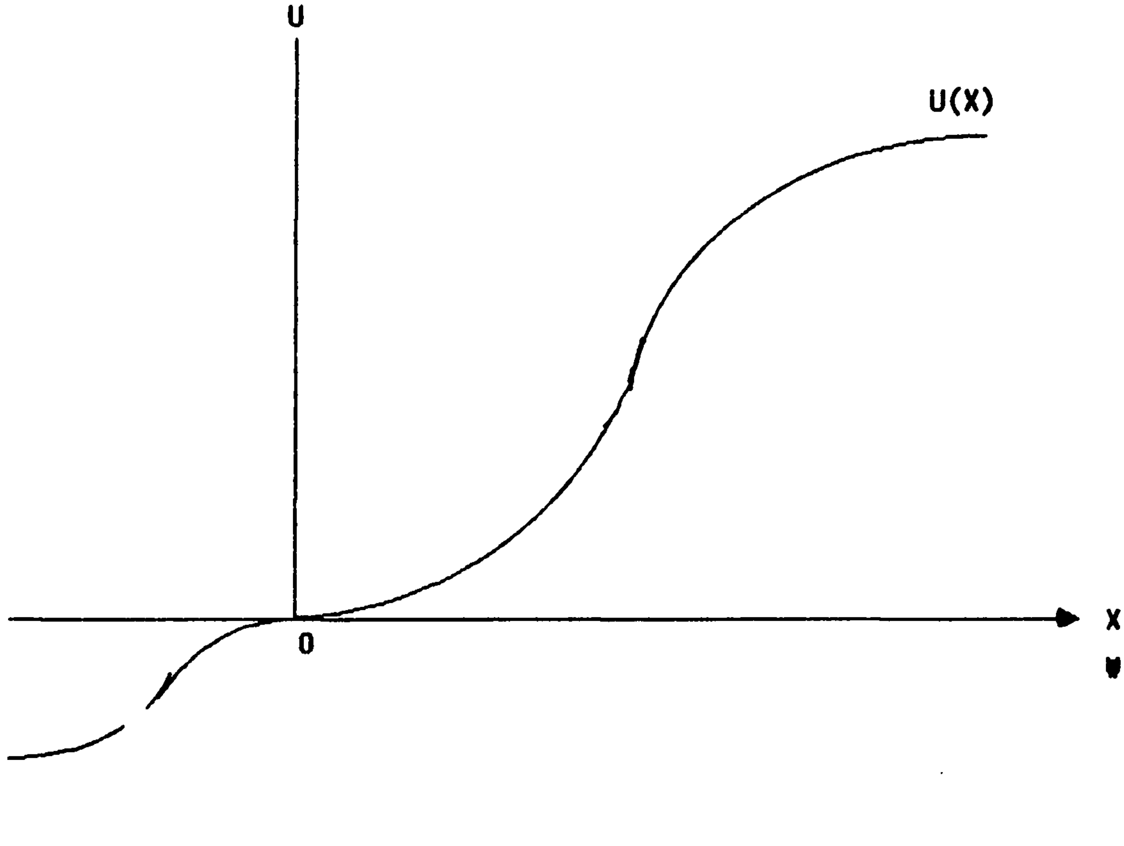
14- Originally Markowitz assumed that the second inflection point corresponded to present wealth. He, however, later pointed out that this may not necessarily be the case due to temporary deviations of this inflection point from present wealth as a result of changes in wealth, due to recent windfalls, for example. The level of wealth corresponding to this inflection point was therefore labeled "customary" wealth. In the absence of windfalls, "customary" and present wealth are identical.

15- This restriction is added for the sole purpose of avoiding inconsistency due to the St. Petersburg paradox.

two arguments: the asset position that serves as reference point, and the magnitude of the change (positive or negative) from that reference point."

Figure 2: Markowitz-type utility function.



Assume a utility function V(M) defined in terms of gains and losses[16] (M represents the certainty equivalent of the prospect under consideration). If asset integration holds[17], then at any given time the relation $U(W_0+M) = V(M)$ holds, implying $V'_M = U'_{W0} = U'_M$, and $V''_M = U''_{W0} = U''_M$, where the "prime" refers to first derivatives and the double "prime" to second derivatives of the respective functions. The slopes of U and V can be described by absolute (A), relative (R) and partial (S) risk aversion. The change of (A) with respect to initial wealth W_0 is: $\partial(A)/\partial W_0 = (-U'''_{W0}*U'_{W0} - U''_{W0}{}^2)/U'_{W0}{}^2$. Recall $(A) = -U''_{W0}/U'_{W0}$. The change of (A) with respect to M is: $\partial(A)/\partial M = (-U'''_M*U'_M - U''_M{}^2)/U'_M{}^2$ $= (-U'''_{W0}*U'_{W0} - U''_{W0}{}^2)/U'_{W0}{}^2$. Since by assumption $U'_{W0} = U'_M$; $U''_{W0} = U''_M$.

The change of (R) with respect to initial wealth W_0, i.e. $\partial(R)/\partial W_0$, is analogously identical to the change of (R) with respect to M, i.e., $\partial(R)/\partial M$, recall $(R) = W(A)$ implying $\partial(R)/\partial W_0 = W\partial(A)/\partial W_0 = \partial(R)/\partial M = W\partial(A)/\partial M$.

16- As indicated by Newberry and Stiglitz (1981), one empirical problem associated with such function is that it hardly gives any indication about the shape of the utility function except in the neighborhood of initial wealth.

17- Quizon et al. have shown that if asset integration does not hold, only the behavior of S can be inferred from a single utility function because any change in initial wealth, if it is large enough, would lead to the shift of the local function which in turn would imply that A and R will no longer be determined by the curvature of the initial function $U(W_0)$ but rather by the curvature of the second function $U(W_1)$.

However, when testing the behavior of (A) with respect to initial wealth and net gains (M) using data from his SAT experiment, Binswanger has found that the wealth of the modal subject must be increased by almost 500[18] times (from an average wealth of 10,000 rupees to more than 78,000 rupees) in order to achieve the same decrease in risk aversion that was achieved by less than 100 rupee increase in certain gains (M), thus adding one more empirical rejection of the assumption of asset integration[19].

The change of (S) with respect to initial wealth is $\partial(S)/\partial W_0 = M\partial(A)/\partial W_0$, recall (S) = M(A). The change of (S) with respect to sure gains is $\partial(S)/\partial M = (A)+M\partial(A)/\partial W_0$. For a risk averse individual (A) > 0, implying $\partial(S)/\partial M > \partial(S)/\partial W_0$. This implies that the response of (S) to changes in net gains will be higher than that to changes in wealth levels.

The rejection of the asset integration hypothesis implies (as indicated by Markowitz) that there would

18- Due to a numerical error (see Quizon et al.), Binswanger originally used the value 100.

19- Binswanger has indicated that one likely criticism of his test is that $\partial \ln(A)/\partial \ln W_0$ was obtained from the cross sectional variation of (A) across households whereas the change in game level is the difference in the geometric average of (A) for the same subject across games. The difference across game scales was significant at the 1% level though. However, as indicated by Quizon et al., this test should be considered as a test of the joint hypothesis of linearity and asset integration rather than a test of the asset integration hypothesis alone.

likely be less variation in risk attitudes across wealth levels and income than it was assumed by the Friedman-Savage hypothesis.

3.13-Probability preferences.

In a series of experiments, Edwards (1953, 1954a, 1954b, 1954c) has found that choices among bets are influenced by preferences among the probabilities involved and that the influence does not disappear even when the bets have different expected values. Preceeding Edwards' findings, Preston and Baratta (1948) have pointed to the same phenomenon. It was found that individuals tend to overemphisize low probabilities and underestimate high probabilities. Preston and Baratta explained such a pattern of behavior by what they labeled "psychological probabilities" defined as the price an individual is willing to pay to take a gamble divided by the gamble's prize, i.e., if a given gamble with prize $1,000 may be won by a price of $100 with probability p = 0.01 ($1,000, 0.01; -$100, 0.99), then the individual who accepts such a gamble is behaving as if the probability of winning $1,000 were 100/1,000 = 0.10, which represents the "psychological probability" of the gamble. Based on the results of their study, Preston and Baratta have indicated that low probabilities (less than 0.05) were systematically overestimated whereas high probabilities (more than 0.25) were systematically underestimated. In another study

(Griffith, 1948) similar conclusions were reached.

The notion of probability preferences (mostly studied by psychologists) constitutes the basis for the so-called "subjective expected utility" models. As Edwards (1962) has put it, individuals supposedly associate with each event a weight "w_i" expressing "...the relative desirability or undesirability of the probability displayed by each event" (p. 127). These individuals thus behave as if they were maximizing a subjective expected utility defined as $(p_i w_i)U_i$ where "p_i" is the probability of the event "i" under consideration, i.e. probabilities were replaced (in a nonlinear fashion) by decision weights $w(p_i)$ or subjective probabilities $f(p_i)$. Mosteller and Nogee (1951) were not at ease with the notion of "psychological probabilities" and were not sure whether they add to one. Later Kahneman and Tversky have pointed out that decision weights should not be confused with probabilities, which they are not, and as such "...do not obey the probability axioms and should not be interpreted as a measure of degree belief." They defined a weighting function increasing with respect to "p" with $w(0) = 0$ and $w(1) = 1$, and since low probabilities are overestimated then $w(p) > p$ and high probabilities are underestimated then $w(p) < p$.

The problem of probability preferences has led to the serious questioning of the adequacy of using NM utility theory to empirically measure utility, e.g. in the Mosteller and Nogee study. However, the researchers who have investigated this issue did not always reach similar conclusions. Mosteller and Nogee results, for example, did not concur with either Preston and Baratta, and Griffith results. More recently, Sillers (1981) has found no evidence suggesting any role of probability preferences in the decision making process. A substantial number of conceptual problems continue to cloud the attempt to replace probabilities by decision weights in order to overcome probability preferences. Examples include potential violations of dominance (Kahneman and Tversky) and inconsistent "triads", i.e., situations where A is prefered to B, B to C and C to A, i.e.,intransitive choices (Edwards, 1953).

Needless to say, most of the evidence reported in the literature since Bernoulli is rather critical as to the expected utility model's usefulness. Schoemaker, however, stated that the model certainly will remain for quite some time "...a worthwhile benchmark against which to compare, and toward which to direct behavior." Furthermore, as indicated by Machina, "...the researcher who would like to drop the expected utility hypothesis and study the nature of general risk aversion can apparently work completely within the framework of expected utility analysis" (p. 297).

3.2- SECURITY BASED MODELS.

These models emphasize the importance of hierarchical goals in the decision making process according to the rule:

Max $E(I)$

S.T. Pr. $(I \leq d) \leq p$.

or Min Pr. $(I \leq d)$.

where "I" is the decision maker's net income, "E" is the expected value operator, "d" is a specified disaster level and "p" a probability level for which net income falls below the disaster level. The safety first model, for example, identifies the probability "p" as risk. The decision rule on which these models are based suggests that the decision maker modifies his constraint set according to a system of priorities (lexicographic ranking). The first priority is the attainment of his household subsistence requirements. The main attraction of these models (in subsistence agriculture, particularly) comes from the logical assertion that subsistence farmers highly rank satisfaction of their subsistence needs. The main limitation of these models seems to lie in their failure to take into consideration aversion to variation in income levels once subsistence requirements are satisfied. Security based models of decision making have extensively been used in the field of agricultural economics, e.g. Boussard and Petit (1967), Roumasset

(1974,1976), Moscardi and de Janvry (1977), Kunreuther and Wright (1979). Basically what the security based models imply is that once the subsistence level is secured, i.e. I > d, then the decision maker's choice will always be directed toward the prospect with the highest expected value, regardless of the variance associated with the outcomes of the prospect under consideration. However, empirical evidence casts doubt upon such an assessment, e.g. Binswanger's study in India, Walker's study in El Salvador, Sillers' study in the Phillipines as well as the present study in Algeria. In all four experiments cited above, only a very small proportion of the subjects who played the games selected the alternative with the highest expected value. Such a behavior on the part of relatively poor subsistence farmers from different parts of the world casts serious doubt as to the appropriateness of such models to correctly predict farmers' decisions under risky conditions.

3.3- STOCHASTIC DOMINANCE

Stochastic dominance is an approach aiming at predicting decision makers' choices among risky alternatives and requiring only minimal information about their utility functions (the only requirements are monotonicity, i.e. $U' > 0$ and concavity, i.e. $U'' < 0$) and which focuses directly on the notions of probability density functions and cumulative distribution functions. First (FSD) and second (SSD) degree stochastic dominance are the types mostly used. In what follows (x) is a random variable defined over the range [y,z]. f(x) and g(x) represent two probability density functions such that f(x) = g(x) = 0 for (x) outside [y,z]. Cumulative distribution functions F and G are obtained by cumulating under f(x) and g(x). $F_1(R) = \int_Y^R f(x)dx$ and $G_1(R) = \int_Y^R g(x)dx$. R is the common domain the two functions, R varies continuously over [y,z].

Given the above definitions, the stochastic dominance approach deals with choices between alternatives described by the random variable (x). Decision makers' preferences for (x) are described by their utility U(x). Maximization of expected utility is assumed to be the decision makers' objective.

First order stochastic dominance (FSD).

The assumption of monotonicity over [y,z] is the only requirement for this rule ($\partial U(x)/\partial x > 0$)[20]. f(x) dominates g(x) by FSD if and only if $F_1(R) \leq G_1(R)$ for all R in [y,z] with strict inequality for at least one R value. This implies that the expected value associated with f(x) is at least as large as that associated with g(x). Therefore, according to the expected utility maximization rule, any decision maker with utility function U(x) will prefer f(x) to g(x).

As shown in figure 3, F_1 lies totally to the right of G_1, implying f(x) dominates g(x) by FSD . However, neither F_1 nor G_1 can be ordered with respect to G'_1.

-Second order stochastic dominance (SSD).

For this rule, the assumption of decreasing marginal utility is added, i.e. $U''(x) = \partial^2 U(x)/\partial x^2 < 0$ implying the concavity of U(x) (assumption of risk aversion). f(x) dominates g(x) according to SSD if and only if $F_2(R) \leq G_2(R)$ for all R in [y, z] with at least one strict inequality for one R value (recall $F_2(R) = \int_y^R F_1(x)\,dx$; $G_2(R) = \int_y^R G_1(x)\,dx$).

If F_1 and G_1 cross twice as illustrated in figure 4, then f(x) dominates g(x) according to SSD only if area C is not larger than area D.

Because of the second restriction ($U''(x) < 0$), the

[20]- Because of this single requirement, the usefulness of FSD is substantially limited, i.e. the efficient set contains too many alternatives.

efficient set should be expected to be smaller under SSD than FSD; however, there is no guarantee that this is indeed the case every time.

Figure 3: Representation of first order stochastic dominance.

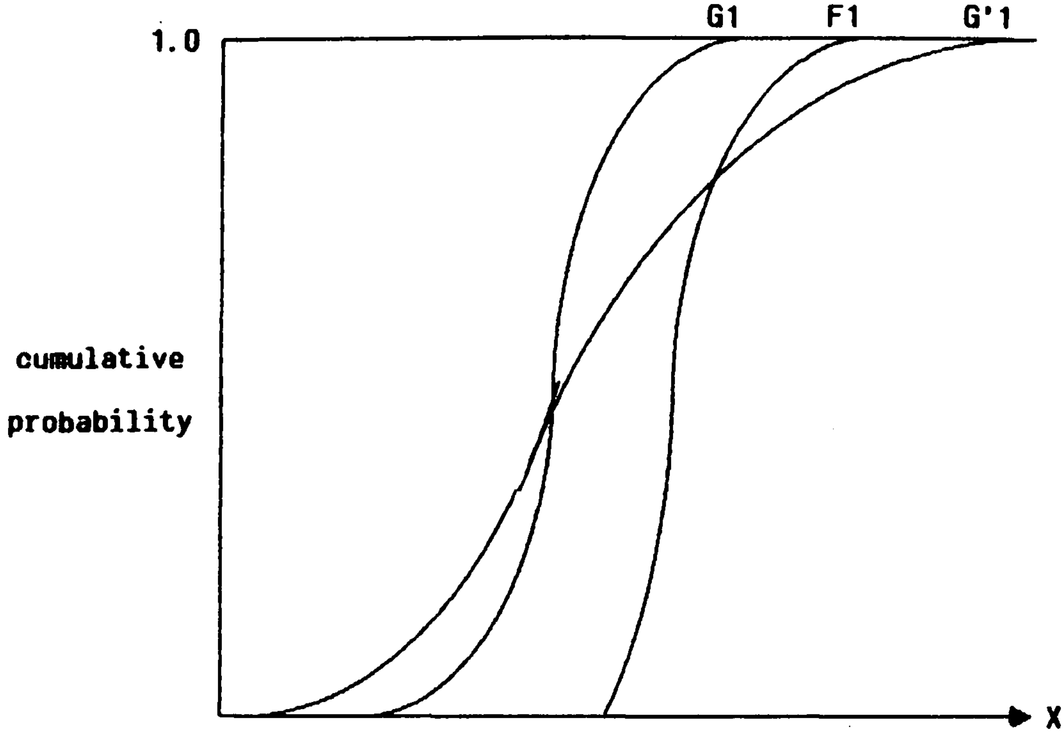
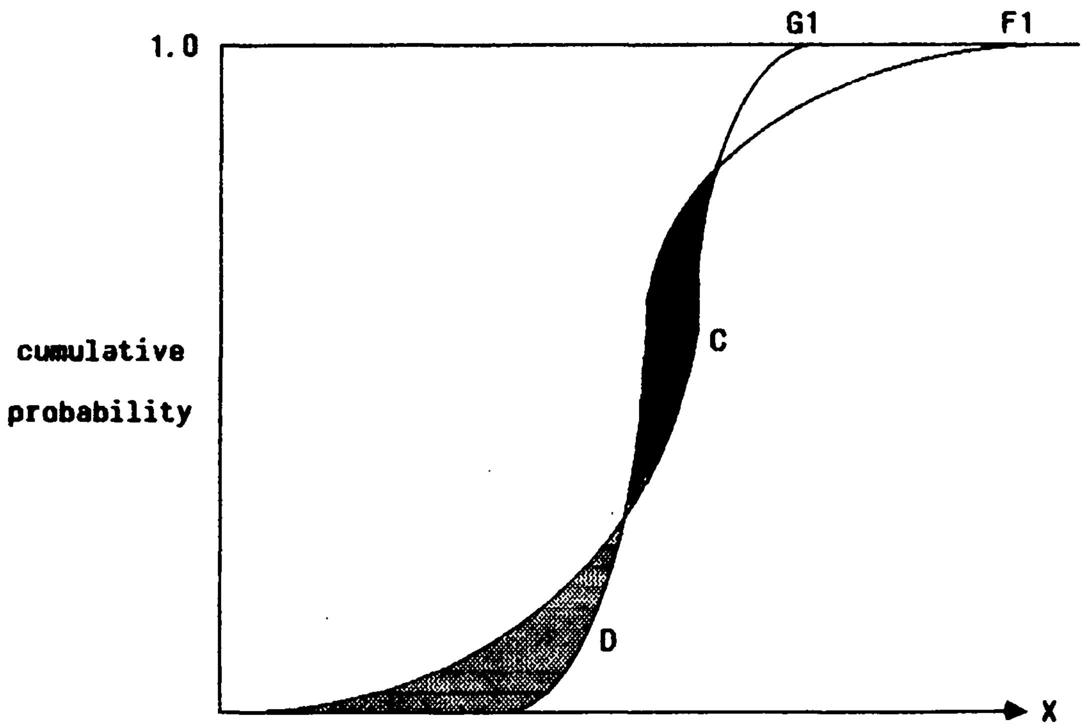


Figure 4: Representation of second order stochastic dominance.



A third restriction (third degree stochastic dominance) on U(x) is sometimes added, i.e. $U'''(x) > 0$, implying decreasing risk aversion as wealth increases or that positive skewness (in terms of x) is prefered to negative skewness.

Another condition (implicit) of the dominant distribution is that its mean cannot be less than that of the dominated distribution. If both distributions have the same mean then the dominating distribution must have a smaller variance.

FSD and SSD constitute the simplest and most widely used efficiency criteria (particularly SSD). However, their discriminatory power is very questionnable, i.e. they usually retain many alternatives implying a large efficient set. Anderson (1975), for example, has applied SSD for the selection of farm plans and has ended up with 20 out of 48 (i.e. 42%) of the plans in the efficient set. This hardly can be considered as a disciminatory means of selecting among farm alternatives.

A more general form of stochastic dominance developed by Meyer (1977) is the Second Stochastic Dominance With Respect to a Function (SDWRF). This approach orders uncertain prospects for individuals knowing only that their absolute risk aversion functions r(x) are bounded by a specified lower ($r_1(x)$) and upper ($r_2(x)$) absolute risk aversion function, i.e. $r_1(x) <= -U''(x)/U'(x) <= r_2(x)$.

No restrictions are imposed on the width or shape of the interval within which the individual's absolute risk aversion function is assumed (King and Robison, 1980). SDWRF compares the expected utilities associated with the uncertain prospects in a pair-wise fashion. This pair-wise comparison requires that all individuals whose risk aversion function lies between the given lower and upper bound be unanimous in their choice between the two risky prospects. As defined by Meyer, "cumulative distribution F(x) stochastically dominates cumulative distribution G(x) in the second degree with respect to k(x) if and only if $\int_0^1 [G(x) - F(x)]dk(x) >= 0$ for all y in [0,1]." When k(x) = x, the expression defines SSD.

As noted by Cochrane et al., the width of the interval $(r_1(x), r_2(x))$ will determine the trade-off between the probability of type I and type II errors, and can be adjusted according to the investigator's objectives.

Another efficiency criterion is the Convex Set Stochastic Dominance or CSD (Cochrane et al.). The CSD efficiency set contains only those alternatives that are prefered by at least one individual (decision maker) and discards all those that are not prefered by anyone. In other words, there need not be unanimity among individuals' choices. CSD compares one risky prospect (e.g. G) to a convex combination of some other risky prospects (e.g. F_i). This is a two stage procedure where an efficient set is first identified through efficiency criteria such as FSD, SSD or SDWRF. The second stage consists of applying CSD to narrow down the number of efficient alternatives.

3.4-UTILITY ELICITATION AND RISK MEASURES.

Under the EU model, the individual's utility function becomes paramount. The decision maker's risk preferences are, therefore, captured by his utility function whose shape determines his behavior in face of risky prospects. Throughout the years, a considerable number of methods have been suggested for utility elicitation (see, for example, Anderson et.al., 1977). For the sake of simplicity, only the experimental and direct elicitation methods will be considered[21].

3.41-Methods of utility elicitation.

a- The direct elicitation method.

This method is based on a series of interviews and aims at determining points of indifference between certain outcomes and risky prospects involving real or hypothetical gains and losses. Several variants of this technique are usually used. The von Neuman-Morgenstern approach originally consisted in presenting a subject with a choice between a gamble yielding X_1 with probability p and X_2 with probability (1 - p) as outcomes and a sure prospect X_3. Such an approach was criticized on two grounds, 1) since X_1 and X_2 have a different probability

21- The risk interval approach (King and Robison) and the observed economic behavior (Moscardy and de Janvry) constitute two other methods of utility elicitation.

of occurence, a problem is likely to arise if the subject exhibits probability preferences, 2) since the subject is offered a choice between a risky and a sure prospect, his choice is likely to be biased if he has a utility or disutility for gambling. A modified version of this approach using neutral probabilities, i.e. p = 0.50 = (1-p) was subsequently proposed in order to eliminate any potential probability preference bias. The use of the latter method was pioneered by Mosteller and Nogee.

The Ramsey approach, on the other hand, by presenting the subject with two gambles (instead of a gamble and a sure prospect) and using neutral probabilities was successful in overcoming the two previous criticisms. Davidson, Suppes and Siegel (1957) were the first to use the Ramsey approach empirically.

Despite all the refinements , the direct elicitation method still suffers from various sources of bias. Interviewer bias has been found to play an important role in patterning the selection of choices. Another potential source of bias is the very questionnable representativeness of choices derived through hypothetical (or in some cases real but very trivial) payoffs (gains and losses).

b- The experimental method.

This method involves the use of real and significant payoffs and requires choices among alternatives characterized by only two possible outcomes with the same probability of occurence. This approach was developed by Binswanger (1977) and has been used since by Walker (1980) in El-Salvador and Sillers (1981) in the Phillipines. This approach substantially remedies some of the most serious problems associated with the direct elicitation approach (e.g. interview bias, simplicity in understanding, real choices). Comparing results obtained with both approaches, in terms of interview bias and stability of choices, Binswanger (1980) concluded that "...one is tempted to dismiss the interview studies as unreliable and potentially misleading" (p. 402). However, the experimental approach is costly in terms of time and resources. A more detailed presentation of both approaches is provided by Young (1979), Knowless (1980) and Binswanger (1980). Chapter 4 provides a thorough presentation of the experimental approach as applied in this study.

3.42-Measures of risk aversion.

Throughout the literature, measures quantifying risk preferences have been developed. These are used to classify subjects as risk averse, risk neutral or risk prone. A risk averter is an individual, given a fair gamble, who prefers the sure amount equal to the expected value of the gamble to the gamble itself, i.e. if the possible outcome of the gamble is represented by X , then U[E(X)] > E[U(X)]. Strict concavity of U is a necessary and sufficient condition for the above relation to hold. If U[E(X)] < E[U(X)] then the individual is risk prone. Strict convexity of U is a necessary and sufficient condition in this case. The relation between the slope of U and the individual risk attitudes is illustrated in figure 5.

One measure that quantifies risk preferences is known as the certainty equivalent concept. Given a gamble (X_1, p; X_2, (1-p)), the certainty equivalent associated with it is defined as a sure payment Y such that the subject is indifferent between receiving the latter (for certain) and taking the gamble. Aversion to risk is then determined according to the size of Y relative to the expected value of the gamble, i.e. Y >,=,< [$p(X_1) + (1-p)X_2$] then the subject is risk prone, risk neutral or risk averse, respectively. If two subjects are offered the same gamble generating two certainty equivalents Y_1 and Y_2, then the subject with the lowest certainty equivalent is said to be more risk averse.

Another measure of risk aversion derived from the certainty equivalent and the expected value of a gamble is the risk premium concept. It is defined as the expected value of the gamble less the certainty equivalent. The subject is said to be risk averse, risk neutral or risk prone if his risk premium is positive, zero or negative, respectively.

The concepts of risk premium and certainty equivalent are illustrated in figure 6 for the case of risk aversion.

Figure 5: Utility functions with different risk types.

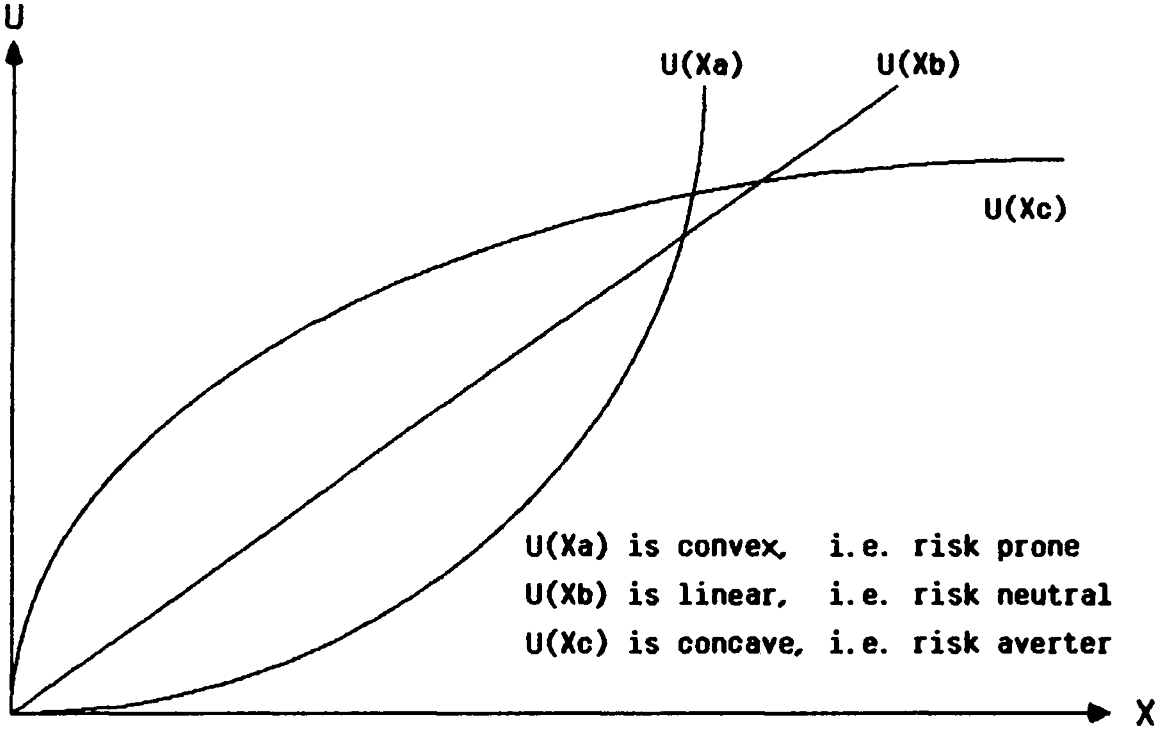
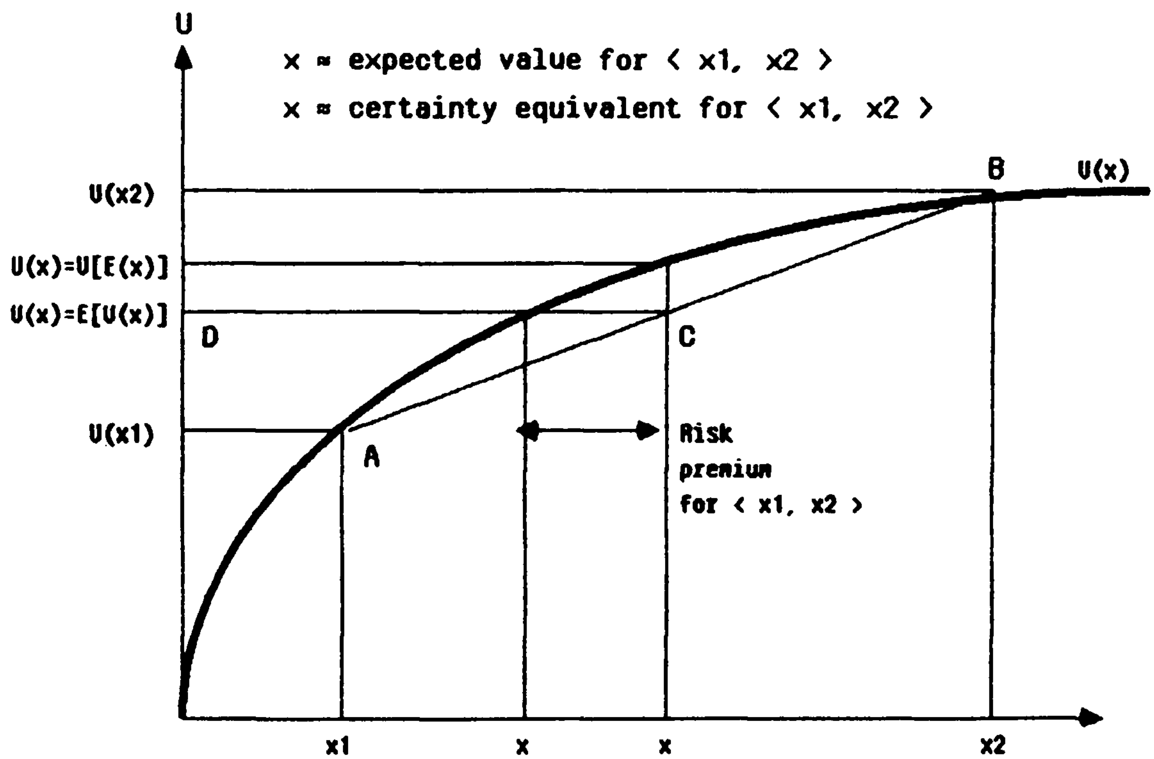


Figure 6: Risk premium for a concave utility function



However, the three measures of risk aversion that have received most attention in the literature are the absolute (A), relative (R) and partial (S) risk aversion coefficients. Define a utility function U(W) = U(W0 + M) where W = final wealth, W0 = initial wealth and M = certainty equivalent of a given risky prospect, i.e. W = W0 + M. Then absolute risk aversion (A) = $-U''w/U'w = -U''_{W0}/U'_{W0} = -U''_M/U'_M$, where $U'i = \partial U/\partial i$; $U''i = \partial^2 U / \partial i^2$; i = W, W0, M. The non satiation assumption (U/ i > 0) and the concavity assumption ($\partial^2 U/\partial i^2 < 0$) imply that (A) > 0 for a risk averse individual.

(A) traces the behavior of individuals faced with a fixed fair gamble at different wealth levels. A decreasing (A) is usually assumed, i.e., as one's wealth rises so does his willingness to accept a fair gamble or $\partial(A)/\partial W < 0$. However, only few utility functional forms present such characteristics, e.g., U(W) = logW and U(W) = W^t, 0< t <1. The quadratic utility function U(W) = W + bW^2 , b < 0, for example, implies an increasing rather than a decreasing (A), i.e., $\partial(A)/\partial W > 0$.

The other measure of risk aversion (relative risk aversion) is defined as (R) = $-W\,U''w/U'w$ = W(A). The relevance of this measure becomes important when the gamble and wealth are raised by the same proportion. It has been hypothesized (Arrow, 1971) that (R) is usually increasing[22], i.e., $\partial(R)/\partial W > 0$ implying that if an individual , with a given wealth level, is presented with a gamble, his willingness to accept the gamble will decrease as his wealth and the gamble are multiplied by a common scalar. Since (A) > 0 it follows from the relation (R) = W(A) that (R) is also positive for risk aversion. These two measures of risk aversion are due to Pratt (1964).

Finally, the third measure of risk aversion (partial risk aversion) is defined as $(S) = -M(U''w/U'w) = M(A)$. This measure becomes relevant when studying the behavior of an individual when wealth is maintained constant whereas the scale of the gamble is varied by a scalar k. An increasing (S) relates to the decrease in the willingness to accept a gamble as the scale of the payoffs at stake increase. (S) was independently proposed by Menezes and Hanson (1970) and Zeckauser and Keeler (1970). However, the "partial risk aversion" terminology was specifically offered by the former whereas the latter have used the term of "size of risk aversion". Furthermore, Menezes and Hanson have indicated that for an individual endowed with some positive initial wealth and when (S) is monotonic (in the scalar k), then it must be constant or increasing as the scalar k is increased.

22- Binswanger (1981) reported a decreasing relative risk aversion. However, as pointed out by Quizon et al., his finding was wrong. After correction, it was shown that relative risk aversion was indeed increasing.

CHAPTER IV

MEASURING RISK PREFERENCES: AN EXPERIMENTAL APPROACH

The two main objectives which guided the field experiment sample selection were:

1- Attempt to relate farmers' measured risk attitudes to their agro-ecological zone and to their production behavior. The attainment of such an objective requires that the sample should include farmers producing wheat and/or barley in the three agro-ecological zones of the daira.

2- Estimate the effect of socioeconomic characteristics on the measured risk preferences of the farmers constituting the sample. This in turn implies that the sample should include small as well as large farming units and subsistence as well as commercial farmers.

In Algeria most of the winter cereals are grown on the high plateaus. The Wilaya of Setif is representative of this agroclimatic region. The daira of El-Eulma was chosen because it covers three distinct agro-ecological zones usually encountered in the high plateau region.

Also El-Eulma was one of the three[23] pilot dairate where the OIRD program (see footnote 7) was conducted (from 1973 to 1979). Finally the author worked in El-Eulma for two years (from December 1974 to November 1976) as an agronomist with the "Institut de Developpement des Grandes Cultures", OIRD program.

4.1- THE QUESTIONNAIRE.

The first step was to briefly survey the three communes (Beni Fouda, El-Eulma and Oum Ladjoul) to construct a sampling frame of all farmers (private as well as socialist) by farm size. An official list of private farmers of the communes was made available by the Agrarian Revolution Service of the Wilaya of Setif. At the outset an attempt was made to classify farmers according to the size of their holdings. However, when surveying, it became clear that the actual holdings were quite different (usually larger) than those reported by the Agrarian Revolution Service[24]. Since it was not possible to resurvey to determine the exact size of actual individual holding, it was decided to select the farmers at random

[23]- The other two dairate were Mahdia in the Wilaya of Tiaret and Hamam Bou Hadjar in the Wilaya of Sidi Bel Abbes (western Algeria).

[24]- Because of size limitation dictated by the agrarian revolution service, farmers usually declare far below their actual holdings.

based on the official list of private farmers of each site.

Once the sample was completed, a questionnaire was developed. The questionnaire was designed to capture technical as well as socioeconomic characteristics of the sampled population. All the selected farmers were contacted directly by the author[25]. Each farmer in each site was visited at least twice[26].

Some farmers were skeptical when first approached (in fact there were few instances where selected farmers refused to answer the questions; when this occurred, the refusing farmer was dropped from the sample). Considerable effort was taken in explaining the object of the questionnaire and letting farmers understand that they did not have to answer the questions. Generally, once they understood the purpose of the research they agreed to collaborate and did it with real enthusiasm. One farmer said ,"this is the first time someone has expressed interest in my farming practices, therefore, I will do my best not to let this opportunity pass by". Part of the enthusiasm may also be explained by the fact that the

[25]- In one site (Oum Ladjoul) the author was helped by the staff of the IGC experiment station of Setif. In all 3 sites we were helped by a volunteer farmer who knew the area and the farmers and without whom the field work could not have been conducted.

[26]- The questionnaire contained 51 questions. Very often it was not possible to conduct the questionnaire in one or even two visits.

survey was conducted during the months of January through March which correspond to a relatively light work period.

Farmers' responses related to production costs, estimated annual income and livestock versus crop income need to be carefully interpreted. Some farmers had trouble determining wheat and/or barley production costs and estimating their annual gross income. Private farmers do not keep good records and very few keep receipts of items bought and/or sold.

A serious attempt was made to minimize interviewer bias. First, the author conducted more than 85% of the interviews. Second, before the interviews started all the interviewers (there were 4 in all) agreed on a single way to ask questions. And, finally, the author personally reviewed all questionnaires.

Since each farmer was contacted individually, the interviews were very time consuming. The farms were in most cases scattered over a relatively large area without easy access (unpaved country roads). In some instances (particularly in Beni Fouda) heavy snow falling during January and February delayed contact of several selected farmers.

The interview procedure followed was: contact the selected farmer usually through the peasants union (UNPA); explain to him the object of the interview , the type of questions that would eventually be asked; ask the farmer to give a general presentation of his farming unit and the problems encountered[27]; and finally make an appointment for the interview[28]. In some instances up to four return visits were made to complete the questionnaire. Farmers involved in the questionnaire were very interested and very enthusiastic about it. Even farmers not previously selected offered to contribute. Unfortunately because of time and staff shortage, it was not possible to increase the sample size.

The questionnaire as designed was not applicable for socialist farms where decisions are made by groups rather than individuals. Only the presidents and directors of ten socialist farms were asked to respond to the questionnaire and later participate in the experiment. The president, who is elected by the management committee, is the legal representative of the farm members; the director is nominated by the government (Ministry of Agriculture) and represents the latter in the farm

27- This preliminary phase of the interview is crucial to gaining farmers' confidence. Farmers usually like to share their everyday problems, e.g. production, administrative, environmental, etc. If the interviewer shows a willingness to listen to them they will act accordingly during the interview and will cooperate with him. During this phase, coffee and food were always offered by farmers and/or relatives.

28- In some instances the interview started at this point. But, as pointed out above, because of the length of the questionnaire, more than two visits were sometimes needed to complete the interview.

decision making process. The final decision is jointly made by these two persons.

Three months were necessary to complete the interview process. The process of locating, contacting and meeting the selected farmers was very slow due to the large sample size in the three sites (34, 32 and 20 private farmers in El-Eulma, Oum Ladjoul and Beni Fouda respectively), the difficult climatic conditions of January and February (frequent snow falls), and above all the shortage of staff.

All farmers who took part in the interviews were asked to participate in the experiment. Nothing was said about the experiment during the interview process since it was feared that the prospect of possible money gains could influence farmers'answers and attitude. Only after completion of all the interviews was the experiment explained to the selected farmers.

4.2- THE EXPERIMENT.

Attempts to elicit farmers' risk preferences have usually been conducted through interviews (the interview approach is also known as the direct approach). Farmers' utility functions for money (U(X)) are elicited by asking a series of questions based on the continuity axiom. After a series of points in utility-money space are obtained, a utility curve is fitted to them. However, the lack of incentives may induce the subjects interviewed to capriciously choose among the alternative prospects. Also the interview approach makes use of the abstract principle of subjective probabilities in choosing among alternatives. This may be a serious drawback when the subjects are uneducated farmers from developing countries usually with no knowledge of the notion of subjective probabilities. As pointed out by many authors (e.g. Sillers), the use of such an approach implies that the subjects involved not only should understand the notion of subjective probabilities but also should be able to immediately associate it to their decision making process regarding the alternatives offered to them. These two limitations, not to mention interviewer bias, pose serious doubt as to the reliability of the estimates derived through this approach. An alternate approach was designed (Binswanger) to overcome these limitations. This approach, known as the experimental approach, deals with real and nontrivial choices and was used in this reseach in order to make inferences about the shape of farmers' utility functions and subsequently derive estimates of their risk aversion measures.

The experiment consisted of offering the subject a choice among eight alternatives whose outcome is determined after a toss of a coin. Based on the outcome money was collected or distributed. The schedules of alternatives are shown below.

Scale	Alternatives	Payoffs in Dinars Tail	Head	Exp.Va	St.Dev
		REAL GAMES			
5 DA	A	0	0	0	
	B	-.50	4.50	2	2.50
	C	-1.00	7.00	3	4
	E	-2.00	10.00	4	6
	F	-3.00	11.00	4	7
	G	-4.00	14.00	5	9
	H	-5.00	15.00	5	10
50 DA	A	0	0	0	0
	B	-5.00	45.00	20	25
	C	-10.00	70.00	30	40
	E	-20.00	100.00	40	60
	F	-30.00	110.00	40	70
	G	-40.00	140.00	50	90
	H	-50.00	150.00	50	100
200 DA	A	0	0	0	0
	B	-20.00	180.00	80	100
	C	-40.00	280.00	120	160
	E	-80.00	400.00	160	240
	F	-120.00	440.00	160	280
	G	-160.00	560.00	200	360
	H	-200.00	600.00	200	400
		HYPOTHETICAL GAMES			
1000.00	A	0	0	0	0
	B	-100.00	900.00	400	500
	C	-200.00	1400.00	600	800
	E	-400.00	2000.00	800	1200
	F	-600.00	2200.00	800	1400
	G	-800.00	2800.00	1000	1800
	H	-1000.00	3000.00	1000	2000
5,000.00	A	0	0	0	0
	B	-500.00	4500.00	2000	2500
	C	-1000.00	7000.00	3000	4000
	E	-2000.00	10000.00	4000	6000
	F	-3000.00	11000.00	4000	7000
	G	-4000.00	14000.00	5000	9000.
	H	-5000.00	15000.00	5000	10000

During the experiment $1.00 was approximately equal to 4.75 DA.

Each schedule lists seven alternatives out of which each subject was asked to select one. Each of the seven alternatives consists of two amounts of money (a gain under head and a loss under tail). Every game contains a safe alternative (alternative A) which is equivalent to not playing the games (zero payoff if tail or head).

Prior to playing the games each subject was given an amount of money according to the game scale. This money was a true windfall and was distributed as follows:

-20 DA eight days before the first of the four 5 DA scale rounds (5 DA * 4 = 20 DA).

-100 DA eight days before the first of the two 50 DA scale rounds (50 DA * 2 = 100DA).

-200 DA five days before the single 200 DA scale round.

Real money was given to avoid any potential problems due to liquidity constraints on choices as well as to avoid the moral problem of potentially taking money from participating farmers.

The newness of the experiment to the farmers (they have never been exposed to a similar experiment or to any experiment for that matter) necessitated extra care in explaining the process to them. It was vital that they clearly understood that the money given to them was theirs to keep. The seven alternatives were carefully explained (photographs of alternatives were distributed when the money was handed out). Two rounds at the 5 DA scale (hypothetical) were played to accustom the subjects to the games and to determine and eventually correct any potential problem before actually starting the experiment. Each subject was asked to identify the alternative he prefered, then the author tossed a coin. Depending on the outcome of the toss, the subject then was paid (if a head) or had to return (if a tail) the amount of money specified for the alternative he selected.

The type and sequence of games were patterned after Binswanger's method to measure risk attitudes with a slight modification. Instead of using a "gains only" sequence as in the original structure of the method, a "gains-and-losses" sequence was used in this experiment. Going from alternative A to H the expected gain increases but so does the deviation between the outcomes of the same alternative. Alternatives E and F, for example, have the same expected value but F has a larger deviation and is, therefore, said to be stochastically inefficient.

In all three sites the subjects were divided into subgroups to reduce the travel necessary to play the games. There were 3, 2 and 2 such subgroups in Oum Ladjoul, El-Eulma and Beni Fouda, respectively. At each meeting, an area was provided into which only the author and the subject were allowed. This was done so that the subject could reveal his choice to the author without interference from other subjects. While one subject was revealing his choice, the remaining could discuss the various alternatives offered to them. When each subject was ready to play he let the author know and moved to the isolated area. Before tossing the coin the author systematically reminded each subject that he was free to toss the coin himself (making practice tosses if he wanted), or have the author or another individual do it for him. If a subject expressed the need to have a companion when revealing his choice in the isolated area, the author complied. However, in the course of the experiment only a few subjects expressed such a need. Most of them prefered to reveal their choice to the author alone and the latter to toss the coin. There were a few instances when the subject tossed the coin.

Whenever there was a round scheduled in a particular site each subgroup had a three hour period (known before hand and not changed) during which any subject of the subgroup could play the scheduled round. No game was played after the three hour period. If there was a subject who did not show up at the agreed time, it was assumed that he had chosen alternative A (this happened ten times during the whole experiment). Usually the round was completed in less than two hours. Most of the subjects had made their choice long before coming to play and very few of them admitted to having changed their initial choice during the game period or as a result of discussion with other subjects and/or the author.

Before and after each game, a very enthusiastic discussion related to the pros and cons of every alternative, the possible gain and loss, etc, took place among the subjects. The discussions continued at home and at the cafe according to the subjects. In fact, during the whole experiment, it was not possible for the author to meet someone (a subject or otherwise) without exchanging comments about the experiment. The experiment was on everybody's mind.

Once a subject decided it was time to play, he came forward to the isolated area where the author would ask him if he fully understood the game being played. Regardless of the answer the author would give a detailed description of the procedure and the rules of the game, making certain that every subject knew exactly what he was doing. This was particularly important as most of the subjects were illiterate. Then, the subject and the author would work on an unmarked copy of the schedule of alternatives (provided by the author) for the game being played that day. The author would ask the subject to indicate the alternative he had selected. The author would then ask him why he had selected that particular alternative. The other alternatives were also discussed. Once the subject had indicated his final choice, the author would toss the coin to determine the outcome. The subject would collect the money on the table if a head had come up, otherwise the author would collect the amount of money specified by the schedule of alternatives. After each game the author thanked the subject for his collaboration. In some circumstances (see the experiment schedule) instructions and a new schedule of alternatives were handed to him before he left.

The same process was used for the hypothetical games. The only difference between real versus hypothetical games is that during the latter, no money was distributed.

Table 9: Experiment Schedule.

Procedure	O.Ladjoul	E.Eulma	B.Fouda
Instructions for rounds 1,2, 3 and 4 (5 DA scale), hand out schedules and capital for rounds 1 through 4.	March 5	March 12	March 12
-Round 1 (5 DA scale)	March 13	March 20	March 20
-Round 2 (5 DA scale)	March 14	March 21	March 21
-Round 3 (5 DA scale)	March 15	March 22	March 22
-Round 4 (5 DA scale)	March 16	March 23	March 23
Instructions for rounds 5,6, 7 and 8, hand out schedules for 50 DA and 200 DA scales. Hand out capital for rounds 6 and 8 (50 DA scale)	March 16	March 23	March 23
-Round 5 (200 DA scale) Hypothetical	March 24	March 31	March 31
-Round 6 (50 DA scale)	March 25	April 1	April 1
-Round 7 (200 DA scale) Hypothetical	March 26	April 2	April 2
-Round 8 (50 DA scale)	March 27	April 3	April 3
Instructions for rounds 9,10, 11 and 12, hand out schedules for 1,000 DA and 5,000 DA scales. Hand out capital for round 10 (200 DA scale).	April 8	April 15	April 15
-Round 9 (1,000.00 DA scale) Hypothetical	April 12	April 19	April 19
-Round 10 (200 DA scale)	April 13	April 20	April 20
-Round 11 (5,000.00 DA scale) Hypothetical	April 23	April 27	April 27
-Round 12 (200 DA scale) Hypothetical	April 24	April 28	April 28

While the questionnaire was taken from 86 private farmers, only 68 of them took part in the experiment (26,22 and 20 in Oum Ladjoul, El-Eulma and Beni Fouda respectively). All the farmers interviewed were offered the opportunity to take part in the experiment. However, some farmers said that they would not be able to come regularly to the games due to heavy schedules or frequent absences from the experiment site. No farmer interviewed turned down the offer to participate in the experiment on the grounds that the latter was viewed as gambling. This occured despite the fact that in these rural areas, the people are very religious and sensitive to any issue which might shed the slightest doubt as to its compatibility with their own beliefs. Only one subject (in El-Eulma) started the experiment then quit after the last round of the 5 DA scale because he was told by religious "authorities" that he was gambling (this subject was 75 years old).

4.3-APPLICATION OF THE EXPERIMENT TO THE SOCIALIST SECTOR.

Decision making in the socialist sector, a priori, was expected to be less influenced by risk considerations. Risk associated with production and prices in the socialist sector is shared between the "farmers" of this sector and the government (through the Ministry of Agriculture). The Ministry provides assistance in according priority for scarce inputs (e.g. seeds, fertilizers, herbicides, etc.), credit facilities, and under particular circumstances, exemption from the payment of certain inputs (particularly new inputs) in case of low production.

The main objective of the experiment, in this sector, was to determine if the exogenous support provided by the Ministry of Agriculture leads the decision makers, i.e. the president and the director, to exhibiting risk neutrality.

In order to play the games with "socialist" farmers, the process was slightly modified. Decision making in the socialist sector is theoretically shared at different levels (workers' assembly, management committee, Ministry of Agriculture) making it impossible to use the experiment format. The decision making process rests with only two persons, the president who is the workers' legal representative and the director who is the government representative. These two jointly selected among the experiment alternatives. Of course they did not always agree, in which case they had to compromise. This exchange reflects the decision making process as it occurs on the "socialist" farms. The process sustained another minor modification; the 5 DA rounds were eliminated (the payoffs were thought to be too low to be shared by two persons). Therefore, instead of playing four rounds at the 5 DA scale, two rounds at the 10 DA scale were played with subjects of the socialist sector.

One criticism of the experimental method of eliciting farmers' risk attitudes is that the money given to the subjects to play the games is not considered by them as their own money. To overcome such criticism, the necessary money was handed out at least five days prior to the games. It was explained to each subject that it was his from that moment on and that he could use it for his daily transactions. The only requirement was that when he chose an alternative he had to have the amount required to pay back the author if a tail came up when the coin was tossed. As an example, let's assume that the subject is playing round 6. Eight days prior to the game he was given 50 DA representing the necessary capital to playing the game. The subject selects alternative C. Between the day he was given the 50 DA (round capital) and the day of the game, he is free to spend what was given to him as long as he had (when playing) the 10 DA required to give to the author should he toss a tail. Had he selected alternative A, however, he could spend the entire 50 DA. Giving capital before the games led the subjects to believe that they were playing with their own money and not a kind of "funny money". This was confirmed during the games. When subjects had to return money (i.e. when tail came up) they usually said that it was due to bad luck or that "they pulled too strongly on the string", etc. If it was pointed out to them that even when a tail came up they "gained" since they were not betting their own money, they always disagreed saying that since they had the possibility to keep the money (i.e. choosing alternative A), selecting any other alternative implied that they were in fact betting their own money.

Another common criticism of the experimental approach relates to the size of the payoffs involved. In this experiment the highest payoff at the 5 DA scale was 20 DA which is equivalent to about 1/4 of the average daily wage. The highest payoff at the 200 DA scale was 800 DA which is equivalent to an average of 10 days wages. The hypothetical payoffs are much higher (up to 20,000.00 DA which represents about 5/4 of a tractor driver annual income). Therefore, it is believed that the payoffs were quite substantial and that farmers were not making capricious choices.

CHAPTER V

RESULTS AND IMPLICATIONS

The risk preference distributions recorded during the games are reported below. The subjects had to choose among seven alternatives (A,B,C,E,F,G and H) during each game. Table 10 displays for each of the alternatives: the payoffs for a tail or a head; the corresponding risk classification[29], the range of the approximate partial risk aversion coefficient, S; and the range of the risk measure, Z.

Table 10:Risk classification (200 DA level).

Choice	Payoff in DA		Risk class	S measure	Z measure
	Tail	Head			
A	0	0	Extreme	Inf. to 7.5	1 to .80
B	-20.00	180.00	Severe	7.5 to 1.74	.80 to .66
C	-40.00	280.00	Intermediate	1.74 to .81	.66 to .50
E	-80.00	400.00	Moderate	.81 to .316	.50 to .33
F	-120.00	440.00	Inefficient	-----------	---------
G	-160.00	560.00	Slight to neut.	.316 to 0	.33 to 0
H	-200.00	600.00	Neutral to 0	0 to - Inf.	0 to -Inf.

Note: The measure Z is defined as the change of the payoff expected value over the change of the payoff standard deviation of two choices.

29- The subjects were classified as extremely risk averse (choice of alternative A) or as risk neutral to risk prone (choice of alternative H). This risk classification was first proposed by Binswanger (1977).

Following the work of Binswanger, a constant partial risk aversion function on gains and losses of the form $U = (1-S)M^{(1-S)}$ was used to approximate S. However, to circumvent the problem of raising a negative number (i.e. a loss) to a negative power ($1-S < 0$ if $S > 1$), the scale value of the game under consideration was added to all payoffs of the game, e.g. for the 200 DA level shown in table 10 a value of 200 was added to each payoff under tail and head. This procedure may be challenged on grounds that if the utility function is assumed to be over gains and losses rather than on ultimate wealth, i.e. if the asset integration hypothesis is rejected, then translating the payoffs upward by a constant (which is represented by the neutral alternative A) would not preserve the subject's true preferences. Sillers, for example, found a dissimilarity between the behavior of the "gains only" and "gains and losses" subsamples. However, in the Sillers study the difference in behavior was most likely due to some intrinsic dissimilarity of the two subsamples since the latter were found to behave quite differently even when they were selecting alternatives from the same game ("gains only" game at the 500 peso level).

The translation of the payoffs to the positive, i.e. gains, branch of the utility function does not imply that the subjects treat opportunity losses and direct losses as essentially the same. The "gains and losses" sequence was used to determine farmers' risk attitudes, i.e. what alternative they select, when faced with "real" losses. The "gains only" sequence was found to be misleading because it was difficult for the subjects to have a feeling of the notion of risk associated with it.

The appropriate way to solve for S when losses are included may be to use two different functional forms, one for the gains, as the one used here, and another one for the loss branch. However, as to date the author is not aware of any satisfactory functional form capable of modeling the loss segment.

The other measure of risk aversion (Z) shown in table 10 is the slope of the trade off curve between expected value and standard deviation of two choices.

Results of the experiment are given in tables 11-17. The tables indicate that the distributions shift to the left, i.e. more risk averse choices, as the payoff scale rises implying increasing partial risk aversion. For Beni Fouda and the Socialist Sector, for example, the percentage of choices for alternatives G and H, i.e. neutral to risk prone classes, is between 5 and 10% for the 5 DA and 50 DA levels and then goes to 0 for the 200 DA (real game), 1,000 DA and 5,000 DA levels. In El Eulma and Oum Ladjoul the percentage remains relatively constant regardless of payoff scale (except for the 5 DA level in

El Eulma and the 5,000 DA level in Oum Ladjoul). The intermediate and moderate classes together contain 50% or more of the subjects in all four sites (in Beni Fouda only 45% of the subjects chose these two classes at the 5,000 DA level). Seventy percent or more of the subjects from the Socialist Sector sample fall in these two categories. The extreme and severe risk aversion class contains between 15% of the subjects at the 5 and 50 DA levels and up to 36% (e.g. El Eulma) of the subjects for the higher payoff scales in three sites (El Eulma, Oum Ladjoul and Socialis Sector). In Beni Fouda between 25 and 50% of the individuals fall in the extreme to severe class. This high percentage occurs since at high levels of payoff the subjects switch from the intermediate and moderate class to the more conservative class, i.e. A&B. This result contrasts with the Indian experiment where at most 15% of the subjects fell in the A&B category.

In any given round, no more than 13% of the subjects selected the inefficient alternative F. In the Socialist Sector sample very few individuals selected the latter after the first three rounds. The selection of the inefficient alternative varies with the site. In the Socialist Sector, for example, 8 out of 10 rounds were played without anyone selecting alternative F (see table 14). In the other three sites only 6, 4 and 3 out of 12 rounds were played without the inefficient alternative being selected in Beni Fouda, Oum Ladjoul and El Eulma respectively.

These results show that, on average, about 70% of the farmers who took part in the experiment exhibit intermediate to moderate risk aversion. This implies that for these farmers risk aversion is a very important characteristic of their economic behavior.

For each site the homogeneity of various distributions is tested using Pearson's chi square test. The values of the test are reported below each table.

Table 11: Distribution of risk preferences by scale of payoffs (El Eulma).

round	Scale	A	B	C	E	G	H	F	Sample size
1	5 DA	2	3	9	1	0	4	3	22
2	"	2	4	5	0	2	7	2	"
3	"	2	3	9	1	0	4	3	"
4	"	1	2	8	4	4	3	0	"
5*	200DA	0	5	10	2	0	3	2	"
6	50DA	1	3	10	5	1	1	1	"
7*	200DA	1	4	9	4	1	3	0	"
8	50DA	1	2	8	7	2	2	0	"
9*	1,000DA	2	4	8	4	1	1	2	"
10	200DA	1	3	10	4	2	1	1	"
11*	5,000DA	2	6	8	2	2	1	1	"
12*	200DA	1	4	10	3	0	2	2	"

* refers to a hypothetical game.

Distributions tested:

	X^2	df	$X^2_{.05}$	Prob.
1 vs 2 vs 3 vs 4	20.80	18	28.86	.289
6 vs 8	2.41	6	12.59	.877
4 vs 6	4.33	"	"	.632
4 vs 8	1.68	"	"	.946
6 vs 10	.44	"	"	.998
4 vs 8 vs 10	5.78	12	21.03	.926
5 vs 7 vs 10 vs 12	9.50	18	28.86	.947
9 vs 10	1.36	6	12.59	.967
10 vs 11	2.22	"	"	.898
9 vs 10 vs 11	3.48	12	21.03	.991

Table 12: Distribution of risk preferences by scale of payoffs (Oum Ladjoul).

Round	Scale	A	B	C	E	G	H	F	Sample size
1	5DA	2	5	12	3	1	1	2	26
2	"	3	3	11	5	3	0	1	"
3	"	2	2	10	8	3	0	1	"
4	"	2	2	8	9	2	2	1	"
5*	200DA	2	4	12	6	1	0	1	"
6	50DA	2	2	10	7	3	0	2	"
7*	200DA	3	4	10	6	3	0	0	"
8	50DA	2	2	12	8	2	0	0	"
9*	1,000DA	3	4	10	6	3	0	0	"
10	200DA	1	5	15	3	1	0	1	"
11*	5,000DA	3	5	12	5	0	0	1	"
12*	200DA	2	4	11	6	3	0	0	"

* refers to a hypothetical game.

Distributions tested:

	X^2	df	$X^2_{.05}$	Prob.
1 vs 2 vs 3 vs4	12.31	18	28.86	.830
6 vs 8	2.44	6	12.59	.874
4 vs 6	3.03	"	"	.808
4 vs 8	3.85	"	"	.696
6 vs 10	5.55	"	"	.475
4 vs 8 vs 10	13.00	12	21.03	.368
5 vs 7 vs 10 vs 12	7.62	18	28.86	.983
9 vs 10	5.10	6	12.59	.530
10 vs 11	2.83	"	"	.829
9 vs 10 vs 11	7.80	12	21.03	.800

Table 13: Distribution of risk preferences by scale of payoffs (Beni Fouda).

Round	Scale	A	B	C	E	G	H	F	Sample size
1	5DA	2	4	9	4	0	1	0	20
2	"	1	6	4	6	1	2	0	"
3	"	3	4	5	5	0	1	2	"
4	"	2	3	6	7	0	1	1	"
5*	200DA	2	3	11	2	1	1	0	"
6	50DA	1	5	9	2	2	1	0	"
7*	200DA	1	6	6	6	1	0	0	"
8	50DA	0	7	11	1	1	0	0	"
9*	1,000DA	2	7	7	3	0	0	1	"
10	200DA	1	6	9	3	0	0	1	"
11*	5,000DA	2	7	8	2	0	0	1	"
12*	200DA	2	3	8	6	0	0	1	"

* refers to a hypothetical game.

Distributions tested:

	X^2	df	$X^2_{.05}$	Prob.
1 vs 2 vs 3 vs 4	12.60	18	28.86	.814
6 vs 8	3.19	6	12.59	.784
4 vs 6	7.20	"	"	.302
4 vs 8	12.55	"	"	.050
6 vs 10	4.28	"	"	.638
4 vs 8 vs 10	15.15	12	21.03	.233
5 vs 7 vs 10 vs 12	14.16	18	28.86	.718
9 vs 10	.66	6	12.59	.995
10 vs 11	.66	"	"	.995
9 vs 10 vs 11	1.00	12	21.03	1.00

Table 14: Distribution of risk preferences by scale of payoffs (Socialist Sector).

Round	Scale	A	B	C	E	G	H	F	Sample size
1	10DA	0	3	4	3	0	0	0	10
2	"	0	1	5	2	1	0	1	"
3*	200DA	0	2	4	2	1	0	1	"
4	50DA	0	1	5	3	1	0	0	"
5*	200DA	0	1	4	5	0	0	0	"
6	50DA	0	1	5	3	1	0	0	"
7*	1,000DA	0	3	5	2	0	0	0	"
8	200DA	0	2	4	4	0	0	0	"
9*	5,000DA	0	3	5	2	0	0	0	"
10*	200DA	0	3	3	4	0	0	0	"

* refers to a hypothetical game.

Distributions tested:

	X^2	df	$X^2_{.05}$	Prob.
1 vs 2	3.30	6	12.59	.77
4 vs 6	1.08	"	"	.98
2 vs 4	1.19	"	"	.98
2 vs 6	2.28	"	"	.89
4 vs 8	1.58	"	"	.95
2 vs 6 vs 8	3.55	12	21.03	.99
3 vs 5 vs 8 vs 10	8.43	18	28.86	.97
7 vs 8	.97	6	12.59	.98
8 vs 9	.97	"	"	.98
7 vs 8 vs 9	1.39	12	21.03	.999

Table 15: Distribution of risk preferences by site in %.

Risk class	Payoff	E.Eulma	O.Ladjoul	B.Fouda	S.Sector
	5 DA(1)	13.64	15.38	25.00	10.00
	50 DA(2)	13.64	15.38	35.00	10.00
	200 DA	18.18	23.08	35.00	20.00
(A & B)	200 DA(3)	22.73	24.36	28.38	20.00
	1,000 DA	27.27	26.92	45.00	30.00
	5,000 DA	36.36	30.77	50.00	30.00
	5 DA(1)	54.55	65.38	65.00	70.00
	50 DA(2)	68.18	76.92	60.00	85.00
	200 DA	63.64	69.23	60.00	80.00
(C & E)	200 DA(3)	57.58	65.38	65.00	73.33
	1,000 DA	63.64	61.54	50.00	70.00
	5,000 DA	45.45	65.38	45.00	70.00
	5 DA(1)	31.82	15.38	5.00	10.00
	50 DA(2)	18.18	7.69	5.00	5.00
	200 DA	13.64	3.85	0.00	0.00
(G & H)	200 DA(3)	13.64	8.97	5.00	3.33
	1,000 DA	9.09	11.54	0.00	0.00
	5,000 DA	13.64	0.00	0.00	0.00
	5 DA(1)	0.00	3.85	5.00	10.00
	50 DA(2)	0.00	0.00	0.00	0.00
	200 DA	4.55	3.85	5.00	0.00
(F)	200 DA(3)	6.06	1.28	1.66	3.33
	1,000 DA	9.09	0.00	5.00	0.00
	5,000 DA	4.55	3.85	5.00	0.00

(1) refers to game 2 for the Socialist Sector site and to game 4 for the other sites.

(2) refers to game 6 for the Socialist Sector site and to game 8 for the other sites.

(3) refers to hypothetical games 3 + 5 +10 for the Socialist Sector site and to hypothetical games 5 + 7 + 12 for the other sites.

Note: Due to rounding errors totals may not add up to 100.

Table 16: Tests of the risk distributions (real games) in the four sites

Site	A	B	C	E	G	H	F	No.Obs.
				Game # 4 (5 DA level)				
1-E.E	1	2	8	4	4	3	0	22
2-O.L	2	2	8	9	2	2	1	26
3-B.F	2	3	6	7	0	1	1	20
4-S.S	0	1	5	2	1	0	1	10
				Game # 8 (50 DA level)				
5-E.E	1	2	8	7	2	2	0	22
6-O.L	2	2	12	8	2	0	0	26
7-B.F	0	7	11	1	1	0	0	20
8-S.S	0	1	5	3	1	0	0	10
				Game # 10 (200 DA level)				
9-E.E	1	3	10	4	2	1	1	22
10-O.L	1	5	15	3	1	0	1	26
11-B.F	1	6	9	3	0	0	1	20
12-S.S	0	2	4	4	0	0	0	10

E.E = El Eulma; O.L = Oum Ladjoul; B.F = Beni Fouda; S.S = Socialist Sector.

Distributions tested:

	X^2	df
1 vs 2 vs 3 vs4	12.32	18
1 vs 2	3.81	6
1 vs 3	7.55	"
1 vs 4	4.63	"
2 vs 3	2.32	"
2 vs 4	3.36	"
3 vs 4	5.09	"
9 vs 10 vs 11 vs 12	11.71	18
9 vs 10	2.65	6
9 vs 11	4.10	"
9 vs 12	3.79	"

Distributions tested:

	X^2	df
5 vs 6 vs 7 vs 8	19.30	18
5 vs 6	2.88	6
5 vs 7	11.00	"
5 vs 8	1.69	"
6 vs 7	9.98	"
6 vs 8	.88	"
7 vs 8	4.96	"
10 vs 11	1.83	6
10 vs 12	4.58	"
11 vs 12	3.06	"

Table 17: Test of risk distributions (hypothetical games) for the 4 sites.

Site	A	B	C	E	G	H	F	No.Obs.
				Game # 9 (1,000 DA level)				
1'-E.E	2	4	8	4	1	1	2	22
2'-O.L	3	4	10	6	3	0	0	26
3'-B.F	2	7	7	3	0	0	1	20
4'-S.S	0	3	5	2	0	0	0	10
				Game # 11 (5,000 DA level)				
5'-E.E	2	6	8	2	2	1	1	22
6'-O.L	3	5	12	5	0	0	1	26
7'-B.F	2	8	7	2	0	0	1	20
8'-S.S	0	3	5	2	0	0	0	10

Distributions tested:

	X^2	df		X^2	df
1' vs 2' vs 3' vs 4'	13.46	18	5' vs 6' vs 7' 8'	12.96	18
1' vs 2'	4.51	6	5' vs 6'	5.07	6
1' vs 3'	3.26	"	5' vs 7'	3.25	"
1' vs 4'	3.48	"	5' vs 8'	3.70	"
2' vs 3'	5.85	"	6' vs 7'	2.75	"
2' vs 4'	3.35	"	6' vs 8'	1.93	"
3' vs 4'	2.02	"	7' vs 8'	2.55	"

$X^2_{.05,18} = 28.86$; $X^2_{.05,6} = 12.59$

One of the objectives of the experiment was to indicate whether or not farmers in marginal areas , e.g. Oum Ladjoul, are more risk averse than farmers in more favorable areas and, also, whether private farmers are more risk averse than those in the socialist sector. These two hypotheses are tested and reported in tables 18 (real games) and 19 (hypothetical games). Based on chi square values the hypothesis that the choice distributions are independent of the site cannot be rejected at the 5% probability level. In other words, in all four sites farmers exhibit very similar pure risk attitudes for most payoff levels. However, despite the failure of the results to show any statistical difference in the choices across sites for most payoff levels, the chi square values of 11 (distribution 5 vs 7), and 9.98 (distribution 6 vs 7) relative to a critical value of 12.59 ($X^2_{.05}$ for 6 degees of freedom) are sufficiently high to suggest a possibility of differences between private farmers in El Eulma and Oum Ladjoul and those in Beni Fouda, even if this possibility arises only for the 50 DA level (real game). On the other hand, tables 18 and 19 suggest a tendency towards intermediate and moderate risk classes on the part of socialist sector farmers, regardless of payoff scale, and a shift to the extreme and severe classes as payoff rises on the part of private farmers. Such tendencies although not statistically significant may become significant with larger samples.

Based on these results, it can be concluded that the differences (when they exist) among the four subsamples are not significant (from a statistical point of view) and are not large enough to support the existence of sharp differences in farmers' willingness to take risks due to agroecological factors (farmers in marginal areas versus farmers in more favorable areas) or to institutional factors (private versus socialist sector farmers). Undoubtedly, there exist differences in farmers' ability to take risk, particularly between private and socialist sector farmers. Such differences, however, are likely to relate to their constraint set (e.g. mechanical power, labor, input and/or credit availability, etc) rather than to their willingness to take risk per se.

5.1 IMPACT OF PAYOFF SCALE.

In this section the investigation of the subjects' responses to changes in payoffs, in terms of their partial risk aversion coefficients, within each subsample is reported.

In the course of the experiment, payoff level was varied by a factor of 40 (real games) and 1,000 (hypothetical games) whereas mean wealth (average annual gross income was used as a proxy for mean wealth) was left virtually constant. The maximum amount of money given to the subjects prior to the highest real game payoff was 200 DA which increased mean wealth by a factor of 0.004, 0.007, and 0.005 in El Eulma, Oum Ladjoul and Beni Fouda, respectively. Obviously this is negligible relative to the payoff increase.

The experimental method used in this study was intended to make inferences about the shape of the subjects' utility function and hence derive risk aversion measures, e.g. absolute, relative and partial risk aversion coefficients. In order to do so, an appropriate functional form must be selected such that the implied utility function is consistent with the general choice pattern observed in the experiment.

Past experiments (e.g. Binswanger, Sillers and Walker) have shown that, in general, subject choices tend to shift to the more risk averse alternatives (alternatives A and B) as payoff scale rises implying increasing partial risk aversion. A utility function (in gains) exhibiting such a choice pattern may be expressed as: $U(M) = 1-\exp(-aM^b)$ where $M >= 0$; $b > 0$ and $a > 0$. This function is referred to as the increasing partial risk aversion (IPRA) function (Binswanger, 1978). It has an upper asymptote (usually set at 1 for convenience, i.e., $0 <= b <= 1$) and for the strict inequality $0 < b < 1$ the function is everywhere concave. The first derivative of the IPRA is:

$\partial U(M)/\partial M = U' = [-\exp(-aM^b)](-abM^{b-1})$ implying $U' > 0$. Recall $e^x > 0$ for all x and $e^{-x} = 1/e^x > 0$. The second derivative is: $\partial^2 U(M)/\partial M^2 = [-\exp(-aM^b)(-abM^{b-2})(b-1)] + [-\exp(-aM^b)](-abM^{b-1})^2 = U'' < 0$. Partial risk aversion $(S) = -MU''/U' = abM^b + 1 - b$. For $M = 0$, $S = 1-b$ implying S is less than 1 (recall $b <= 1$). Thus, "b" determines the initial partial risk aversion whereas "a" shows how fast S rises with M , for a given b.

The use of the IPRA function for deriving risk measures, however, is very cumbersome. It would necessitate equations in at least two rounds at different payoff levels, i.e. utility functions need to be fitted to two indifference points at two different payoff scales games in order to define two equations which, jointly could be solved for a and b. The IPRA limitations are best explained by Sillers as follows:

1-"It requires the assignment of unique values of the parameters a and b to each observed experimental choice out of a whole range of parameter pairs which could support the observed preference."

2-"Any observed choice in a given round may have been subject to transient influences, which in turn creates a problem as to which pair of observed choices to use in computing individual risk preference parameters." (appendix pp:173-79).

In order to overcome the problems associated with the use of the IPRA function, it is possible to assume that a subject's utility function can be approximated by a constant partial risk aversion (CPRA) function. The latter is a power function of the form $U(M)=(1-S)M^{(1-S)}$. Given this functional form the first derivative is: $\partial U(M)/\partial M = (1-S)^2 M^{-S} = U' > 0$; and the second derivative is: $\partial^2 U(M)/\partial M^2 = -S(1-S)^2 M^{-S-1} = U''$. Partial risk aversion is defined as $M(-U''/U') = M[S(1-S)^2 M^{-S-1}/(1-S)^2 M^{-S}] = S$, implying that partial risk aversion S is independent of payoff scale.

Using the CPRA function the partial risk aversion S is derived by solving the equation for indifference (equal expected utility) between two neighboring alternatives. As explained earlier the "gains and losses" sequence used in this study was designed to account for choices including losses because it appeared that the "gains only" sequence initially used when the experiment started was quite confusing to the subjects and somehow misleading. In order to solve for S using the CPRA function with a "gains and losses" sequence it was necessary to transform all the possible outcomes of all the alternatives to positive values as previously explained. Once the transformations were completed it became possible to solve for S as follows: In the tenth round (200 DA scale), for example, the expected utility of alternative B may be expressed as: $[(1-S)/2](80^{(1-S)} + 380^{(1-S)})$ whereas that of alternative C may be expressed as $[(1-S)/2](160^{(1-S)} + 480^{(1-S)})$; setting both expressions equal allows solving for S. However, this does not yield a unique value of the parameter S but rather an interval value (see table 10). In order to get a unique value of S for each alternative the arithmetic mean of endpoints may be assigned to each alternative. However (as shown in table 10), the more risk averse alternatives , particularly alternatives A and B, have a wider interval whereas at the other extreme the alternatives have a very narrow range. Assigning the arithmetic mean under such circumstances would be misleading since it will put more weight on the risk averse alternatives. As a result, the geometric mean of endpoints was used instead to calculate a unique value for S. For the other risk measure shown on table 1, i.e. Z, the arithmetic mean of endpoint values was assigned since the ranges are relatively identical.

For alternative H both risk measures were given the value of zero. Only one person (at El Eulma) selected the alternative at high payoff levels. Therefore, assigning the value of zero to S and Z for alternative H appears reasonable. In subsequent logarithmic transformations, however, this value was arbitrarily set to 0.005. For alternative A the upper bound is infinity whereas the lower bound is 7.5 (for S). However, even at high payoffs few subjects chose alternative A (7.6% at El Eulma, 10.25% at Oum Ladjoul, 8.33% at Beni Fouda and 0% for the Socialist Sector on average for the 200, 1,000 and 5,000 DA levels). It is , therefore, fair to assume that the S value for this alternative would not greatly exceed the lower bound value, i.e 7.5. As a result the unique value assigned to alternative A was obtained by inflating the lower bound value by a factor of .01 yielding the value 8.25. The implied unique values used in subsequent calculations are reported below.

Alternative	S value	Z value
A	8.25	.90
B	3.61	.73
C	1.18	.58
E	.51	.415
F	----	----
G	.158*	.165
H	0.00**	0.00**

* This S value is equal to the arithmetic mean of the interval because its lower bound was zero.
** For logarithmic transformations the value of 0.005 was used instead.

Table 18: Effect of payoff scale on partial risk aversion (El Eulma).

rounds	Scale	Mean S small scale	Mean S large scale	t	df
4 vs 8	5 vs 50 DA	1.25	1.30	-.099	42
4 vs 10	5 vs 200 DA	1.25	1.53	-.504	"
4 vs 9	5 vs 1,000 DA	1.25	1.98	-1.14	"
4 vs 11	5 vs 5,000 DA	1.25	2.24	-1.56	"
8 vs 10	50 vs 200 DA	1.30	1.53	-.408	"
8 vs 9	50 vs 1,000 DA	1.30	1.98	-1.06	"
8 vs 11	50 vs 5,000 DA	1.30	2.24	-1.48	"
10 vs 9	200 vs 1,000 DA	1.53	1.98	-.707	"
10 vs 11	200 vs 5,000 DA	1.53	2.24	-1.12	"
9 vs 11	1,000 vs 5,000DA	1.98	2.24	-.377	"

$t_{.05,42} = -1.67$

Scale	Average S	% increase in average S
5 DA	1.25	
		4%
50 DA	1.30	
		17%
200 DA	1.53	
		29%
1,000 DA	1.98	
		13%
5,000 DA	2.24	

Table 19: Effect of payoff scale on partial risk aversion (Oum Ladjoul).

rounds	Scale	Mean S small scale	Mean S large scale	t	df
4 vs 8	5 vs 50DA	1.48	1.62	-.238	50
4 vs 10	5 vs 200DA	1.48	1.77	-.539	"
4 vs 9	5 vs 1,000DA	1.48	2.09	-.940	"
4 vs 11	5 vs 5,000DA	1.48	2.30	-1.28	"
8 vs 10	50 vs 200DA	1.62	1.77	-.282	"
8 vs 9	50 vs 1,000DA	1.62	2.09	-.731	"
8 vs 11	50 vs 5,000DA	1.62	2.30	-1.07	"
10 vs 9	200 vs 1,000DA	1.77	2.09	-.537	"
10 vs 11	200 vs 5,000DA	1.77	2.30	-.909	"
9 vs 11	1,000 vs 5,000DA	2.09	2.30	-.307	"

$t_{.05,50} = -1.67$

scale	Average S	% increase in average S
5 DA	1.48	
		9%
50 DA	1.62	
		9%
200 DA	1.77	
		18%
1,000 DA	2.09	
		10%
5,000 DA	2.30	

Table 20: Effect of payoff scale on partial risk aversion (Beni Fouda).

Rounds	Scale	Mean S small scale	Mean S large scale	t	df
4 vs 8	5 vs 50DA	1.92	1.94	-.034	38
4 vs 10	5 vs 200DA	1.92	2.12	-.295	"
4 vs 9	5 vs 1,000DA	1.92	2.60	-.904	"
4 vs 11	5 vs 5,000DA	1.92	2.63	-.954	"
8 vs 10	50 vs 200DA	1.94	2.12	-.355	"
8 vs 9	50 vs 1,000DA	1.94	2.60	-1.10	"
8 vs 11	50 vs 5,000DA	1.94	2.63	-1.17	"
10 vs 9	200 vs 1,000DA	2.12	2.60	-.706	"
10 vs 11	200 vs 5,000DA	2.12	2.63	-.761	"
9 vs 11	1,000 vs 5,000DA	2.60	2.63	-.045	"

$t_{.05,38} = -1.68$

Scale	Average S	% increase in average S
5 DA	1.92	
		1%
50 DA	1.94	
		9%
200 DA	2.12	
		22%
1,000 DA	2.60	
		1%
5,000 DA	2.63	

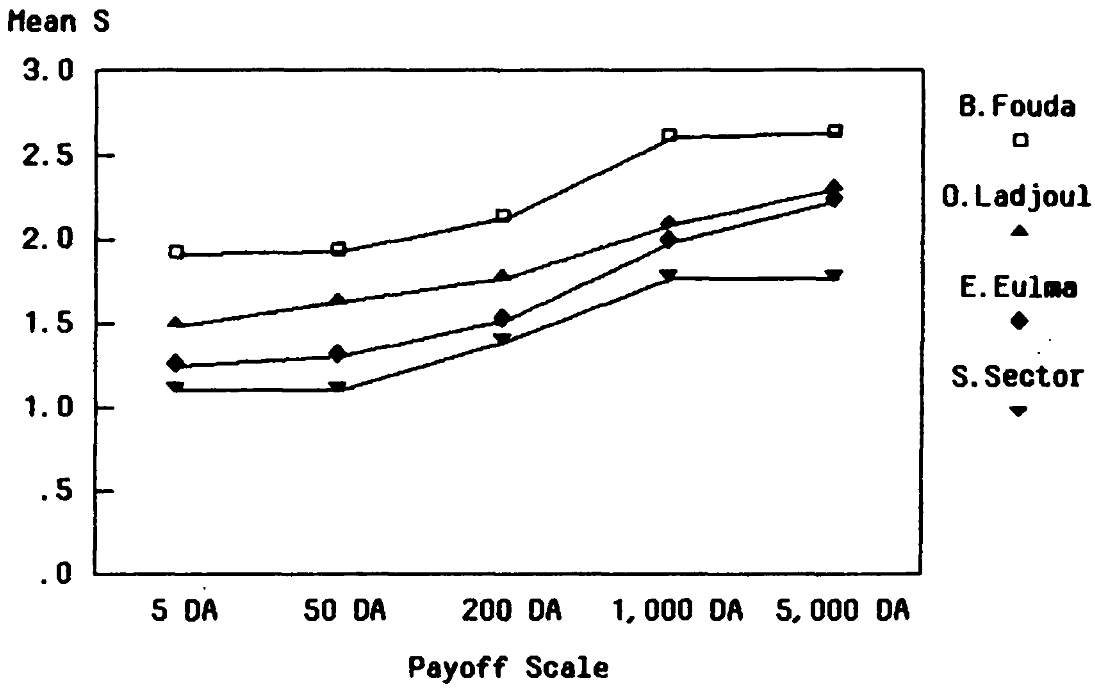
Table 21: Effect of payoff scale on partial risk aversion (S. Sector).

Rounds	Scale	Mean S small scale	Mean S large scale	t	df
2 vs 6	10 vs 50DA	1.12	1.12	0.00	18
2 vs 8	10 vs 200DA	1.12	1.39	-.57	"
2 vs 7	10 VS 1,000DA	1.12	1.77	-1.28	"
2 vs 9	10 vs 5,000DA	1.12	1.77	-1.28	"
6 vs 8	50 vs 200DA	1.12	1.39	-.57	"
6 vs 7	50 vs 1,000DA	1.12	1.77	-1.28	"
6 vs 9	50 vs 5,000DA	1.12	1.77	-1.28	"
8 vs 7	200 vs 1,000DA	1.39	1.77	-.67	"
8 vs 9	200 vs 5,000DA	1.39	1.77	-.67	"
7 vs 9	1,000 vs 5,000DA	1.77	1.77	0.00	"

$t_{.05,18} = -1.73$

Scale	Average S	% increase in average S
10 DA	1.123	
		0%
50 DA	1.12	
		24%
200 DA	1.39	
		27%
1,000DA	1.77	
		0%
5,000DA	1.77	

Figure 7: Effect of payoff scale on mean partial risk aversion by site



Increase in mean S from 5 DA to 5,000 DA

E.Eulma : 79%	B Fouda : 36%
O.Ladjoul : 55%	S.Sector : 58%

Tables 18 through 21 show that average partial risk aversion increases as payoff scale rises. For example, it increases from 1.25 to 1.53 in El Eulma, from 1.48 to 1.77 in Oum Ladjoul, from 1.92 to 2.12 in Beni Fouda and from 1.12 to 1.39 in the Socialist Sector between the 5 and 200 DA levels, an increase of about 22, 19, 9 and 24% respectively in the four sites. These increases, of course, are based on averages which might not reflect individual behavior, i.e. for subjects who usually choose intermediate or moderate risk aversion alternatives (alternative C or E) at the low payoff scale and extreme or severe risk aversion alternatives (alternative A or B) at the higher payoff scale, the increase in S is not as large as for those who usually select higher risk alternatives (alternative G or H) at low payoff scale and low risk alternatives (alternative A or B) at high payoff scale. The observed shift in S as a result of a higher payoff seems, therefore, to suggest that a utility function characterized by an increasing partial risk aversion would be more appropriate in representing individual behavior than the constant partial risk aversion (CPRA) function. However, as shown in tables 18 through 21, the increase in S as payoff scale rises is not statistically significant, even between the 5 and 5,000 DA levels, in all four sites and for all the samples tested.

Under such circumstances, the question is raised whether the CPRA function indeed represents a close approximation of the IPRA function. One way to find out would be to derive risk measures, e.g. S, through the IPRA function and then compare them to those derived via the CPRA function. The IPRA function $U(M) = 1-\exp(-aM^b)$ implies a partial risk aversion $S = 1-b+abM^b$, as indicated earlier. The parameters a and b can be solved by using indifference at two game levels, e.g. if an individual is indifferent between alternatives B and C at the 50 DA level then it is possible to form the following equation: $\exp(-a45^b) + \exp(-a95^b) = \exp(-a40^b)+\exp(-a120^b)$. On the other hand, if this individual is also indifferent between alternatives A and B at the 200 DA level, then a similar equation can be defined using the respective outcomes under tail and head. Seven such pairs of equations can be formed for any two payoff scales. An iterative computer program can then be used to solve for a and b. This is usually a very tedious procedure. Since the shift in S as payoff scale rises was not found to be significant (for the samples studied) it was assumed that the CPRA function does indeed appropriately represent individual behavior, i.e. the CPRA function is an acceptable approximation of the IPRA for this study.

5.2-RELATION OF PARTIAL RISK AVERSION TO FARMERS' CHARACTERISTICS.

Another test of interest is whether there exists any relation between farmers' socio-economic characteristics and their risk aversion coefficients. The personal characteristics that will be considered are presented in tables 23 and 24. Regressions are performed with S as dependent variable using the semilog form lnS.

Table 22: Definition and expected signs of the explanatory variables used in the regressions.

Explanatory variable	Definition	Exp. sign
Age	In years of the decision maker*	+
Schooling	In years of the decision maker	-
Work. age child.	Ratio of working age children to total children in the household	-
Off farm income	Percentage of total income generated through off farm job by the decision maker and/or working age children	-
An. gross inc.	In 1,000 of DA	-
Herd size	Number of sheep heads owned by the decision maker	?**
Area cropped	Number of hectares cropped in 1982 by the decision maker	?**
Tractors	Number of tractors owned by the decision maker	-
Tv and/or radio	Dummy (0 if none, 1 otherwise)	-
Luck	Total wins minus total losses in previous games	-

* By decision maker it is meant the family member who makes the farm decisions. The decision maker is not necessarily the oldest member of the household. The decision maker is the household member who took part in the experiment.

** The question mark refers to an undeterminate sign.

Throughout the literature it is usually assumed that old and uneducated farmers will exhibit a higher aversion to risk than younger farmers. The latter may be more willing to take risks due to lower dependency ratios (fewer children to support) and other socio-psychological factors. As a result, age is expected to be positively correlated with partial risk aversion.

Area cropped is also considered . It seems reasonable to assume that as the area cropped increases so does the probability of securing household consumption needs, ceteris paribus. However, one may argue that as area cropped increases so does the magnitude of potential loss due to weather variability. If this is true, it implies a higher risk associated with a larger area. As a result, the expected sign of the cropped area cannot be determinated a priori, i.e., it could be negative or positive.

Herd size is considered as an important risk mitigator in the area and hence should be expected to be negatively correlated with partial risk aversion. However, when feed shortages occur (as a result of a drought, for example) a smaller herd is better. In this case herd size should be expected to be positively correlated with the risk measure. Again, the sign associated with the coefficient of this variable cannot be determined a priori.

Farmers owning one or more tractors are expected to cultivate their land on time and may be able to do custom work for those who do not own a tractor. This variable is therefore considered as a source of income and is expected to be negatively related to partial risk aversion.

Off farm income (by the decision maker and/or by one or more working age children) is expected to lessen the effect of yield variability on the decision maker's behavior, thereby, allowing him to take more risk without jeopordizing the survival of his household. In Algeria cereal prices are fixed. Thus, uncertainty comes only from yield variability. In the absence of price stabilization, yields and prices should be expected to move in opposite directions. Such a pattern of negative correlation (between yield and prices) will tend to stabilize farm income in the presence of highly variable yields due to low and erratic precipitation and high risk of late frost and/or sirocco. If, however, the yield-prices negative relationship is broken (through price stabilization schemes, for example), the likely effect would be the destabilization of farm income. As a result, off farm income is an important device for mitigating farm income instability.

The "working age children" variable is defined as the ratio of working age children (children of age 15 and higher who are currently working on or outside the farm) to the total number of children. These working children generate a supplementary income stream which is expected to increase the willingness of the decision maker to take risk, hence, the expected negative sign associated with this variable.

For the category of decision makers who took part in the experiment (excluding the Socialist Sector subsample) land and livestock (mainly sheep) represent, on average, more than 60% of their physical assets whereas farm equipment (mainly tractors) and/or transportation equipment (mainly light trucks) represent more than 20%. Since land (through area cropped), herd size and the number of tractors have all been included individually in the regression, annual gross income from the farm is used as a proxy for the remainder of gross wealth. Consistent with the bulk of the literature, this variable is expected to have a negative sign.

Education also may be considered as another source of wealth (human capital) and therefore is expected to be negatively correlated with partial risk aversion. Schooling (number of years the decision maker spent in school) is used in the regression as a proxy for this form of wealth.

Possession of television and/or radio sets is important for the transmission and communication of agricultural information to remote areas. Like formal schooling they also help educate farmers as to how to interact with their agroecological and socioeconomic environment. As a result it is assumed that farmers who do not have access (own) to either are likely to be more risk averse than those who do. This variable, used as a dummy, is also expected to have a negative sign.

Technically one should not expect any effect of luck during the previous games on the subject's subsequent alternative choices since each alternative payoff is randomly determined (by the toss of a coin). However, people in the research area exhibit an acute sense of fatalism, i.e. a positive outcome in the previous game is usually interpreted as God's willingness to reward the subject. As a result this variable is expected to have an impact on the subjects' choices, i.e. the luckier the subject was in previous games the more inclined he will be to choose alternatives with higher payoff (more risky alternatives). A value of 1, -1 and 0 is associated with a win, a loss and choice of alternative A respectively. For example, if a subject playing game number 4 (5 DA level) has won during games 1 and 2 and lost during game 3 then the "luck" variable would be equal to 1 + 1 - 1 = 1.

Table 23: Mean and coefficient of variation of variables used in regressions.

Variable	E.Eulma Mean	E.Eulma Cv	O.Ladjoul Mean	O.Ladjoul Cv	B.Fouda Mean	B.Fouda Cv
Age	49.54	27.3	47.07	31.5	52.35	22.6
Schooling	1.40	156.4	1.67	203.5	.60	250.0
Work age child	.153	130.0	.115	133.9	.254	95.6
Herd size	37.27	86.6	48.07	82.6	33.55	135.0
Off farm inc.	20.00	146.3	18.26	155.2	14.50	115.1
Area cropped	15.79	118.0	27.25	85.8	18.47	60.2
Tractors	.272	202.2	.423	152.0	.400	149.5
Gross income	49.09	143.0	27.78	63.8	38.80	94.7
Tv and/or radio	.727	62.6	.807	49.7	.807	43.0
Luck 4	.000	---	.269	551.6	-.350	-406.8
Luck 8	-.590	-284.7	.614	347.8	-.200	-1198.5
Luck 10	-.363	-655.9	.230	1168.2	.000	-----
Luck 9	-.545	-365.6	.423	543.7	.100	2595.
Luck 11	.045	4920.0	.423	652.2	-.200	-1293.5

Note: The variables "off farm income" and "luck" were subsequently dropped from the regressions.

The regression results for the whole sample as well as for the three subsamples are reported in tables 24 through 28. These results show that for round 4 (5 DA level) none of the coefficients are significant (except for area in the E.Eulma subsample). It is possible that at this low payoff level the prospects under each alternative are not high enough (compared to outcomes induced by farming decisions) to capture the effect of the explanatory variables on risk aversion.

Another observation worth mentioning is the weak and, generally, inconsistent relationship between lnS and gross annual income. In general, gross income was found to be positively correlated with lnS. This variable may not be very reliable due to measurement[30] errors. One way to circumvent such a problem would be to use an instrumental variable in place of gross income. Unfortunately no appropriate instrument could be found. Therefore, this variable was dropped from the regression model. In the model gross income was used as a proxy for wealth. However, other variables, e.g. schooling, area cropped, tractor and herd size also can be considered as proxies for wealth. Also working age children constitute an important contribution to the household annual gross

[30]- As explained previously, very few private farmers keep any farm records. As a result, the annual gross income data are probably not error free. These data are based on the ability of farmers to recall the past expenses and entries(sales, off farm income, etc). Data collected under such conditions are likely to be plagued by measurement errors.

income and as such is assumed to capture part of the effect of wealth on risk aversion. As expected this variable ,i.e. working age children is, generally, negatively correlated with risk aversion although its estimated coefficient is not always significant.

Age has the expected sign (except in O.Ladjoul and B.Fouda at the 5 DA level). Its estimated coefficient is usually significant.

The regression coefficient of the dummy site 1 ,i.e. E.Eulma, shows that there is a significant difference in lnS between E.Eulma and B.Fouda at the 50 and 200 DA levels. The respective coefficients associated with both dummies,i.e. site 1 and site 2 show the average change in lnS associated with a change from E.Eulma and O.Ladjoul sites to B.Fouda. According to these results, lnS at the 50 and 200 DA levels is significantly lower in E.Eulma than in B.Fouda, whereas there is no significant difference between them at the other levels nor is there any significant difference between O.Ladjoul and B.Fouda at any game level.

The estimated coefficient for the variable "schooling" is not always consistent with expectations. However, the only instance where the coefficient of this variable was significant (round 8 whole sample with gross income included) it had the expected sign. The t value associated with the coefficient of this variable was usually less than 1.

Herd size is usually positively related to risk aversion; however, it is not always significant. Whenever there is a negative relationship between this variable and lnS (O.Ladjoul and B.Fouda) its estimated coefficient was generally not significant. The dichotomy in signs was expected, as previously explained due to the high risk involved with large herds during drought years. However, if this were the case, most of the positive signs should be found in the O.Ladjoul subsample which is characterized by a high drought risk. The results are otherwise. One possible explanation is that, in contrast to E.Eulma, sale of livestock in O.Ladjoul and B.Fouda is used as the primary means of risk adjustment (see the adjustment to risk section in the appendix) as a result of fewer off farm job opportunities in both sites.

Area cropped is almost always negatively related to risk aversion in the whole sample and the E.Eulma and O.Ladjoul subsamples and is usually significant. However, a very intriguing result is that in the B.Fouda subsample, unlike the other subsamples, the estimated coefficients of this variable (except at the 5 DA level) have positive signs, i.e. the larger the area cropped the more risk averse the farmer tends to become. However, the coefficient is never significant. This is explained by the difficult and uneven topography (less than 20% of total area is cropped at this site as indicated in table 3) characterizing this site which makes it difficult to mechanize (particularly planting and harvesting). Therefore, for this site it is reasonable to expect increasing the area cropped to have a positive effect on risk aversion. With little mechanization it becomes riskier to crop large areas.

Contrary to expectations, the number of tractors owned did not always reduce risk aversion (the estimated coefficient of this variable, however, was never significant). In the E.Eulma site this variable is positively related to lnS (for all payoff levels). Its lack of significance may be due to the small percentage of E.Eulma farmers who own tractors (less than 28% of E.Eulma private farmers own a tractor whereas more than 40 and 42% of private farmers own one at B.Fouda and O.Ladjoul, respectively).

The radio/Tv variable (contrary to expectations) has a coefficient which is generally positively correlated with lnS, except for the E.Eulma site where the relation is as expected, i.e. negative correlation. At E.Eulma, the t value associated with the estimated coefficient of this variable at high payoff levels (200, 1,000 and 5,000 DA) was quite high whereas it is never significant in the other sites. A priori, it was assumed that this variable would likely increase the farmers' ability (through communication and information) to apply new farming techniques. E.Eulma is the largest urban center of the daira where most off farm job opportunities are found and where most of the government agencies (agricultural and otherwise) are located. Therefore, it is assumed that information plays a much greater role in this site than in the other two.

The explanatory power of the estimated regression (R^2) is not very high. Age, the dependency ratio (working age children) and schooling are (usually) expected to be strongly correlated with risk aversion. In this study, however, the effect of these variables is mixed. Age tends to consistently and significantly (particularly at high payoff levels) increase aversion to risk. The number of working age children consistently (except in B.Fouda), though not significantly, reduces risk aversion. Schooling is neither consistently nor significantly negatively correlated with risk aversion. The result is not surprising since school years mean is only 1.40, 1.67 and .60 with a coefficient of variation of 156, 203 and 250 in El Eulma, Oum Ladjoul and Beni Fouda, respectively. Among the 68 subjects who took part in the experiment only 18 individuals had any education at all. Among the latter only 6, i.e. less than 9% had gone beyond elementary school. Therefore, at least for this particular sample, schooling per se should not be expected to be significant.

The effect of the other variables of the model on partial risk aversion is not significant and/or consistent and very often seems to be site dependent, i.e. the effect differs across sites. Herd size tends to significantly increase aversion to risk, particularly in E.Eulma, but not always consistently, e.g. O.Ladjoul. Area cropped tends to significantly and consistently reduce risk aversion, except in B.Fouda. The number of tractors owned neither significantly nor consistently explains the variation in risk aversion. Radio and/or Tv reduces aversion to risk (consistently and significantly) in E.Eulma only.

Farmers in E.Eulma tend to be less risk averse than those in B.Fouda. However, this does not necessarilly imply any drastic difference in farmers' willingness to take risk in the two sites. The difference in risk aversion likely is the result of the combined effect of factors such as topography and isolation (relative to urban centers) on the constraint set.

Other variables which have contradicting signs and/or which have no significant effect on risk aversion and which were dropped from the model are gross annual income, off farm income and luck.

According to the results, other sets of explanatory variables should be tried in order to increase the explanatory power of the model. This would require additional data, however, which are not readily available and whose gathering is likely to be extremely demanding (time and personnel). In the absence of such additional data, one may be tempted to criticize the method used for measuring farmers risk attitudes on grounds that it does not capture true risk attitudes of the farmers of the area when in reality the failure occurs because of the data base.

Another possible explanation of the poor explanatory power of the model is the unreliability of the data used. Except for the age and schooling variables, all the others are suspect. As indicated earlier, farmers usually declare far below their current area cropped, herd size or even number of tractors owned. The quasi nonexistence of farm records makes it even more difficult to have reliable approximate yields, costs, consumption, etc.

Finally, the likelihood of a two way causality , i.e., simultaneous equations systems, should not be overlooked. Model misspecification is, therefore, a potential explanation of the weakness of the results obtained in this analysis.

Table 24: Regression of socioeconomic characteristics on partial risk aversion (whole sample with gross annual income included).

scale & round	5 DA	50 DA	200 DA	1,000 DA	5,000 DA
Variables	Round 4	Round 8	Round 10	Round 9	Round 11
Age	.0110	.0195	.025**	.0192	.0222
	(.0208)	(.0130)	(.0117)	(.0140)	(.0133)
Schooling	-.0523	-.1168*	-.0050	.0295	.0215
	(.1072)	(.0671)	(.0603)	(.0721)	(.0683)
Work age child	-1.2008	-2.386**	-.6801	-.4431	-.1851
	(1.544)	(.9668)	(.8684)	(1.0388)	(.9841)
Herd size	.00018	.0073	-.0026	.00069	.00083
	(.0075)	(.0047)	(.0042)	(.0051)	(.0048)
Area cropped	-.00016	-.0154	-.0085	-.0207*	-.0217*
	(.0180)	(.0112)	(.0101)	(.0121)	(.0114)
Tractor	-.2777	-.3963	-.2464	.2512	.2733
	(.5206)	(.3259)	(.2928)	(.3502)	(.3318)
Site 1	-.8883	-1.3194**	-.7664**	-.6584	-.6248
	(.6223)	(.3896)	(.3500)	(.4186)	(.3966)
Site 2	-.3887	-.4361	.2224	-.3287	-.0029
	(.6082)	(.3808)	(.3421)	(.4092)	(.3877)
Radio/Tv	.5755	.2190	.0061	-.1925	-.0548
	(.5992)	(.3751)	(.3369)	(.4031)	(.3819)
Gross income	.0045	.0040	.0034	-.0013	.0014
	(.0055)	(.0034)	(.0031)	(.0037)	(.0035)
Constant	-.8763	-.0733	-.5074	.2104	-.2023
R^2	.0738	.2929	.1962	.1300	.1506
F	.454	2.361	1.361	.851	1.010
No.of obs.	68	68	68	68	68

Dependent variable = lnS
$t_{.10,58} = 1.672$
$t_{.05,58} = 2.00$
$F_{.10,9,60} = 1.74$
Standard errors in parenthesis.
* = Significant at the 10% level; ** = Significant at the 5 % level.

Table 25: Regression of socioeconomic characteristics on partial risk aversion (whole sample with gross income not included).

Scale & round Variables	5 DA Round 4	50 DA Round 8	200 DA Round 10	1,000 DA Round 9	5,000 DA Round 11
Age	.0098	.0184	.0241*	.0195	.0218
	(.0207)	(.0131)	(.0117)	(.0139)	(.0131)
Schooling	-.0375	-.1036	.0062	.0252	.0260
	(.1054)	(.0664)	(.0596)	(.0706)	(.0669)
Work age child	-1.0102	-2.2165**	-.4960	-.4994	-.1273
	(1.5226)	(.9591)	(.8604)	(1.0194)	(.9660)
Herd size	.0011	.0081*	-.0019	-.0002	.0011
	(.0074)	(.0047)	(.0042)	(.0050)	(.0047)
Area	-.0012	-.0163	-.0093	-.0204*	-.0220*
	(.0179)	(.0113)	(.0101)	(.0120)	(.0113)
Tractor	-.1984	-.3257	-.1865	.2279	.2973
	(.5103)	(.3214)	(.2883)	(.3416)	(.3237)
Site 1	-.8242	-1.2623**	-.7180**	-.6774	-.6053
	(.6157)	(.3878)	(.3479)	(.4122)	(.3906)
Site 2	-.4371	-.4792	-.0142	-.3144	-.0176
	(.6038)	(.3803)	(.3412)	(.4042)	(.3830)
Radio/Tv	.6555	.2902	.0665	-.2161	-.0305
	(.5897)	(.3714)	(.3332)	(.3948)	(.3741)
Constant	-.8088	-.0131	-.4563	.1904	-.1818
R^2	.0627	.2758	.1788	.1280	.1483
F	.431	2.454	1.403	.946	1.122
No. of obs.	68	68	68	68	68

Dependent variable = lnS
$t_{.10,59} = 1.672$
$t_{.05,59} = 2.00$
$F_{.10,8,60} = 1.77$
Standard errors in parenthesis.
* = Significant at the 10% level; ** = Significant at the 5% level.

Table 26: Regression of socioeconomic characteristics on partial risk aversion (E.Eulma subsample).

Scale & round	5 DA	50 DA	200 DA	1,000 DA	5,000 DA
Variables	Round 4	Round 8	Round 10	Round 9	Round 11
Age	.0742	.0540	.0922**	.0637**	.0712**
	(.0469)	(.0373)	(.0239)	(.0286)	(.0293)
Schooling	.1396	-.0598	.1044	.0775	.1982
	(.2364)	(.1881)	(.1206)	(.1442)	(.1474)
Work age child	-4.7710	-6.0882**	-4.5700**	-2.4736	-3.0535
	(3.2105)	(2.5547)	(1.6377)	(1.9585)	(2.0027)
Herd size	.0116	.0157	.0211*	.0297**	.0370**
	(.0208)	(.0166)	(.0106)	(.0127)	(.0130)
Area cropped	-.1025**	-.0619*	-.0946**	-.0871**	-.1085**
	(.0439)	(.0349)	(.0224)	(.0268)	(.0274)
Tractor	.7035	.3811	.7513	.0301	.4133
	(1.0469)	(.8330)	(.5340)	(.6386)	(.6530)
Radio/Tv	-1.7534	-.2339	-1.9451**	-2.2008**	-2.4930**
	(1.2715)	(1.0117)	(.6486)	(.7756)	(.7931)
Constant	-1.7821	-1.8812	-2.3632	-1.0128	-1.2377
R^2	.3659	.4268	.6613	.5729	.6024
F	1.154	1.489	3.905	2.682	3.031
No. of obs.	22	22	22	22	22

Dependent variable = lnS
$t_{.10,14} = 1.761$
$t_{.05,14} = 2.145$
$F_{.10,7,14} = 2.16$
Standard errors in parenthesis.

Table 27: Regression of socioeconomic characteristics on partial risk aversion (O.Ladjoul subsample).

Scale & round	5 DA	50 DA	200 DA	1,000 DA	5,000 DA
Variables	Round 4	Round 8	Round 10	Round 9	Round 11
Age	-.0183	.0213	.0295*	.0118	.0297*
	(.0358)	(.0183)	(.0154)	(.0240)	(.0168)
Schooling	-.1219	-.0988	.0108	.0608	.0380
	(.1603)	(.0818)	(.0690)	(.1076)	(.0752)
Work age child	1.6682	-1.0320	-.1406	-.2734	-.5506
	(3.0973)	(1.5799)	(1.3332)	(2.0793)	(1.4531)
Herd size	-.0022	.0107	.0022	-.0027	-.0008
	(.0144	(.0074)	(.0062)	(.0097)	(.0068)
Area cropped	.0353	-.0132	-.0070	-.0245	-.0242*
	(.0250)	(.0128)	(.0108)	(.0168)	(.0017)
Tractor	-.0626	-.6513	-.6448	.5603	.1724
	(.9710)	(.4953)	(.4180)	(.6519)	(.4556)
Radio/Tv	.5883	.1786	-.0360	.0809	.2817
	(1.042)	(.5317)	(.4487)	(.6998)	(.4891)
Constant	-.9323	-.7516	-.7521	-.1095	-.6696
R^2	.1596	.2999	.3152	.1488	.3273
F	.488	1.101	1.184	.450	1.251
No. of obs.	26	26	26	26	26

Dependent variable = lnS
$t_{.10,18} = 1.734$
$t_{.05,18} = 2.101$
$F_{.10,7,18} = 2.04$
Standard errors in parenthesis.
* = Significant at the 10% level; ** = Significant at the 5% level.

Table 28: Regression of socioeconomic characteristics on partial risk aversion (B.Fouda subsample).

Scale & round	5 DA	50 DA	200 DA	1,000 DA	5,000 DA
Variables	Round 4	round 8	Round 10	Round 9	Round 11
Age	-.0011	.0206	.0114	.0358	.0171
	(.0408)	(.0251)	(.0188)	(.0261)	(.0215)
Schooling	.3137	.0426	.1649	.0217	.1620
	(.2803)	(.1726)	(.1291)	(.1793)	(.1474)
Work age child	-1.3789	-.6417	1.3311	-.0644	1.3540
	(2.5163)	(1.5496)	(1.1587)	(1.6096)	(1.3232)
Herd size	.00941	.0017	-.0110*	-.0104	-.0062
	(.0121)	(.0075)	(.0056)	(.0077)	(.0064)
Area cropped	-.0391	.0300	.0387	.0476	.0450
	(.0433)	(.0266)	(.0199)	(.0277)	(.0227)
Tractor	.4903	-.2624	-.0571	.0056	.4559
	(.8844)	(.5446)	(.4072)	(.5657)	(.4651)
Radio/Tv	1.8958	-.3521	.7141	.2728	.3980
	(1.2155)	(.7486)	(.5597)	(.7775)	(.6392)
Constant	-1.2582	-.7374	-1.5321	-2.0112	-1.8124
R^2	.4024	.1569	.5444	.3606	.5268
F	1.154	.319	2.048	.967	1.909
No. of obs.	20	20	20	20	20

Dependent variable = lnS
$t_{.10,12} = 1.782$
$t_{.05,12} = 2.179$
$F_{.10,7,12} = 2.28$
Standard errors in parenthesis.
* = Significant at the 10% level; ** = Significant at the 5% level.

CHAPTER VI

USE OF THE DERIVED RISK COEFFICIENTS IN A RISK PROGRAMMING MODEL

6.1- A BRIEF REVIEW OF OPTIMIZATION AND PROGRAMMING MODELS.

In economics, equality constrained optimization problems are solved through classical Lagrangian techniques. Given the problem:

Max F(X)

S.T. G(X) = B

where X is a column vector of decision variables; G is a matrix of constraint functions and B a column vector of constant resource endowments.

The optimization of this problem is obtained through the Lagrangian method:

$L(X,\lambda) = F(X) - \lambda[G(X) - B]$, where Š is a row vector of Lagrangian multipliers. As stated the Lagrangian function is defined as the objective function minus the inner product of the "Š" row vector and column vector difference between the constraints function and the constant resource endowments.

Optimality conditions of $L(X,\lambda)$ with respect to X and are:

$$\partial L/\partial X\ (X^0,\lambda^0) = \partial F(X)/\partial X\ (X^0) - \lambda^0\ \partial G(X)/\partial X\ (X^0) = 0 \qquad (1)$$

$\partial L / \partial (X^0, \lambda^0) = B - G(X^0) = 0$ (2)

Where (X^0, λ^0) refer to the coordinates of the point at which all partial derivatives of $L(X, \lambda)$ equal zero.

Equation (1) states that the gradient vector of F(X) must equal (Lagrange multiplier vector) times the Jacobian[31] of the constraint functions. Equation (2) is a restatement of the constraints.

A linear programming model where all the variables are non zero and where all the constraints are binding has exactly the same optimality conditions than (1) and (2). Also, the λ's are no more than the dual variables (shadow prices) of the LP problem.

Equations (1) and (2) only yield a stationary point. Whether the solution gives a local or global optimum is investigated through the second order conditions involving the Hessian matrix[32].

If the problem includes inequality constraints then the optimality conditions involve Kuhn Tucker conditions which are:

1. $\partial F/\partial X\ (X^0) - \lambda^0\ \partial G/\partial X\ (X^0) \quad 0$
2. $[\partial F/\partial X\ (X^0) - \lambda^0\ \partial G/\partial X\ (X^0)]\ X^0 = 0$
3. $X^0 >= 0$

31- The Jacobian is the matrix of first order partial derivatives.

32- The Hessian is the matrix of second order partial derivatives. For more details on sufficiency conditions, see, for example, Silberberg, chapter six.

4. $G(X^0) - B <= 0$

5. $[G(X^0) - B] \lambda^0 = 0$

6. $\lambda^0 >= 0$

In economic terms (assuming that the objective function deals with maximizing profits and that the λ's are costs of the resources involved in the production process), condition one requires that the marginal revenue of any decision variable be less or equal to the marginal cost of producing it. The second condition indicates that the difference between marginal revenue and marginal cost times the decision variable should equal zero. Condition three is a nonnegativity condition ,i.e. no negative production is allowed. Taken together these three conditions imply that either production is at a nonzero level in which case $\partial F/\partial X (X^0) - \lambda^0 \partial G/\partial X (X^0) = 0$, i.e. marginal revenue is equal to marginal cost, or that no production takes place ($X^0 = 0$) in which case $\partial F/\partial X (X^0) - \lambda^0 \partial G/\partial X (X^0) <= 0$[33], i.e marginal revenue is less or equal to marginal cost. Condition four requires that the constraints must be binding. The fifth condition requires that the constraints times λ must be equal to zero. The last condition requires that λ be non negative.

Conditions 4,5 and 6 imply that the constraints are either binding in which case $\lambda >= 0$ or nonbinding in which case λ

[33]- In non degenerate cases the relation should be a strict inequality, i.e. $\partial F/\partial X (X^0) - \lambda^0 \partial G/\partial X (X^0) < 0$.

= 0.

Conditions 2 and 5 are equivalent to the complementary slackness conditions of linear programming.

The existence of a saddle point at the extreme value is a necessary and sufficient condition for the existence of a constrained optimum at X^0 and λ^0. The Kuhn Tucker conditions (when they hold) provide a necessary and sufficient condition for the existence of a saddle point and therefore guarantee a global optimum.

The above optimality conditions are usually used for analytical purposes only. Their use for numerical problems is rare, to say the least.

Linear programming is the method most often used in optimizing farm planning where optimality is expressed in terms of the maximization (or minimization) of an objective function subject to a set of linear constraints.

Max. $f(x)$		Min. $f(x)$
S.T. $g(x) <= b$	or	S.T. $g(x) >= b$
$x >= 0$		$x >= 0$

Conventional linear programming models are based on four underlying assumptions: additivity, proportionality, continuity and certainty. The latter condition implies that all coefficients (objective function, resource endowments and technical coefficients) are known with certainty. The relaxation of this assumption is achieved through the incorporation of risk in one or more of the set of coefficients.

Explicit account of risk in programming models was first attempted through quadratic risk programming where risk is considered only in the objective function (e.g. risk associated with gross margins). In these types of models the mean, variance and covariance of the activities under consideration constitute the relevant statistics. Markowitz (1959) argued that in portfolio theory diversification is a rational choice made by decision makers. He formulated the portfolio selection problem in a quadratic programming framework where the objective function consists of minimizing the variance of the portfolio given different levels of expected returns. This approach is known as the E.V (mean-variance) analysis approach. Freund (1956) was one of the first to apply quadratic programming to a farm planning problem. In recent years many applications of QP to farm planning can be found in the literature, e.g. Barry and Willmaun (1976), Scott and Baker (1972), Lin et.al (1974), to name only a few.

In matrix notation the QP model can be expressed as follows:

$$\text{Max. } C'X - \lambda X'V X$$

$$\text{S.T. } AX \le B$$

$$X \ge 0$$

Where C is an n*1 column vector of expected returns associated with each activity; X is an n*1 column vector of activity levels; B is an m*1 column vector of resource endowments; A is a m*n matrix of technical coefficients of resource usage (where n is the number of activities and m the number of constraints); V is the variance covariance matrix of activity returns and λ is a risk aversion coefficient.

Quadratic risk programming is consistent with decision theory. The objective function is no more than a quadratic utility function having expected returns and their variance as its arguments. The most important limitations of this model have been its computational complexity and the unavailability of algorithms, although the latter have become more available in recent years.

The two major limitations of QP mentioned above have led to the development of a linear approximation to quadratic programming. This approach known as MOTAD (Minimization Of Total Absolute Deviations) consists of minimizing total absolute deviations about expected returns subject to a constraint set. Hazell (1971) who developed the MOTAD approach also exposited a revised version where expected returns are maximized with a parametric constraint on the sum of negative deviations. The revised version of the MOTAD is the approach used in this thesis. A more detailed presentation of the formulation is given below. Studies using the MOTAD approach are numerous. Examples of empirical applications using MOTAD include Gembreskal and Shumway (1979), Mapp et al.(1979), Brink and McCarl (1978), Hazell and Scandizzo (1974), Apland et al. (1980), Hazell (1971), Tillak and Mapp(1980), O'Brien (1981), Musser et al. (1984) and many others.

One early criticism of MOTAD was directed to its failure to take covariance into consideration. However, as shown in the formulation below, deviations from the mean for each activity are summed across all activities and since negative deviations in one activity cancel out positive deviations in another, correlation between the activities is accounted for by the model. In terms of efficiency, the most important limitation of the model is its relatively low discriminatory power. Another potential weakness of MOTAD is its solution sensitivity (Schurle and Erven, 1979).

6.2- THE RISK PROGRAMMING MODEL

In rainfed agriculture risk incorporation in decision models is desirable due to yield variability, stochastic technical coefficients and variability in resource availability, or any combination of the latter. Farmers make decisions under risky conditions (particularly in rainfed agriculture), i.e. the outcome of their decisions is subject to a probability distribution.

Furthermore, farmers' decisions also are made under uncertainty, i.e. farmers do not have perfect knowledge of the relevant probability distributions. Most studies on adoption of new technology (particularly in developing countries) rely on the assumption that farmers are reluctant to take risk and therefore their rate of adoption of any new technology (usually assumed to be more risky than the one currently used) MAY be low. Moscardi and de Janvry, for example, stated that "attitudes toward risk are major determinants of the rate of diffusion of new technologies among peasants and of the outcome of rural developments programs". According to Roumasset,however, "the a priori assumption that risk aversion of low income farmers causes serious misallocation has no theoretical or empirical basis". This implies that risk averse farmers will not necessarily choose (provided they have the necessary resources to do so) a low mean-low variance technology. Walker, on the other hand, has found that farmers who adopted new technologies (adopters) were not necessarily less risk averse than those who did not (non adopters). Other factors e.g. credit constraints, input accessibility, etc. may be the cause of adoption differentials among farmers in a given region.

The results obtained in the first sections of this thesis indicate that aversion to risk is a common characteristic of the studied farmers. In order to incorporate risk aversion in the farmers' decision making process, a risk programming model aimed at determining optimal plans for private as well as socialist sector farmers of the region is developed.

The risk programming model developed for this study takes into account stochasticity in the objective function using Hazell's MOTAD method. As shown by McCarl and Bessler, the Pratt absolute risk aversion coefficient (A) = $-U''(x)/U'(x)$) and the risk aversion coefficient from a MOTAD model (λ) are related as follows: $A = \lambda/\sigma$, where σ is the standard error of the risky prospect under consideration. Using the relation S = MA (recall, S is the partial risk aversion, M is the certainty equivalent), it is possible to derive the respective average absolute risk aversion coefficient at each game level and then compute the appropriate to use in the MOTAD model. This approach was not used, however, because the standard error component could not be appropriately estimated due to a lack of data. As a result, the average (geometric average) partial risk aversion coefficients at three game levels (50, 200 and 5,000 DA) were used in the model. The model is formulated as follows:

$$\text{Max. } U = \bar{C}_j X_j - \lambda\sigma \quad (1)$$

$$\text{S.T.} \quad a_{ij} X_j \leq b_i \quad (2)$$

$$-\sum_j (C_{kj} - \bar{C}_j) X_j - Y_k \leq 0 \quad (3)$$

$$-\sigma/\Delta \quad + \sum_k Y_k \quad = 0 \qquad (4)$$

$$X_j >= 0 \qquad (5)$$

$$Y_k >= 0 \qquad (6)$$

$j = 1,2,\ldots\ldots\ldots. n$ activities.

$i = 1,2,\ldots\ldots\ldots. m$ resources.

$k = 1,2,\ldots\ldots\ldots. l$ states of nature.

Where:

X_j = units of activity j.

C_{kj} = per unit gross margin of activity j under state of nature k.

$\bar{C}_j$ = Average gross margin per unit of activity j.

a_{ij} = usage of resource i by activity j.

Y_k = absolute value of negative deviation in net return under state of nature k.

b_i = endowment of resource i.

λ = risk aversion coefficient reflecting farmer's behavior towards risk.

σ = standard deviation of expected net returns. Assuming normality (or approximate normality) an unbiased estimate of the population variance is given by $M^2[\pi n/2(n-1)]$. Therefore standard deviation can be defined as:

$\sigma = M[\pi n/2(n-1)]^{1/2}$ where M is the mean absolute value of total (positive and negative) deviations and n is the number of observations.

$$\sigma = 2 \sum_k Y_k/n[\pi n/(n-1)]^{1/2} = \sum_k Y_k[2(\pi n/2(n-1))^{1/2}/n]$$

$$= \sum_k Y_k[4\pi n/2n^2(n-1)]^{1/2} = \sum_k Y_k \; [2\pi/n(n-1)]^{1/2}$$

setting $[2\pi/n(n-1)]^{1/2} = \Delta$, yields $\sigma = \Delta\sum_k Y_k$ where Δ is the Fisher's correction factor converting mean absolute deviations to standard deviation. π = mathematical constant =22/7.

The MOTAD model assumes the maximization of a utility function represented by expected gross margins less the cost of bearing risk (standard deviation of expected gross margins weighted by a risk aversion coefficient) subject to a set of constraints. Equation (1) is a linear objective function. Equation (2) represents a set of linear constraints and their endowments. Equation (3) determines the absolute negative gross margin deviations for each state of nature. Equation (4) converts absolute values of negative deviations to standard deviation through Fisher's correction factor. Equations (5) and (6) are non negativity constraints. Equation (3) together with equation (6) imply that if $(C_{kj} - \bar{C}_j) > 0$ then Y_k = 0, i.e. only negative deviations are considered. Y_k is set to zero for positive deviations.

The model focuses on the annual farm decisions involved in winter cereal, i.e wheat (Durum and/or Bread wheat) and barley, and livestock (sheep) production. The analysis is limited to these two crops because they constitute the major crops grown (more than 70% of total land). The integration cereal-livestock is a common practice in the region justifying the inclusion of a livestock operation in the model. In the study area characterized by a high weather induced risk (drought, frost and sirocco), livestock is considered as an important risk adjustment device (refer to appendix A).

The data base covers a period of eight years (1976-1983). However, the activities and constraints of the model are different in the two sectors.

6.21- <u>Private sector.</u>

Cultural practices in the private sector are very elementary, i.e. fertilizers, herbicides, new varieties, etc. are not used. As a result, the activity set includes crops (durum wheat, bread wheat and barley) using the same technology, a livestock enterprise and a land leasing alternative. The model selects the optimal plan given the expected gross margins specified, the degree of risk aversion and the resource endowments under consideration. Sets of activities and constraints constitute the structure of the model. There are two implicit assumptions: (1) homogeneity of the farm land and (2) the area planted is the same every year.

<u>Activities:</u>

The activities of the model consist of crop (durum, bread wheat and barley), livestock, leasing land, feed (straw consumption and grazing) annual labor and annual machinery activities.

<u>Constraints:</u>

The model constraints consist of land, factor (labor, machinery and feed), subsistence and deviation constraints.

1-<u>Land constraints:</u> There exists a restriction regarding the land available for crops and livestock. The number of hectares available is determined by the average area held by private farmers in each subsample area as indicated in table 23. Based on the survey results it is estimated that every head of livestock owned requires at least 1/40 of a hectare of land per year for housing and grazing requirements.

2-<u>Factor constraints:</u> These include feed, labor and machinery constraints.

2.1-<u>Feed :</u> These constraints include supplement grazing provided by fallow (owned and/or rented) and straw consumption. The limit on rented fallow is set at 4, 5 and 4 hectares for E.Eulma, O.Ladjoul and B.Fouda subsample respectively (average maximum fallow area rented by interviewed farmers for grazing purposes). The requirement for fallow grazing supplement is approximately equal to 1/20 of a hectare. Straw consumption (straw is used as a supplement to grazing , particularly in winter) is about 15 bales per head and per year (Morel, 1976). Straw availability (own and purchased) is, on average, no higher than 1,000 bales per year.

Before it is plowed, fallow is used for grazing. Fallow for grazing can be provided by owned fallow and/or rented fallow:

GF = OF + RF. Where,

GF = fallow for grazing.

OF = Own fallow.

RF = Rented fallow.

If the farmer has excess grazing capacity, i.e. OF > rL (r = grazing fallow area requirement per head of livestock estimated to be equal to 1/20; L = number of livestock heads), then he can lease the surplus. The latter is represented by the variable OFR (owned fallow leased). RF and OFR are mutually exclusive, i.e. the farmer has no incentive to rent fallow (RF > 0) and lease his own fallow (OFR > 0) at the same time since the price per unit of RF and OFR are identical. If RF > 0, then OFR = 0 and conversely. This relationship between RF and OFR is insured by the following constraints added to the model:

OFR - MZ <= 0

RF - M(1-Z) <= 0

Z <= 1 and integer; M is some large number.

On the other hand, RF > 0 only if rL > OF.

Fallow area required for grazing should not be confused with livestock required area (1/40 of a hectare per head of livestock). The latter is an area exclusively devoted to livestock. Fallow grazing is assumed to take place from December to April. Fallow for grazing is used as a supplement for grazing area in winter and early spring due to low grazing potential.

In addition to grazing, straw is also used for livestock feeding. Straw is either produced on the farm (own straw) or purchased (purchased straw). 15L = OS + PS. Where, OS and PS refer to bales of own straw and purchased straw, respectively, and L represents the number of sheep (recall annual straw comsumption per sheep is set to 15 bales).

2.2-<u>Labor:</u> Plowing and planting take place from September 15 to December 15 (after December 15 yield loss is very substantial) implying a total of 90 days out of which up to 50% (45 days) are not usable (precipitation, equipment repairs, holidays, etc.). The same conditions prevail in the spring. Assuming an eight hour work day gives a total of 45 * 8 = 360 hours of labor availability per worker in the fall and in the spring. Harvesting, straw baling and hauling occur from June 20 to August 20 for a total of 60 days. However, in the summer up to 10 hours constitutes the average work day length. According to interview results, about 17% of the June 20 - August 20 period are unusable due to sporadic precipitation, holidays, etc., yielding a total of no more than 50 * 10 = 500 hours available per worker. According to the farmers interviewed, the decision maker or one member of his household (usually a son) supervises all the cultural operations during all three periods[34]. Therefore, the fall and spring labor endowment is no higher than than 45 * 8 * 1 = 360 hours per farm whereas that of summer is 50 * 10 * 1 = 500 hours.

Labor availability does not include labor neede for livestock care (shepherds). The latter is provided generally by children between 10 and 18 years of age[35].

2.21-<u>Fall labor</u>: Fall cultural operations include plowing and planting. Wheat and barley require 9 hours of labor per hectare (4 hours for plowing and 5 hours for planting[36]). The requirement for livestock labor is approximately one shepherd per day for every 75 heads[37]. Assuming an 8 hour day yields a requirement of 1/75 * 8 = 0.10 hour per day per head. This requirement is assumed to be constant for all three periods. The total livestock

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34- It is assumed that all cultural operations are fully mechanized. This is not always the case, however.

35- Most of these children either go to school on a part time basis or as it often happens, are taken out from school by their parents at an early age in order to contribute to farm work (taking care of livestock, mainly). Sometimes (if the farmer does not have children in that age bracket, for example), livestock labor is provided by shepherds external to the farm in return for the possibility of grazing their own herd on the farmer's land and a monthly salary.

36- These requirements include the time spent by the farmer for buying seeds, searching for equipment rental, transporting the seeds to the field, etc.

37- Codron and Cros (1979) reported up to 280 heads per shepherd in the socialist sector.

labor requirement per period therefore is equal to 4 * 30 * 0.10 = 12 hours per head per year.

2.22-<u>Spring labor</u>: The only operation performed in the spring is fallow plowing (5 hours per hectare). Livestock labor requirement is as specified above.

2.23-<u>Summer labor</u>: Summer operations include harvesting, baling and hauling. Harvesting requires 5 hours of labor per hectare (tying the bags, for example). Baling and hauling require 3 hours each. It implies a summer labor requirement of 11 hours per hectare.

An implicit assumption is that there is no distinction between internal and hired labor, i.e. the decision maker or any other worker perform the same job.

The above labor technical data yield the following row constraints in the model:

<u>Fall</u>:

$$4\,DW + 4\,BW + 4\,B + 5\,CAPF \leq \text{Fall endowment}$$

$$12\,L \leq \text{Fall endowment}$$

<u>Spring</u>:

$$5\,F \leq \text{Spring endowment}$$

$$12\,L \leq \text{Spring endowment}$$

<u>Summer</u>:

$$11\,DW + 11\,BW + 11\,B \leq \text{Summer endowment}$$

$$12\,L \leq \text{Summer endowment}$$

<u>Annual labor</u>: $15DW + 15BW + 15B + 5F + 5CAPF + 36L - AL \leq 0$

Where crop fall and spring labor endowment is 360 hours and crop summer endowment is 510 hours. Fall, spring and summer livestock labor endowment is 2 * 8 * 100 = 1600 hours.

DW, BW, B, CAPF and F stand for durum wheat, bread wheat, barley, cereal area plowed in fall and fallow respectively.

2.3-Machinery: The average number of tractors per farmer (in the three sub areas) is reported in table 23. Fall and spring machinery deals with tractor availability (plowing and planting) whereas summer machinery deals with combine (harvesting is assumed to be mechanically accomplished) as well as tractor (baling and hauling) availability. The average number of combines per private farm (0.05 combine per farm) is very low (Mecanisation de l'Agriculture, 1982. Willaya de Setif: communes 204, 207 et 213- MARA/DGPV- BNEDER- 27/04/84). As already mentioned, plowing and planting occur between September 15 and December 15 for a total of 90 days out of which only 40 days are usable. For summer, the number of usable days is 50. Also 10 hours are worked per day. The machinery endowments are as follows:

Fall and spring:

E.Eulma: 40 * 8 * 0.27 = 86.4 hours

O.Ladjoul: 40 * 8 * 0.42 = 134.4 hours

B.Fouda: 40 * 8 * 0.40 = 128 hours

Summer:

Harvester combines (all 3 areas): 50 * 10 * 0.05 = 25 hours

Baling and hauling:

E.Eulma: 50 * 10 * 0.27 = 135 hours

O.Ladjoul: 50 * 10 * 0.42 = 210 hours

B.Fouda: 50 * 10 * 0.40 = 200 hours

2.31-Fall machinery: Plowing requires 3 hours of tractor per hectare. When the crop is grown after fallow, plowing is performed on fallow (usually in spring). When the crop is grown after another crop, e.g. barley after wheat, then plowing is performed right before planting (referred to as CAPF in the model). Planting requires two hours per hectare[38]. Harrowing requires another hour (after broadcast seeding harrowing is done to recover the seeds). Therefore, tractor requirements in the fall are 6 hours per hectare.

2.32-Spring machinery: Spring operations consist of fallow plowing only. As mentioned earlier, no farmer interviewed used fertilizer. Fallow plowing requires 3 hours per hectare.

2.33-Summer machinery: Summer operations consist of harvesting, baling and hauling. The requirements per hectare are 2 hours for harvesting, 2 hours for baling and One hour for hauling implying a two hour combine

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[38]- Again, this also includes seeds transportation from purchase site to the farm and then from the farm to the field.

requirement and a three hour tractor requirement.

The machinery requirements yield the following machinery row constraints:

Fall: 3 DW + 3 BW + 3 B + 3 CAPF <= tractor endowment

Spring: 3 F <= tractor endowment

Summer: 2 DW +2 BW + 2 B <= combine endowment

Annual machinery: 5DW + 5BW + 5B + 3CAPF + 3F - AM <= 0

where AM stands for annual machinery and where fall and spring tractor endowment is equal to 86.4, 134.4 and 128 hours for E.Eulma, O.Ladjoul and B.Fouda, respectively. The combine endowment is equal to 25 hours for all three sites.

3-Subsistence constraints: Two subsistence requirements are included in the model.

3.1-Human consumption: According to the farmers interviewed, at least one tenth of the area is always allocated to durum, regardless of the site, for household consumption and seed. Although durum flour price is subsidized farmers prefer to provide their own supply due to transportation problems and potential interruptions in market supply. Interruption of seed supply also causes farmers to produce their own seeds.

3.2-Animal consumption: Barley is usually used as feed supplement for livestock, particularly during dry years when grazing is limited. On the average, one twentieth (1/20) of a hectare of barley is grown per sheep owned.

Barley is used for human consumption as well.

Figure 8: Tableau representation (Private Sector).

	Z	DW	B	L	OFR	A	F	TC	CAPF	GF	OF	RF	OS	PS	AL	AM	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	SD		
1:		C	C	C	C																				-A	MAX	
2:						1																				<	B
3:		1	1	U		-1	1																			<	
4:		1	1					-1																		<	
5:		1	1				-1		-1																	<	
6:										1	-1	-1														<	
7:					1		-1				1															<	
8:				U						-1																<	
9:	2											1														<	2
10:	-C				1																					<	
11:				B									-1	-1												<	
12:														1												<	C
13:		-B	-B										1													<	
14:		4	4						5																	<	C
15:				B																						<	D
16:							5																			<	C
17:				B																						<	D
18:		B	B																							<	C
19:				B																						<	D
20:		B	B	B			5		5						-1											<	
21:		3	3						3																	<	C
22:							3																			<	C
23:		2	2																							<	B
24:		5	5				3		3							-1										<	
25:																	1	1	1	1	1	1	1	1	-A	=	
26:		-C	-C	-B	-B												-1									<	
27:		B	C	A	B													-1								<	
28:		C	C	-T	-B														-1							<	
29:		C	B	B	A															-1						<	
30:		B	-C	B	B																-1					<	
31:		-C	-C	-B	A																	-1				<	
32:		-C	-C	-B	-B																		-1			<	
33:		C	C	-A																				-1		<	
34:		-1				U																				<	
35:			-1	U																						<	

Note: This is an abbreviated picture of the coefficients of the LP given by the computer program LINDO (Linear, INteractive, Discrete Optimizer). For an explanation of the letter code, see appendix D.

6.22-Socialist sector:

In this sector the crops are grown under two levels of technology. Under level one no fertilizers are used. This level of technology is similar to that of the private sector except for one additional cultural operation (disking). In level two both phosphorus and nitrogen are used (at a flat rate of 100 kilograms of P_2O_5 45% and N 33.5% per hectare). Phosphorus is applied before plowing whereas nitrogen is applied in early spring (tillering). In addition the livestock enterprise is more intensively conducted in this sector. As a result, the area requirement per head is doubled compared to the private sector (0.05 hectare per head). The other requirements (fallow grazing and straw consumption) remain as in the private sector.

In this sector the fallow area is broken down into fallow with no phosphorus applied (F0) and fallow with 100 kilograms of phosphorus applied before plowing (F1). Resource endowments (land, labor, machinery) are much higher. Socialist farms do not lease fallow neither do they resort to purchasing straw. The model constraints are:

1-Land: On average, 1500 hectares are devoted to cereals (including fallow) and livestock.

2-Labor: There are, on average, 28 permanent workers per farm affected to cereals with the possibility of hiring up to 10 seasonal workers[39] during all three periods yielding a labor endowment of 40 * 38 * 8 = 13,680 hours for fall and spring and 50 * 38 * 10 = 19,380 hours for summer.

1.1-Fall labor: The requirements per hectare are identical to those of the private sector. However, 2 hours per hectare are added when fertilizer (phosphorus) is applied (transportation and application).

1.2-Spring labor: Fallow (without fertilizer) requires 4 hours of labor per hectare. When fertilizers are applied (phosphorus to fallow and nitrogen to cereals) the labor requirements becomes 6 hours per hectare.

1.3-Summer labor: Harvesting, baling and hauling require 10 hours (no fertilizer) and up to 13 hours (fertilized crops) per hectare.

1.4-Livestock labor: Each shepherd is responsible for 160 head of livestock implying a daily labor requirement of 1/160 * 8 = 0.05 hour per head or a per period requirement of 0.05 * 120 = 6 hours per head. There are up to 8 shepherds available per farm. The total shepherd time endowment per farm is thus 120 * 8 * 8 = 7.680 hours per period.

2-Machinery: There are, on average, 12 tractors and 5 combines per socialist farm, yielding a machinery endowment of 12 * 40 * 8 = 3,840 hours of tractors for

39- The potential for hiring labor is much greater in the socialist sector because of the possibility for seasonal workers to change status (i.e. become permanent workers) after a specified number of hours worked per year.

fall spring and 50 * 10 * 5 = 2,500 hours of combine harvester time.

2.1-<u>Fall machinery</u>: The requirement is 8 hours (3 hours for plowing, 2 hours for planting and 2 hours for disking and one hour for phosphorus application including transportation) per hectare.

2.2-<u>Spring machinery</u>: The spring requirement is 5 hours (3 hours for fallow plowing and 2 hours for fertilizer application) of tractor time per hectare.

2.3-<u>Summer machinery</u>: Harvesting requirement is 2 hours per hectare. Baling and hauling on the other hand require 3 hours of tractor time per hectare.

3-<u>Fertilizers</u>: According to socialist farmers no more than 1,000 hectares can be fertilized due to the unavailability of fertilizer . Therefore, the fertilizer endowment is 1,000 quintals (one quintal = 100 kilograms) per year. It also is assumed that the land receiving phosphorus receives nitrogen and conversely.

<u>4-Standard deviation of gross margins:</u> the standard deviation of the gross margin is estimated by $\sigma = \Delta \sum_k Y_k$, where $\sum_k Y_k$ is the absolute value of negative deviations from average gross margin in year k. The deviation from average gross margin is given by $C_{kj} - \bar{C}_j$ $j = 1,2,....7$; $k = 1,2,...5$

Annual absolute negative deviations are given by :

$$-\sum_j (C_{kj} - \bar{C}_j) - Y_k <= 0$$

If $\sum_j (C_{kj} - \bar{C}_j) >= 0$ then $Y_k = 0$

Standard deviation of gross margins is obtained using Fisher's relation $\Delta = [2\pi/n(n-1)]^{1/2}$ where n is the number of observations (8 years).

$\Delta = (2 * 3.14/8 * 7)^{1/2} = 0.3349$

The standard deviation row is $- 1/\Delta + \sum_k Y_k = 0.$

Since $\Delta = 0.3349$ the model equation representing standard deviation of gross margins is $- 1/0.3349 + \sum_k Y_k = 0$

or $- 2.986 + \sum_k Y_k = 0.$

In considering variation of gross margins the distinction between expected (trend) and random variation must be made. Although it may be argued that farmers base their decisions on the long term mean of returns and that any deviation from this mean is considered by them (the farmers) as a random event, another alternative is to approximate expected returns by a linear trend model[40]. In this case, the deviation from the trend is considered as random variation. The gross margins generated for all activities (crops, fallow and livestock) were tested for possible trend using the following model: $C_t = a_1 + a_2t$ where "t" is time and C_t is gross margin at time "t". Although the existence of a trend was not significant for all activities in all subsamples, the residuals from the detrended regressions were used as estimates of deviations

40- An exhaustive list of approaches dealing with the measurement of the random component of gross margins is provided by Young (1980).

instead of $C_{kj} - \bar{C}_j$.

<u>5-Non negativity constraints:</u> These constraints insure that only positive X_j and positive Y_k are considered.

Figure 9: Tableau representation (Socialist Sector).

Row	D0	D1	BW0	BW1	B0	B1	L	SD	A	TD	TBW	TB	TF	F0	F1	CAPF0	CAPF1	GF	OF	OS	AL	AM	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	FERT	TC		
1:	C	C	C	C	C	C	C	-A																									MAX	
2:	1	1								-1																							<	
3:			1	1							-1																						<	
4:					1	1						-1																					<	
5:													-1	1	1																		<	
6:							U		-1	1	1	1	1																				<	
7:	1		1		1									-1		-1																	<	
8:		1		1		1									-1		-1																<	
9:															1		1														-1		<	
10:																															1		<	C
11:																		1	-1														<	
12:													-1						1														<	
13:							U											-1															<	
14:							B													-1													<	
15:	4	6	4	6	4	6										5	6																<	E
16:							6																										<	D
17:		2		2		2								4	6																		<	E
18:							6																										<	D
19:	A	B	A	B	A	B																											<	E
20:							6																										<	D
21:	B	B	B	B	B	B	B							4	6	5	6				-1												<	
22:	4	4	4	4	4	4										3	4																<	D
23:		1		1		1								3	4																		<	D
24:	2	A	2	A	2	A																											<	D
25:	6	A	6	A	6	A								3	4	3	4					-1											<	
26:								-A															1	1	1	1	1	1	1	1			=	
27:	-B	-B	-B	-B	-B	-B														1													=	
28:									1																								=	D
29:	-C	-C	-C	-C	-C	-C	-B																-1										<	
30:	C	C	C	C	C	C	A																	-1									<	
31:	C	C	B	C	-B	C	A																		-1								<	
32:	C	C	C	C	C	C	B																			-1							<	
33:	-C	-C	-A	-B	-C	-C	B																				-1						<	
34:	-A	-B	B	A	C	C	-A																					-1					<	
35:	-C	-C	-C	-C	-C	-C	-B																						-1				<	
36:	C	C	C	C	C	C	-B																							-1			<	
37:	-1	-1	-1	-1	-1	-1																										1	=	
38:		1		1		1																									-1		<	

Note: This is an abbreviated picture of the coefficients of the LP given by the computer program LINDO Linear, Interactive, Discrete Optimizer). For an explanation of the letter code, see appendix D.

Table 29: Summary statistics of estimated gross margins (Private sector).

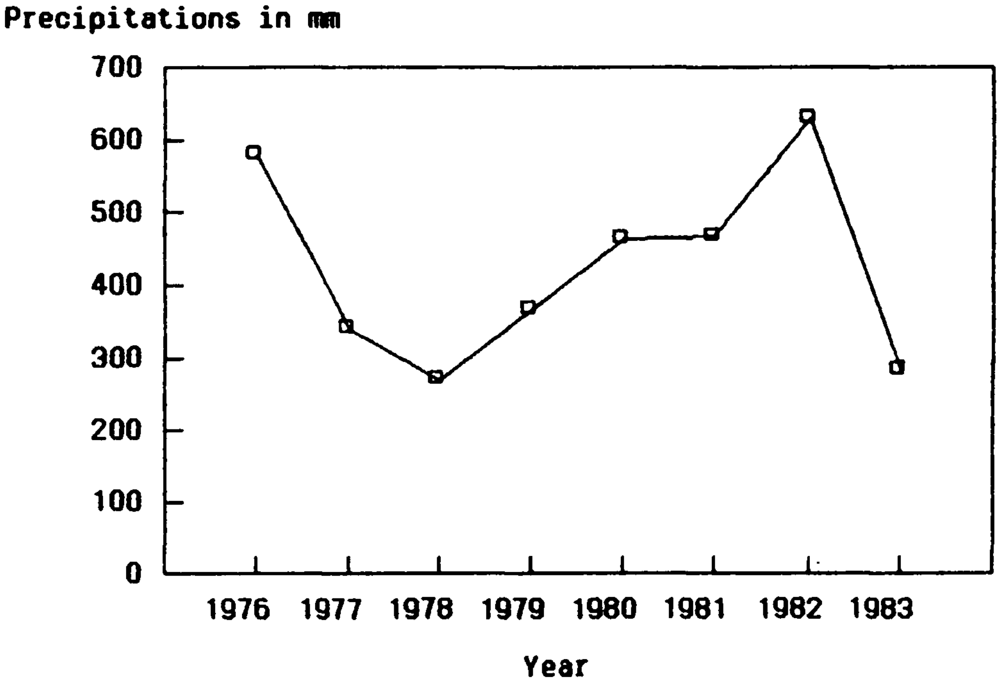
Activity	Mean	CV	Skewness	Kurtosis
		E.Eulma		
D.Wheat	578.1	52.85	-.0917	2.175
B.Wheat	456.9	59.16	.1352	1.875
Barley	664.61	66.78	.1447	1.562
Livestock	363.50	30.39	.5260	1.522
Land leased	318.75	18.63	.3161	1.747
		O.Ladjoul		
D.Wheat	341.52	74.63	.5434	2.584
B.Wheat	359.44	69.60	.1793	2.614
Barley	608.06	64.97	.7237	3.439
Livestock	363.50	30.39	.5260	1.522
Land leased	318.75	18.63	.3161	1.747
		B.Fouda		
D.Wheat	749.76	71.86	.8613	2.118
Barley	703.69	65.47	.2998	1.680
Livestock	363.50	30.39	.5260	1.522
Land leased	318.75	18.63	.3161	1.747

Table 30: Summary statistics of estimated gross margins (Socialist sector).

Activity	Mean	CV	Skewness	Kurtosis
		E.Eulma		
D.Wheat	623.55	49.42	.0493	1.701
D.Wheat Fert	782.42	55.34	.2502	1.531
B.Wheat	704.36	55.17	.4032	2.769
B.Wheat Fert	876.65	60.38	.6465	2.737
Barley	769.64	50.91	-.0994	1.845
Barley Fert	946.12	55.81	.2366	1.647
Livestock	308.94	31.44	.6319	1.625
		O.Ladjoul		
D.Wheat	349.06	96.92	.0371	1.784
D.Wheat Fert	464.96	91.51	.2096	1.737
B.Wheat	478.40	88.83	.3506	1.939
B.Wheat Fert	634.82	88.77	.4219	1.873
Barley	392.39	66.68	-.4946	1.738
Barley Fert	497.64	65.22	-.3528	1.821
Livestock	308.94	31.44	.6319	1.625
		B.Fouda		
D.Wheat	936.04	43.54	-.0763	2.046
D.Wheat Fert	1125.10	44.28	.0799	1.945
B.Wheat	893.77	72.01	1.038	3.704
B.Wheat Fert	1111.22	77.15	1.215	3.873
Barley	600.27	50.93	-.0742	2.356
Barley Fert	746.45	55.04	-.4052	2.341
Livestock	308.94	31.44	.6319	1.625

Figure 10: Rainfall in E.Eulma

1975/76-1982/83



Source: Office National de Meteorolgie-
Wilaya de Setif-Station El-Sulma

Table 31: Empirical results E.Eulma (Private sector).

	Risk aversion coefficients			
	0	0.70	0.90	1.18
Gross mar.	28,530	24,028	21,889	21,186
St.Dev	6,431	6,431	6,074	5,124
D.Wheat	1.6	1.6	3.5	3.75
B.Wheat	0	0	0	3.85
Barley	10.9	10.9	9	4.90
Livestock	53	53	53	53
L. leased	0	0	0	0
R. Fallow	0.5	0.5	0.5	0.5
P. Straw	304	304	309	319

Current activity levels.*

	Mean	CV
Durum	3.88	139.20
B.Wheat	0	-----
Barley	7.5	112.00
Livestock	38	86.60

* These represent average activity levels (1982) of E.Eulma farmers who participated to the experiment. The data used in the model (acreage and yields) reflect activity levels (1976 to 1983) of all farmers of the site, i.e., including farmers who did not participate to the experiment.

Table 32: Empirical results O.Ladjoul (Private sector).

	Risk aversion coefficients			
	0	0.98	1.28	1.50
Gross mar.	30,302	24,530	23,348	22,496
St.Dev	8,430	5,259	3,873	3.873
D.Wheat	2.8	2.8	2.8	2.8
B.Wheat	0	0	0	0
Barley	9.7	7.5	2.8	2.8
Livestock	53	53	53	53
L. Leased	11.5	13.6	18.4	18.4
R. Fallow	0	0	0	0
P. Straw	307	392	583	583

Current activity levels.*

	Mean	CV
Durum	2.75	169.10
B.Wheat	1.20	259.17
Barley	11.00	98.64
Livestock	48.00	82.60

* These represent average activity levels (1982) of O.Ladjoul farmers who participated to the experiment. The data used in the model (acreage and yields) reflect activity levels (1976 to 1983) of all farmers of the site, i.e., including farmers who did not participate to the experiment.

Table 33: Empirical results B.Fouda (Private sector).

	Risk aversion coefficients			
	0	0.92	1.52	2.04
Gross margin	29,789	24,221	21,050	19,124
St. Deviation	7,345	5,651	3,775	3,775
D. Wheat	9.85	1.85	1.85	1.85
Barley	2.65	10.65	2.66	2.66
Livestock	53	53	53	53
Land leased	2	2	10	10
Rented fallow	0	0	0	0
Purchased straw	325	300	619	619

Current activity levels.*

	Mean	CV
Durum	7.00	70.71
B.Wheat	0.00	-----
Barley	3.20	84.38
Livestock	34.00	135.00

* These represent average activity levels (1982) of B.Fouda farmers who participated to the experiment. The data used in the model (acreage and yields) reflect activity levels (1976 to 1983) of all farmers of the site, i.e., including farmers who did not participate to the experiment.

Table 34: Empirical results E.Eulma (Socialist sector).

	Risk aversion coefficients			
	0	0.83	1.05	1.39
Gross margin	1,151,078	779,528	682,281	562,216
St. Deviation	447,649	447,649	416,433	319,676
D. Wheat	0	0	0	0
D. Wheat Fert	0	0	0	0
B. Wheat	0	0	193.5	661
B. Wheat Fert	0	0	0	0
Barley	0	0	0	0
Barley Fert	799	799	622	154
Livestock	1,280	1,280	1,280	1,280
Fallow	637	637	621	621

Table 35: Empirical results O.Ladjoul (Socialist sector).

	Risk aversion coefficients			
	0	0.83	1.05	1.39
Gross margin	902,452	545,826	480,339	384,221
St. Deviation	512,994	297,668	297,668	272,634
D. Wheat	0	0	0	0
D. Wheat Fert	0	0	0	0
B. Wheat	0	0	0	0
B. Wheat Fert	799	0	0	0
Barley	0	0	0	359
Barley Fert	0	799	799	456
Livestock	1,280	1,280	1,280	1,280
Fallow	637	637	637	621

Table 36: Empirical results B.Fouda (Socialist sector).

	Risk aversion coefficients			
	0	0.83	1.05	1.39
Gross margin	1,294,023	998,734	925,409	825,474
St. Deviation	362,100	333,539	300,700	283,051
D. Wheat	0	194	341	473
D. Wheat Fert	799	622	474	325
B. Wheat	0	0	0	17
B. Wheat Fert	0	0	0	0
Barley	0	0	0	0
Barley Fert	0	0	0	0
Livestock	1,280	1,280	1,280	1,280
Fallow	637	621	621	621

6.3- EMPIRICAL RESULTS AND DISCUSSION.

The results of the six MOTAD model runs (3 for the private sector and 3 for the socialist sector) are reported in tables 31 through 36.

6.31-Results for the private sector.

The model has been specified with the assumption that all farms, regardless of their geographic location, have the same constraint set (except for area cropped and fallow rented). Input as well as output prices are identical in the three sites. Variation among sites comes from yield levels and degree of risk aversion. The yields used are those recorded from the official bulletins of the DAP (statistics service) of Setif. They are reported in appendix B. The risk aversion coefficients for each site and sector are those estimated in part one of this study at the 50, 200 and 5,000 DA levels[41].

6.311-E.Eulma subsample: There is no change in the basis between the risk neutral solution and the solution at λ = .70. No bread wheat is grown. Durum area is limited to the subsistence requirement. Barley is grown on 12 hectares. The total area cropped amounts to 12.5 hectares with the remainder allocated to livestock and fallow.

41- Because of the wide intervals existing between the extreme and severe risk aversion classes (alternatives A and B) on the one hand, and moderate to neutral classes (alternatives E, G and H) on the other hand, the geometric mean partial risk aversion was used to derive the risk coefficients at these game levels.

Livestock is at the maximum allowed by the straw restriction, i.e. 800 bales per year. At the risk neutral solution, summer machinery (harvester combines) has a shadow price of 359 DA. Also, at the risk neutral solution expected gross margin has a value of 28,530 DA for a standard deviation of 6,431. Expected gross margin decreases by more than 4,500 DA at λ = .70. At the next risk aversion coefficient (.90), more durum is grown but the basis remains unchanged. Expected gross margin decreases by 5,730 DA and standard deviation by 357 (compared to the risk neutral solution). At the highest risk aversion coefficient bread wheat enters the basis. The area is divided almost evenly among all three crops. Expected gross margin decreases by 7,344 DA and standard deviation by 1,307 compared to the risk neutral solution, i.e., the decision maker is willing to forego 7,344 DA in expected gross margin (a 26% decrease) for a 1,307 decrease (20%) in standard deviation of gross margin. At the highest level of risk aversion (1.18), the shadow price of summer machinery drops by more than 65% compared to the risk neutral solution (124 DA versus 359 DA). At all risk levels 53 head of livestock are raised annually and nearly 40% of the straw requirement is purchased. If purchased straw supply is decreased by 20%, i.e., no more than 250 bales of straw can be purchased per year, a change in the basis occurs at λ = 1.18 (4.85 hectares of durum and 7.70 hectares of barley will be grown and only 49 sheep will be raised). The risk neutral basis remains unchanged but only 49 sheep are raised. Also, the expected gross margin decreases by 1,335 DA and the shadow price of summer machinery increases to 853 DA (137% increase compared to the initial solution). At all risk levels, the fallow area rented for grazing purposes is relatively low. Herd size is higher than the average herd size reported in table 25. The explanation is that the main factor restricting it (straw and, to a lesser extent rented fallow) may be set at a higher than average level (the latter was defined based on farmers' interviews), i.e., it is possible that farmers overestimate the straw supply.

<u>6.312-O.Ladjoul subsample:</u> The first striking difference between O.Ladjoul and E.Eulma is that even at the risk neutral solution all the area owned is not cropped (41% of the land is leased at the risk neutral level). Durum is only grown at the subsistence requirement level in all solutions. Going from the risk neutral to the next risk aversion level yields the same basis but with a reduction in barley area (less 2.5 hectares) and, as a result, increasing land leased by the same number of hectares. At the next two levels of risk aversion both durum and barley are grown at their respective subsistence requirement levels which implies that more than two thirds of the area

owned is leased. Unlike the E.Eulma subsample, no bread wheat is grown. The expected gross margin difference between the two extreme risk aversion levels (0 and 1.50) amounts to 7,786 DA (a 26% decrease as in E.Eulma), whereas standard deviation decreases by 2.147 (35% decrase versus only 20% in E.Eulma) implying that by foregoing the same proportion of gross margin O.Ladjoul farmers are better off as far as standard deviation is concerned. Herd size is similar to that of E.Eulma, however, at the high risk aversion levels (1.28 and 1.5) almost 74% of the straw requirement is purchased. Again, this may not be feasible because the local straw market is not likely to sustain such high demand. If it is assumed that only one fourth of the purchased straw is actually available then barley area raises to the risk neutral level and herd size decreases to 49. At the risk neutral level, the shadow price of summer machinery is close to 145 DA which is much lower than in E.Eulma. When purchased straw is limited to 250 bales per year the shadow price of summer machinery incrases substantially (288 DA). Also the land lease price should substantially be lowered (e.g. by 84 DA per hectare at = 1.28) in order to obtain a change in the basis.

<u>6.313-B.Fouda subsample:</u> Unlike in the previous subsamples, barley is grown at the livestock requirement level only whereas durum occupies 10 hectares at the risk

neutral level. At the next level of risk aversion, however, the same pattern as before is observed, i.e., durum at the subsistence level and barley occupying the remainder of the cropped area (10.65 hectares). As risk aversion increases (1.53 and 2.04), both durum and barley are grown at subsistence requirement levels and land leased increases to 10 hectares. Gross margin decreases by 10,665 DA as risk aversion coefficient goes from 0 to 2.04 (a 36% decrease conpared to 26% in E.Eulma and O.Ladjoul) whereas standard deviation decreases by 3,570 (49%) over the same range. Herd size remains similar to the two previous subsamples. However, at high risk aversion levels (1.53 and 2.04), purchased straw constitutes more than two thirds of the total straw requirement. Again, such a solution, most likely, reflects farmers' overestimation of straw supply. Assuming that the most likely supply of straw only represents 40% of that in the solution at high risk aversion, i.e., no more than 250 bales can be purchased annually because of market supply availability, then the solution is identical to that with a risk aversion coefficient of .94, however, with only 49 sheep raised and a 30% lower gross margin (16,803 DA versus 24,221DA). Summer machinery shadow price is 185.5 DA for the risk neutral solution but sharply drops to 54 DA for the next risk aversion coefficient (.94). At a risk coefficient of

2.04, the price of land leased must be reduced by up to 154.50 DA (a 49% reduction) in order for the basis to change. This reduction is substantially lower (only 34.65 DA or about 11% reduction) for a change of the basis at a risk coefficient of 1.53.

The empirical results reported in tables 31-33 do not quite reasonnably predict current activity levels given the measured risk aversion coefficients. The reason, however, is not intrinsic to the model. It seems that farmers overestimate straw supply, particularly in O.Ladjoul and B.Fouda, and therefore prefer to lease their land and raise livestock (the coefficients of variation of livestock and land leasing are, on average, 50% lower than those of wheat and barley) and purchase up to 79% of their straw needs. This is not always feasible. By reducing the amount of straw purchased to 40% of total straw requirements (which is more plausible) the model gives a reasonnable prediction of current activity levels. Another explanation of the discrepancies between model solutions and actual levels is that the price of barley used in the model is the official price. However, most private farmers sell (this is particularly true for barley) on the local market whose average price (black market price) is, on average, twice the official price, e.g. at the time of the study, barley local market price was 220 DA versus an official price of 101.20 DA (not to mention transportation costs). Since no data on black market prices could be found, official prices were used instead. Another reason concerns the reliability of the yield data. The yield averages for the eight-year period were very low[42]. The assumption is that official yields (these are calculated mainly on the basis of sales by private farmers to official cereals cooperatives) do underestimate actual yields at least for barley which is usually sold on the black market. Finally, because of potential supply shortages (whose effect is not accounted for by the model) current activity levels should be higher than predicted ones.

6.32-Results for the socialist sector:

As explained in chapter two, cropping patterns in the socialist sector are determined by the Ministry of Agriculture through the DAP and SDA. These two institutions (DAP and SDA) practically establish the acreage of each farm based on the farm management and agronomic potentials and also past performances. The management committee, theoretically, has the authority to determine its own cropping patterns and the DAP and SDA only provide technical assistance in the process of determining the most suitable crops to be grown given the

42- The official yields were inflated by a factor of .40, .15 and .60 for durum, bread wheat and barley,respectively, to account for on farm consumption (human, livestock and seeds). Even after inflation, yields seem too low even by high plateau standards.

potentialities of the farm. In reality, however, the DAP and especially the SDA have substituted themselves to the management committes for the decision as to what to grow year after year based on the assertion that it (the management committee) can not make optimal allocations. Therefore, the model solution will likely be biased since it is derived under the implicit assumption that the director and the president of the farm jointly make all decisions pertinent to the farm yearly activities.

6.321-E.Eulma subsample: Between the two extreme risk aversion coefficients (0 and 1.39), gross margin decrease by 588,862 DA (51% decrease) whereas standard deviation decreases by 127,973 (29% decrease) over the same range. The risk neutral solution indicates that only barley (with fertilization) is grown (799 hectares). Herd size attains 1,280 and is limited by labor (number of shepherds). No change in the solution occurs when the risk coefficient rises to 0.83, however, gross margin decreases by more than 32%. The fall machinery constraint is binding and has a shadow price (at 0.83 risk aversion coefficient) of 41 DA whereas livestock labor has a shadow price of 49 DA (these shadow prices are reduced to 23 and 48 DA for fall machinery and livestock labor, respectively, at the highest level of risk aversion). As the risk aversion coefficient attains 1.05, bread wheat (with no fertilization) enters the basis. Consequently, less barley is grown (621 hectares), bread wheat occupies about 194 hectares and total area cropped increases by 16 hectares. At the highest level of risk aversion (1.39), the basis remains unchanged but bread wheat area increases substantially (661 hectares) whereas barley area drops to 154 hectares. At this level of risk aversion the quantity of fertilizers used is quite low (only 19% of the area cropped receives fertilizers).

6.322-O.Ladjoul subsample: The most striking observation is that gross margin decreases by 518,231 DA (58% decrease) as the risk aversion coefficient rises from 0 to 1.39. Over this same range standard deviation also decreases substantially (47% reduction). At risk neutral level only bread wheat is grown (799 hectares). In this site durum yields are low due to the lightly structured and shallow soils unsuitable for durum. Bread wheat and barley yields are not very different but their respective gross margins are different due to price differentials. When the risk aversion coefficient rises to 0.83, barley (with fertilization) takes the place of bread wheat yielding a reduction in gross margin (42% reduction). This solution remains unchanged when the risk aversion coefficient rises to 1.05 (gross margin decreases, however). At the highest level of risk aversion, only barley is grown but fertilizers are used only on 56% (456 hectares) of the cropped area (which increased by 16 hectares). At this level of risk aversion, the shadow price of fall machinery is only 3.41 DA whereas that of livestock is 46.31 DA. More fertilizers are used (compared to E.Eulma). Fallow area is identical in both sites.

6.323-B.Fouda subsample: As expected (given the average gross margin per hectare) only durum wheat (with fertilization) is grown at the risk neutral level. Gross margin decreases by 468,549 DA (36% decrease) between the two extreme levels of risk aversion (0 and 1.39) whereas standard deviation is reduced by 20% over that range. Unlike the precedent sites no barley is grown, regardless of risk aversion levels. At risk aversion levels of 0.83 and 1.05, only durum is grown, however, with different allocation between durum with fertilization and durum without fertilization. Fertilizer usage decreases as risk aversion increases. At the highest risk aversion level, bread wheat (with no fertilization) enters the basis (16.50 hectares). Less fertilizer is used compared to O.Ladjoul at all risk aversion levels (not including the risk neutral level). The shadow price of fall machinery is the highest for all three sites (61 DA at the highest risk aversion level). the livestock labor constraint, as in the precedent sites is binding yielding a shadow price for livestock equal to 41 DA.

Based on the official document "Plan de Production

1984-85 (SDA E.Eulma :Departement Production Vegetale)", the average government "recommendations" (socialist farms) in the three zones were as follows:

	E.Eulma	O.Ladjoul	B.Fouda
Durum	9.20%	2.67%	42.25%
Bread wheat	33.05%	27.24%	8.25%
Barley	20.20%	20.18%	9.50%
Fallow	37.55%	47.00%	40.00%

These acreage recommendations were included in the three subsample models. The solutions derived under these conditions (referred to as regime 2 in the text) were then compared to the previous solutions derived under the assumption that all relevant decisions were made on the farm (referred to as regime 1 in the text). The solutions for the risk neutral and the highest risk level are given below.

Table 37: Solutions under regime 2 (E.Eulma).

	λ = 0*	λ = 1.39*	λ = 0**	λ = 1.39**
G.Margin	922,791	535,484	1,154,855	569,136
St.deviation	278,683	287,638	444,329	336,907
Durum	109	109	92	129
Durum Fert			37	
B.Wheat	391	391		489
B.Wheat Fert			463	
Barley	239	239		283
Barley Fert			283	
Livestock	1280	1280	1280	1280
Fallow	661	661	526	500
Total Fert	0	0	783	0

* Solutions derived under regime 2 given the constraint set.

** Solutions derived under regime 2 with an increase in the fall machinery endowment (25% increase in number of tractors yielding 4,800 hours of fall machinery).

Under regime 2 and at the risk neutral level, there is a 20% reduction in gross margin (from 1,151,078 to 922,791 DA) compared to regime 1. At the highest risk level, however, there is only a 5% reduction (from 562,216 to 535,484 DA). Given the constraint set, the inclusion of acreage restrictions (government recommendations) leads to an infeasibility because the fall machinery constraint is binding, i.e., there are not enough fall machinery hours available to allow the plowing, disking and planting of all the acres recommended. Given the fall machinery endowment and the crop percentages required, only a total area of 1183 hectares can be considered. Thus, the solutions derived under regime 2 without changing the constraint set are consistent with the crop percentages required provided that total acreage is no greater than 1183 hectares (if total area is greater than 1183 hectares, there is an infeasibility). Allowing an increase in fall machinery endowment (25% increase)[43] reduces the differential in gross margin as a result of government intervention. At the risk neutral level there is only a 5% reduction (from 1,226,767 to 1,154,855 DA), whereas at the highest risk level the reduction is even smaller (5%, i.e., from 584,161 to 569,136 DA) with regime 1 always yielding a higher gross margin.

Under regime 2, the increase in fall machinery endowment leads to 25% and 6.3% increase in gross margins at the neutral and highest risk levels, respectively. These percentage increases are much smaller under regime 1 (6.6 and 4% at the neutral and highest risk levels,

[43]- The increase in fall machinery endowment is considered through increasing the number of tractors available by 25% (from 12 to 15). It is also possible to achieve the same increase in fall machinery hours by extending the plowing-planting period. However, as previously explained, such an extension will lead to yield reduction.

respectively).

Table 38: Solutions under regime 2 (O.Ladjoul).

	λ = 0*	λ = 1.39*	λ = 0**	λ = 1.39**
G.Margin	844,234	318,929	899,023	317,879
S.Deviation	406,222	304,468	454,770	336,977
Durum		38		40
Durum Fert	38		40	
B.Wheat		382		409
B.Wheat Fert	426		492	
Barley		386		462
Barley Fert	325		347	
Livestock	1280	1280	1280	1280
Fallow	613	596	557	525
Total Fert	787	0	879	0

* Solutions derived under regime 2 given the constraint set.

** Solutions derived under regime 2 with an increase in the fall machinery endowment (25% increase in number of tractors yielding 4,800 hours of fall machinery).

Under regime 2, gross margin decreases by 6.5% at the risk neutral level (from 902,452 to 844,234 DA) and by 17% at the highest risk level (from 384,221 to 318,929DA).

This difference in gross margin between the two regimes remains sensibly the same (6 and 18% decrease at the neutral and highest risk levels, respectively) when fall machinery endowment is increased by 25% (from 3840 to 4800 hours available).

Under regime 2, the effect of a higher fall machinery endowment is a 6.5% increase in gross margin at the risk neutral level and a 0.33% decrease in gross margin at the highest risk level.

Given the constraint set, the solutions indicate that government intervention leads to a decrease in farmers' gross margin. This gross margin reduction is much higher at the highest risk level. In addition, increasing the fall machinery endowment does not increase gross margin at the highest risk level under both regimes.

Table 39:Solutions under regime 2 (B.Fouda).

	λ = 0*	λ = 1.39*	λ = 0**	λ = 1.39**
G.Margin	765,169	387,744	1,310,070	822,267
S.Deviation	271,528	271,628	400,359	272,446
Durum	151	151	114	613
Durum Fert	391	391	521	32
B.Wheat	106	106		124
B.Wheat Fert			124	
Barley			143	143
Barley Fert	122	122		
Livestock	1280	1280	1280	1280
Fallow	512	512	536	525

* Solutions derived under regime 2 given the constraint set.

** Solutions derived under regime 2 with an increase in the fall machinery endowment (25% increase in number of tractors yielding 4,800 hours of fall machinery).

In this site, government intervention leads to a very substantial reduction in gross margin (41%, i.e., from 1,294,023 to 765,169 DA at the risk neutral level, and 53%, i.e., from 825,474 to 387,744 DA at the highest risk level).

The difference in gross margin between the two regimes is very much lower (only 5.4 and 7% at the neutral and highest risk levels, respectively) when fall machinery endowment is increased to 4800 hours.

The effect of a larger fall machinery endowment is much more pronounced under regime 2 (a 71 and 112% increase in gross margin at the neutral and highest risk levels, respectively) than under regime 1 (7% increase in gross margin at both risk levels).

The solutions clearly indicate that farmers' gross margin is adversely affected by government intervention (particularly at the highest risk level) in this particular site. In addition, the solutions also point to the necessity of increasing the number of tractors (up to a 25% increase) in order to reduce gross margin differentials between the two regimes.

The impact of government intervention is not identical in all three subsamples. At E.Eulma, the reduction in gross margin under regime 2 is higher at the risk neutral level (20% decrease) compared to the highest risk level (5% decrease). Since farmers of this region are risk averse (their risk aversion coefficient equals 1.39), gross margin generated under regime 2 does not significantly differ from that generated under regime 1. Gross margin difference between the two regimes becomes even smaller as fall machinery endowment is increased.

At O.Ladjoul, gross margin differential between the two regimes amounts to 6.5% (risk neutral level) and 17%

(highest risk level). Unlike E.Eulma, the percentage reduction in gross margin is much higher at the highest risk aversion level. Therefore, O.Ladjoul farmers will be more adversely affected by government intervention compared to those in E.Eulma (even if fall machinery endowment is increased by 25%). In addition, under regime 2, there is no change in gross margin (it even decreases by 0.3% at the highest risk level) as a result of a 25% increase in number of tractors available.

At B.Fouda, regime 2, leads to a very large reductions in gross margins (up to 53% decrease at the highest risk level). If, however, fall machinery endowment is increased by 25%, the gross margin reduction between the two regimes is much lower (7% reduction). Under regime 2, gross margin may be increased by up to 112% as a result of an increase in the number of tractors available.

According to the solutions derived, B.Fouda farmers would be the most affected by government intervention if the number of fall tractor hours remains at its average level, i.e., 3840 hours. O.Ladjoul farmers also will be affected (at a lesser extent, however). E.Eulma farmers are the least affected by government intervention. Increasing the number of tractors by 25% reduces the gross margin differential between the two regimes at E.Eulma and, particularly, at B.Fouda but not at O.Ladjoul.

It is worth mentioning that, given the solutions obtained, gross margin per hectare (total gross margin divided by total land) is much higher in the private sector. For example, the lowest per hectare gross margin in the private sector (O.Ladjoul at risk aversion level of 1.50) is very close (803 DA versus 863 DA) to the highest gross margin per hectare in the socialist sector (B.Fouda at the risk neutral level). Across sector comparison (at risk aversion coefficient derived at the same game level) indicates that gross margin per hectare in the private sector is much higher than in the socialist sector (more than 50% higher).

The other observation concerns the size of the standard deviation in both sectors. In the private sector the standard deviation of gross margin only represents, on average, about 20% of the objective function value (at the highest risk aversion level) whereas in the socialist sector it represents, on average, up to 55% of the objective function value at the highest level of risk aversion.

CHAPTER VII

SUMMARY AND SUGGESTIONS FOR FUTURE EXTENSION

The major result of this research is that farmers in the high plateau region of Algeria unambiguously exhibit risk averse attitudes. At low payoff levels the distribution of risk preferences has a larger spread whereas at higher levels (200 DA and higher) the distribution is narrower and a high proportion of individuals (27% in E.Eulma, O.Ladjoul and S. Sector and 41% in B.Fouda) fall in the extreme to severe risk aversion category. This result supports the previous results of similar experiments conducted in other developing countries (e.g. studies conducted by Binswanger in India, Walker in El Salvador and Sillers in the Phillipines), however, with a higher concentration in the extreme to severe risk aversion class (in the cited studies, at most 15% of the subjects fell in that class). This higher concentration of choices in this class was evident even at low payoff scales for all subsamples. Even at the lowest payoff scale very few subjects chose the risk neutral alternative (no one selected that alternative in the socialist sector), with the exception of the E.Eulma site where about 20% of the subjects selected this alternative at the 5 DA level. At higher payoff levels, again except for the E.Eulma site, this alternative was chosen only twice (B.Fouda, rounds 5 and 6). Most subjects fall in the intermediate to moderate risk aversion class regardless of payoff level. Therefore, even though these results support previous findings relative to risk aversion behavior, the selection patterns do not seem to be similar. One tentative explanation is the nonexistence of gambling (of any form) in the rural areas of Algeria due to religious as well as institutional considerations. As explained in chapter IV, the sample farmers were not part of any previous research. Thus, it is assumed that their behavior (as reflected by their choices) was not influenced by past experience in previous studies or gambling.

Risk aversion increases as payoff scale rises, however, the increase was never significant. The average increase in average partial risk aversion coefficient among payoff scales was much lower than that reported by Binswanger (1978).

Another interesting result of this study concerns the hypothesis that risk attitudes may be site dependent, i.e., the assertion is that in marginal areas ,e.g. O.Ladjoul, risk aversion may be higher as a result of higher weather variability and lower agronomic potentialities. In order to test this hypothesis samples of farmers were selected from three agro-ecological areas representative of the Eastern High Plateau Region of Algeria (refered to in the text as Northern (B.Fouda), Central (E.Eulma) and Southern (O.Ladjoul) zones). The test does not support any significant difference associated with the site factor. As a matter of fact, risk attitudes were lower (though not significantly) in the Southern site (usually referred to as marginal zone) than in the Northern zone (usually associated with milder weather conditions and higher agronomic potential).

Because of the specific structure of the socialist sector, it is (usually) asserted that the farmers of this sector will tend to be risk neutral (see chapter II). Again, the results do not support such hypothesis. Although socialist farmers were found to have, on average, lower risk aversion coefficients (see chapter V), the difference was not significant. The implication is that these results do not support any intrinsic difference in farmers' pure risk attitudes either sectorwise or sitewise. Any difference in farming attitudes is therefore likely to arise as a result of differentials in the constraint set. This implication in turn points to the inappropriatness of policies recommending technologies on the basis of their riskiness to the two sectors of agriculture and among various agroecological regions. These results simply do not warrant such a strategy.

Virtually all farmers who took part in the experiment were found to be risk averse at high payoff levels. Their degree of risk aversion, on average, is much higher than that derived in similar previous studies. The policy implications of this finding are numerous: First, agricultural research (breeding, experimentation), extension programs and policy decisions influencing farmers' conditions should be tailored so that the risk aversion factor is not left out. High plateau farmers are willing to forego higher expected returns in exchange for reduction in their variability. Recommendations and policy decisions which fail to take into account this characteristic will not be accepted. Second, decision planners (e.g. the Ministry of Agriculture) should abandon the technology targeting approach if it is based solely on risk aversion differentials. The pure risk attitudes derived through the experiment do not warrant such a targeting strategy (either sectorwise or sitewise). Third, the concentration of most subjects, at relatively high payoff scales, in the intermediate and moderate risk aversion category supports Binswanger's (1980) conclusion that differences in risk attitudes should not be considered as a major determinant in farmers' investment behavior. The correlation results reported in chapter V reinforce this conclusion. Socioeconomic characteristics (age, schooling, income, area, number of working children, number of tractors owned, etc.) correlate poorly with estimated partial risk aversion coefficients. The implication of the regression results is that the policy decision which likely will have the most impact on subsistence farmers' economic condition is the one geared to lower the cost associated with the risk diffusion mechanisms (see appendix A). Official credit systems play an important role in risk diffusion in the socialist sector. The market cost of bearing risk is much lower in this sector compared to the private sector. As mentioned in chapter IV, under some circumstances, socialist farms were exempted from paying for some inputs. However, for the private sector the only means of risk adjustment available, e.g. sale of livestock and off farm jobs may be quite costly. The credit institutions capable of substantially lowering the market cost of bearing risk by private farmers exist but are not effective. In addition, recent major policy decisions appear in direct conflict with the objective of improving subsistence farmers' economic condition. The recent dissolution of the cooperative system (CAPCS[44]) in 1983, apparently for mismanagement reasons, accentuates the problem. According to most interviewed farmers (particularly those who do not own a tractor) the dissolution of the CAPCS will likely force them to lease their land because they expect equipment shortages and also much higher custom costs. This type of impromptu decision on the part of policy planners is counter productive in so far as the process of lowering market cost of risk bearing is concerned, i.e., it not only increases the cost of input usage but also increases the risk of input availability.

The rejection of the "asset integration" hypothesis implies that the individual's utility function is defined

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[44]-The CAPCS (service cooperatives) were established in order, among other objectives, to provide an input supply, credit and service network to the private sector (as well as to the Agrarian Revolution sector). Among the major tasks of the CAPCS were input supply and custom work activities (plowing, planting and harvesting) at very competitive prices and also to provide credit to private farmers (each CAPCS had a bank branch). Given the low level of mechanization in the private sector the impact of the CAPCS in reducing production costs was substantial (according to private farmers themselves). Each commune had its own CAPCS. As a result of the dissolution of these cooperatives, their entire equipment (tractors, combines, various implements) was auctioned at (sometimes) more than twice its original price after 5 or more years of utilization. Theoretically only private farmers of the commune were allowed to make bids for the auctioned items. However, according to most farmers interviewed, many bidders (who eventually acquired the equipment) were neither from the commune nor were they farmers. The bid prices for tractors and combines were out of reach of average private farmers. It does not appear that the negative effect of the dissolution of the CAPCS on small farmers' welfare was considered before implementing this major decision.

over losses and gains than rather final wealth. This in turn implies that the adequate game format should include gains as well as losses. A game procedure including gains and losses, however, poses analytical problems due to the lack of an adequate functional form. To circumvent this problem the outcomes at each payoff scale were translated into the positive domain by adding a constant represented by the neutral alternative. By using this procedure the constant partial risk aversion utility function can still be used to derive the partial risk aversion coefficients. The "gains only" sequence was used at the early stage of the experiment but the subjects rapidly expressed their discomfort with the method, i.e., they did not feel that they were betting anything since the money was given to them just before starting the games. In other words, they did not have the time to assimilate that the money given to them was in fact own. This unexpected problem has forced the author to revise the game format.

Partial risk aversion has been found to be increasing with higher payoffs. An increasing partial risk aversion utility function would, therefore, seem the appropriate functional form in modeling subjects risk preferences. The use of such a functional form is quite cumbersome and complex. However, the increase in partial risk aversion as payoff scale rises was not statistically significant implying that a constant risk aversion utility function could be used as an acceptable approximation to an increasing risk aversion utility function if it offers analytical simplicity.

The second part of this study was an attempt to use the risk coefficients derived in the experiment in a mathematical risk programming model (MOTAD). Six models (two models per each of the three sites; one model for the private and one for the socialist sector) were run at the various risk aversion levels.

In the socialist sector, the discrepancies between the model solution and actual activity levels were expected. The model solution reflects the director's and president's joint decisions. In reality, however, cropping pattern decisions are made outside the farm with little or no input from the directors and presidents. Credit facilities, easy access to inputs and other services to this sector are made commensurate to the level of adoption of the "recommended" cropping patterns. To appropriately model farming decisions in the socialist sector requires much more effort than available for this dissertation. The author's intent was to try to illustrate the obvious differences between actual practices and optimal solutions, given the technical constraint set. Many socialist farms only use a small proportion of such inputs as fertilizers and herbicides which are supplied to them. Since these farms have priority access to most inputs, they deplete the available market supply, even if none of the inputs acquired will be used, thus, indirectly preventing other farmers,i.e. private farmers, willing to use these inputs from acquiring them. In addition, socialist farms face a serious dilemma. On the one hand, their annual income is a function of their annual economic performance[45], i.e., they seek to maximize expected utility with due allowance to risk and uncertainty, and, on the other hand, they must comply with cropping patterns tailored to meeting local or national needs. The reconciliation of these two objectives is difficult.

In the private sector the risk programming model yielded solutions that are characteristic of the average conditions of the particular site (see notes under tables 31-33 for explanation of the difference between model solutions and current activity levels). In general, the solutions reflect the actual price structure. Given the gross margins per hectare and the variation associated with them, and also given that farmers of the region are risk averse, raising livestock is the most profitable

[45]- Annual net profits are distributed among all workers of the farm and constitute, with the monthly presalary provided by the government, their only source of income. However, as explained by Codron (1979) and most likely due to their inability to reconcile government objectives with optimal farming decisions, most workers resort to what is called parallel activities to the detriment of the overall farm performance.

(because of its small variance) alternative. The price of lamb has reached a very high level (as a result of increasing purchasing power, particularly in urban areas). On average, the price of one lamb approaches 800 DA. With relatively low raising costs (labor is usually provided by children of the household) and no input dependency (with the exception of straw during disastrous years), most private farmers (particularly in the high plateau region where cash crops such as vegetables and fruit trees cannot be grown due to the lack of irrigation possibilities) specialize in livestock and rainfed forages (oats and vetch-oats association). This would drive prices down if it were not for increasing urban demand. The sacrifice of millions of lambs in one single day during the Aid El Adha holiday (religious holiday) guarantees a very prosperous market.

The technical coefficients (labor and machinery) associated with each crop activity are identical. Therefore, at the risk neutral level and with given resource endowments, the crop with the highest gross margin will be selected. This leads to a single crop activity in the socialist sector. At higher risk levels, cereals are grown at their subsistence requirement levels (with the exception of the E.Eulma site) which reflects current price distortions, i.e., cereal output prices are low relative to other prices (livestock and poultry, for example, not to mention vegetables when irrigation is possible) and also the variance associated with cereal gross margins is such that for risk averse farmers leasing land and raising livestock appears to be the most rational and economically attractive alternatives. This should not imply that cereal prices should be increased substantially because it will only widen the gap between farm prices and consumer prices (the government subsidizes bread and flour prices). The reduction of risk bearing costs would certainly constitute a real incentive for these farmers to invest in cereal production. Because of large cereal imports the demand for bread and other cereal byproducts is usually satisfied. However, the supply of commodities such as meat (lamb and poultry, for example), vegetables and fruits most often falls short of demand. It is economically sound, under such circumstances and from the farmers' point of view, to give less weight to cereals (beyond subsistence requirements) in cropping decisions[46].

Finally, the data problem, as experienced in this study, constitutes a serious impediment to any empirical work, particularly in the private sector, but also in the socialist sector where, for example, returns to fertilizer and/or weed control are rarely quantified.

46- This behavior seems to be encouraged by policy planners and stands in direct contradiction with announced objectives. This is illustrated with the following anecdote. In 1983 (the year the study was conducted), the Wali (governor) of Setif issued official selling priority criteria for Mazda pick ups (truck sales are regulated) to private farmers. Paradoxically, in this region where almost three fourths of the area cropped are occupied by cereals, the "growing cereals" criterion was relegated to the last place. Selling priority was awarded to dairy farmers (in order to provide a sustained milk supply to the city consumers), to poultry growers (supply of meat and eggs) and to fresh vegetable farmers, i.e., those having access to irrigation and representing only a very small fraction of the farmer population. Such policies can hardly be considered as incentives to cereals farmers.

SUGGESTIONS FOR FUTURE EXTENSION.

The experiment results have indicated that farmers' pure risk attitudes are similar across sites and across sectors. This is true for the three communes of the E.Eulma Daira. An interesting extension (which was contemplated by the author but later abandoned because of staff and financial shortages) would be to run the experiment in another Wilaya, e.g. Tiaret (see map 1) and compare farmers' risk behavior in the two regions. If the latter is not statistically different, then any differential in input use and cropping pattern will likely be the result of differentials in the constraint set rather than differences in risk aversion. This, of course, poses the problem of cost associated with the experiment. However, since the results show that there is no statistical difference among rounds and between real versus hypothetical games, one alternative would be to first scale down the real payoffs, e.g. include a 100 DA payoff scale instead of a 200 DA and, second, to include more hypothetical rounds. This will substantially reduce the experiment costs and will, in addition, allow the inclusion of a larger sample size in the experiment.

The interviews are time consuming, particularly if the investigator(s) does not reside in the sample area. A practical suggestion to further lower the cost of the experiment would be to involve the experimental stations which would allow the use of their staff and transportation facilities.

The use of the "gains and losses" sequence proved to be prefered to the "gains only" sequence by all subjects. The investigation of the appropriate functional form for modeling both branches of the utility function would constitute an important improvement to the experimental approach. The constant partial risk aversion function used to derive the risk coefficients associated with each alternative has a tendency to inflate average risk aversion whenever there are subjects selecting the extreme or severe risk aversion alternatives. This occurs because of the wide interval of derived partial risk aversion coefficients between high risk alternatives (A and B) and moderate and slight to neutral alternatives (E and G). For example, if in a given sample there are 10 individuals selecting the moderate alternative E (for this alternative S =0.51) and only two individuals selecting the neutral alternative A (S = 8.25), then S will equal 1.80. This points to the need to narrow down the interval between the two most risk averse alternatives (A and B) and the others.

The lack of correlation between partial risk aversion and subjects' socioeconomic characteristics should be investigated more thoroughly. Special caution should be given to data collection relative to the explanatory variables included in the model. Interview and official data do not seem too reliable. Therefore, the investigator should be willing to spend more time and effort in order to carefully check the data before using them. Whenever possible instrumental variables should be used for suspicious data, e.g., income.

The particular structure of the socialist sector points to the appropriateness of multiple goals programming. Decisions at the farm level (in the socialist sector) has a lower weight than that emanating from the SDA, for example. Conventional linear programming (even with risk included) will not yield consistent solutions. Expressing the SDA objectives (in terms of crop acreage) as additional constraints to the socialist farm may constitute a fairly reasonable alternative to approximating the effect of agricultural policies on socialist farmers welfare.

The stochasticity of resource availability (particularly in the private sector) indicates that risk should also be included in the right hand side. This can be done through chance constrained programming (Boisvert). Resource endowment variability could be accounted for through the mean and standard deviation of resource supply as follows: $\sum_j a_{ij}X_j <= \overline{b}_i - \alpha w_i$ where b_i and w_i are the sample means and standard deviations of random b_i's[47] and α is the risk aversion coefficient associated with the individual resource constraints. It reflects the permissible probability of each particular random constraint to be violated. The objective function of the model is therefore maximized subject to the existing constraint set and to the additional constraint that stochastic resource "i" is available with some probability (1 - p) referred to as the security criterion. The relation between α and the security criterion is: $1 - \alpha^2 = (1 - p)$. Increasing the value of "p", i.e., lowering the value of α, will induce a rise in the value of $b_i - \alpha w_i$ implying that optimal solutions of the model are calculated under higher availability of random resources "i".

47- For certain resource endowments, the formulation remains as usual, i.e., $\sum_j a_{ij} X_j <= b_i$.

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APPENDICES

APPENDIX A

ADJUSTMENT TO RISK

The research area is a region characterized by a high weather induced risk (drought, frost,sirocco). What are the options available to farmers of the region to cope with production risk brought about by such an adverse environment? Wheat and barley yields are generally low (even during "good" years) and therefore do not allow a sustained satisfactory consumption level. A poor year may result in the inability of the farmer to satisfy the primary consumption needs of his household. Under such circumstances the farmer may be forced to seek off farm employment. However, job opportunities for unskilled workers (most private farmers are unskilled) are almost exclusively provided by the agricultural sector. The search for temporary off farm employment is discouraging. The insurance system is quasi nonexistent, except for the socialist sector[48]. As a result private farmers rely heavily on their own means for adjustment to risk.

It is usually assumed that subsistence farmers are more concerned in reducing consumption fluctuations rather than in reducing fluctuations in production and income. This implies that if subsistence farmers have the means to maintain their consumption level they would behave as profit maximizers (this, however, is not supported by the findings of this study). The four major means used by private farmers to sustain their consumption in "bad" years, e.g. a drought, are reported in table 1 . A potential use classification is associated with each mean used. Sale of livestock (mainly sheep) is the first potential source of risk adjustment to more than 65% of farmers interviewed. Search for off farm employment (this includes moving to urban centers as well as, in certain circumstances, overseas), is used as a second best

48- Theoretically bank loans and insurance schemes are available to the entire agricultural sector. However, the extention service has done a poor job in providing credit information to private farmers. Most private farmers are either not aware of the available credit possibilities or are intimidated by the heavy bureaucratic apparatus geared to the socialist sector and rich and/or influential farmers.

alternative to diffuse risk (43%). Borrowing[49] is cited as the third potential source of adjustment to risk by more than 47%. Family savings constitute the mechanism used the less. Farmers explained that they seldom have any cash surplus. The surplus (if any) is usually converted to livestock purchase and/or some type of improvement on the farm, e.g. construction, purchase of equipment, etc.

[49]- Private farmers very seldom solicit loans from official credit institutions such as the Bank for Agriculture and Rural Development (BADR) whose objective (at least theoretically) is to assist private farmers. When asked why they do not solicit loans from the BADR most farmers responded that even if they would their requests would not be granted. When asked how they came to this conclusion they usually responded that they had already tried once without success or that they know of other farmers whose requests have been turned down. As a result most of the borrowing is made from friends and/or relatives.

Table 1: Principal means of risk adjustment.

Adjustment mechanism		E.Eulma	O.Ladjoul	B.Fouda
		% of farmers per site		
Livestock sale	1st source	65.62	73.50	70.00
	2nd source	21.87	11.76	20.00
	3rd source	0.00	5.87	10.00
Off farm job search	1st source	12.50	2.95	10.00
	2nd source	43.75	47.05	55.00
	3rd source	25.00	29.41	20.00
Family savings	1st source	12.50	20.58	15.00
	2nd source	12.50	23.52	10.00
	3rd source	21.87	17.64	10.00
Loans	1st source	9.38	2.95	5.00
	2nd source	21.87	17.64	15.00
	3rd source	50.00	47.05	60.00

Note: Due to rounding errors total may not add up to 100.

If it were possible to grant private farmers sufficiently high interest rates for their savings and on the other hand allow them to borrow money at relatively low interest rates when they need it, i.e. drought years, then the capital market through this "balancing effect" could constitute an attractive option for risk diffusion. However, the role of the savings institutions is almost nil in the private sector because of the low and unattractive interest levels offered and/or the lack of confidence in these institutions (the rate of savings is usually very low , particularly in the rural areas where people prefer to invest in livestock or other durable items such as jewlery and land or even just keep the cash at home). The credit institutions, e.g. BADR, and the opportunities they offer, as indicated above, are not well known and are considered, rightly or wrongly, to be at the service of the rich and powerful.

As a result of the lack of impact on the part of the credit and savings institutions, private farmers resort to the options reported in table 1 to diffuse risk. The mechanisms used, however, are not cost free[50]. Farmers, for example, can sell livestock in drought years in order

[50]- It should be noted that, to the best knowledge of this author, there does not exist any quantitative data relative to the costs associated with the various mechanisms used. The assessment of these costs is, therefore, based mainly on observations and interviews.

to sustain their consumption stream and/or make the necessary investment for the following year (seeds, preparation and planting expenses). Once the drought is over they can in turn purchase livestock. Doing so, however, may generate substantial transaction costs, i.e. farmers are forced to sell at relatively low prices due to the high costs of carrying their livestock operation through the drought and may buy at relatively high prices when feed is available and when the demand for livestock is likely to be high (Jodha, 1978). The search for off farm employment is also costly due to transportation costs, food and lodging expenses not to mention the disatisfaction of leaving the family for a period of time. The other two mechanisms used, loans (mostly from friends and/or relatives) and family savings are also costly, through loss of prestige and loss of confidence in the future.

The study area, as already indicated, is characterized by high yield variability. The current options available to the farmers in order to cope with this harsh environment are relatively costly. The reduction of production risk through improved cultural practices and access to inputs may be a long and difficult endeavor[51]. The most urgent task seems to be the lowering

[51]- Many projects aimed at improving farmers' conditions have been conducted throughout the years with, unfortunately, too few successes to report.

of the cost associated with the risk diffusion mechanisms so that private agricultural investment would not shrink after every drought year. The necessary structures , e.g. BADR, already exist. Redesigning these structures' policies such that they can achieve the task for which they were created remains an important task. Unless official credit systems become more effective, farmers will likely continue to resort to the only risk diffusion devices available to them namely sale of livestock, laborious search for off farm employment, borrowing from friends and/or relatives and use of family savings (if any) with all the consequences they imply.

APPENDIX B

ESTIMATED GROSS MARGINS

Estimated Gross Margins for Durum Wheat - Private Sector

Years	76	77	78	79	80	81	82	83
Yield[1] E.E.	11.20	1.50	4.50	4.20	5.60	4.20	7.00	2.40
Yield[1] O.L.	7.00	0.70	2.80	2.10	2.80	2.80	5.60	1.40
Yield[1] B.F.	6.50	4.20	4.20	2.10	5.60	11.20	11.20	4.20
Price[2]	87.20	101.20	121.20	126.20	126.20	141.20	141.20	161.20
Straw Yield[3]	42	36	30	36	42	42	42	30
Straw Price[4]	8.00	9.00	12.00	12.00	13.50	13.50	15.00	17.50
Gr.Inc.[5] E.E	1312.64	475.80	905.40	962.04	1273.72	1160.04	1618.40	976.36
Gr.Inc.[5] O.L	946.40	394.84	699.60	697.02	920.36	962.36	1420.72	750.68
Gr.Inc.[5] B.F	906.28	749.04	869.04	697.02	1273.72	2148.44	2211.44	1202.04
Seed Costs[5]	93.20	107.20	127.20	132.20	132.20	147.20	147.20	167.20
Mach.Costs[5]	273.00	264.00	280.00	309.00	342.00	367.00	396.00	360.00
Labor Costs[5]	24.96	32.50	45.50	45.50	54.86	68.25	68.25	75.14
Var.Costs[5]	391.16	403.70	452.70	486.70	529.05	582.45	611.45	602.34
Gr.Margin[5] E.E	921.68	72.10	452.70	475.34	744.67	577.59	1006.95	374.02
Gr.Margin[5] O.L	555.24	-8.86	246.90	210.32	391.31	379.91	809.27	148.34
Gr.Margin[5] B.F	515.12	345.34	416.34	210.32	744.67	1565.99	1599.99	599.70

1/ In quintals per hectare (1 quintal = 100 kilograms).
2/ In dinars per quintal.
3/ In bales per hectare.
4/ In dinars per bale.
5/ In dinars per hectare.
E.E. = E. Eulma; O.L. = L. Ladjoul; B.F. = B. Fouda.

Estimated Gross Margins for Bread Wheat - Private Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	11.5	1.26	3.2	2.3	5.75	4.6	3.45	3.45
Yield O.L.	8.05	0.25	3.45	2.3	3.45	2.3	5.75	2.3
Price	79.2	91.2	111.2	116.2	116.2	131.2	131.2	151.2
Straw Yield	42	36	30	36	42	42	42	30
Straw Price	8	9	12	13.5	13.5	13.5	15.0	17.5
Gr.Inc. E.E	1246.8	438.91	715.84	699.26	1235.15	1170.52	1082.64	1046.64
Gr.Inc. O.L	973.56	346.8	743.64	699.25	967.89	868.76	1384.4	872.76
Seed Costs	85.2	97.2	117.2	122.2	122.2	137.2	137.2	157.2
Mach. Costs	273	264	280	309	342	367	396	360
Labor Costs	24.96	32.5	45.5	45.5	54.86	68.25	68.25	75.11
Variable Costs	383.16	393.7	442.7	476.7	519.05	572.45	601.45	592.34
Gr.Margin E.E	863.64	45.21	273.14	222.56	898.96	598.07	481.19	454.3
Gr.Margin O.L	590.4	-46.9	300.94	222.56	448.84	296.31	782.95	280.42

Estimated Gross Margins for Barley - Private Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	21.00	1.00	4.51	4.50	12	4.5	14.0	6.0
Yield O.L.	14.0	.80	4.80	4.80	6.4	6.4	16.0	6.4
Yield B.F.	5.30	3.2	3.50	6.80	9.60	14.40	16.0	8.0
Price	56.2	61.2	81.2	81.2	81.2	81.2	81.2	101.2
Straw Yield	44	39	33	39	44	44	44	33
Straw Price	8	9	12	12	13.5	13.5	15.0	17.5
Gr.Inc. E.E.	1532.21	412.20	761.4	833.4	1568.4	959.4	1796.8	1184.7
Gr.Inc. O.L.	1141.28	399.96	785.77	857.76	1113.12	1113.68	1959.2	1225.18
Gr.Inc. B.F.	648.74	546.84	681.82	1000.67	1373.52	1763.78	1959.2	1387.02
Seed Costs	62.2	67.2	87.2	87.2	87.2	87.2	87.2	107.2
Mach. Costs	276	268.5	286	315	347	372	402	369
Labor Costs	24.96	32.5	45.5	45.5	54.86	68.25	68.25	75.11
Variable Costs	363.16	368.7	418.7	447.7	489.06	527.45	557.35	560.01
Gr.Margin E.E	1169.05	44.0	342.7	385.7	1079.34	431.95	1239.95	624.69
Gr.Margin O.L	778.12	31.76	367.07	410.06	624.06	586.23	1401.85	665.17
Gr.Margin B.F	285.58	178.64	263.12	552.97	884.46	1235.82	1401.86	827.01

Estimated Gross Margins for Livestock*

Years	76	77	78	79	80	81	82	83
Yield	30	30	30	30	30	30	30	30
Price[1]	13.5	13.5	17	17	18	23	26	28
Wool[1]	10	12	12	12	15	15	20	20
Gr.Income[2]	415	417	522	522	555	705	800	860
Grazing Costs[2]	12.5	12.5	15	15	15	17.5	20	20
Straw Costs[2]	120	135	180	180	202.5	202.5	225	262.5
Lab.Costs[2] SS	41.5	54.0	75.6	75.6	91.15	113.4	113.4	124.80
Lab.Costs[2] PS	14.0	18.5	25.0	25.0	30.5	38.0	38.0	43.5
Var.Costs[2] SS	174.0	201.5	270.6	270.6	308.65	333.4	358.4	407.3
Var.Costs[2] PS	146.5	166	220	220	248	258	283	346.50
Gr. Marg.[2] PS	268.5	251	302	302	307	447.0	517.0	513.5
Gr. Marg.[2] SS		241.0	215.5	251.4	251.4	246.35	371.6	441.6

1-/ In dinars per kilo.
2-/ In dinars per sheep.
PS = Private Sector; SS = Socialist Sector.

* Based on an average 30 kgs lamb.

Estimated Gross Margins for Durum Wheat - Socialist Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	11.62	4	5.25	3.4	7.7	5.95	8.5	4.75
Yield O.L.	10.5	1.0	4.75	5.0	1.92	3.75	6.4	0.85
Yield B.F.	11.20	8.58	7.5	3.5	7.75	11.5	9.4	10.15
Price	87.2	101.2	121.2	126.2	126.2	141.2	141.2	161.2
Straw Yield	42	36	30	36	42	42	42	30
Straw Price	8	9	12	12	13.5	13.5	15.0	17.0
Gr.Inc. E.E	1349.25	728.8	996.3	861.08	1538.74	1407.14	1830.2	1290.7
Gr.Inc. O.L	1251.6	425.2	935.7	1063	809.3	1096.5	1563.68	662.02
Gr.Inc. B.F	1312.64	1192.29	1269	873.7	1545.05	2190.8	1957.28	2161.18
Seed Costs	93.2	107.2	127.2	132.2	132.20	147.2	147.2	167.2
Mach. Costs*	363.5	353	372	412	451	480	514.5	478
Lab. Costs**	32.5	38.4	59	59	71.3	89	89	98
Var. Costs	489.2	498.6	558.2	603.2	654.5	716.2	750.7	743.2
Gr. Mar. E.E	860.06	230.2	438.1	257.88	884.24	690.94	1079.5	547.5
Gr. Mar. O.L	762.4	-73.4	377.5	459.2	154.8	380.3	812.9	-81.18
Gr. Mar. B.F	823.44	693.69	710.8	270.5	890.55	1474.6	1206.58	1417.98

Estimated Gross Margins for Bread Wheat - Socialist Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	13.45	3.4	6.25	4.35	7.15	6.9	11.7	6.5
Yield O.L.	13.78	1.46	4.33	7	3.35	4.8	9.7	1.4
Yield B.F.	15.10	2.7	10.6	5.25	8.5	8.15	18.0	4.6
Price	79.2	91.2	111.2	116.2	116.2	131.2	131.2	151.2
Straw Yield	42	36	30	36	42	42	42	30
Straw Price	8	9	12	12	13.5	13.5	15.0	17.5
Gr. Inc. E.E	1401.24	634.08	1055.00	937.47	1397.83	1472.28	2165.04	1507.80
Gr. Inc. O.L	1427.37	457.15	841.49	1245.4	956.27	1196.76	1902.64	736.58
Gr. Inc. B.F	1531.92	570.24	1538.72	1042.05	1554.7	1636.28	2991.6	1220.52
Seed Costs	85.2	97.2	117.2	122.2	122.2	137.2	137.2	157.2
Mach. Costs	363.5	353	372	412	451	480	514.5	478
Labor Costs	32.5	38.4	59	59	71.3	89	89	98
Var. Costs	481.2	488.6	548.2	593.2	644.5	706.2	740.7	733.2
Gr. Mar. E.E	920.04	145.48	506.8	344.27	753.33	766.08	1424.34	774.6
Gr. Mar. O.L	946.17	-31.95	293.29	652.2	311.77	490.56	1161.94	3.38
Gr. Mar. B.F	1050.72	81.64	990.52	448.85	910.2	930.08	2250.9	487.32

Estimated Gross Margins for Barley - Socialist Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	20.7	4.36	10.75	7.40	15.6	6.65	15.8	8.4
Yield O.L.	12.55	1.5	2.5	8.0	4.45	4.5	8.65	6.78
Yield B.F.	21.5	3.7	10	5.8	8.85	11.55	6.9	5.5
Price	56.2	61.2	81.2	81.2	81.2	81.2	81.2	101.2
Straw Yield	44	39	33	39	44	44	44	33
Straw Price	8	9	12	12	13.5	13.5	15.0	17.5
Gr.Inc. E.E	1515.34	616.6	1268.9	1068.88	1860.72	1133.98	1942.96	1427.58
Gr.Inc. O.L	1057.31	442.8	599.00	1176.6	955.34	959.4	1362.38	1263.63
Gr.Inc. B.F	1560.3	577.44	1208.00	938.96	1312.62	1527.86	1220.28	1134.10
Seed Costs	62.2	67.2	87.2	87.2	87.2	87.2	87.2	107.2
Mach. Costs	366.5	317.5	378	418	456	485	520.5	487
Labor Costs	32.5	38.4	59	59	71.3	89	89	98
Var. Costs	461.2	463.1	524.2	564.2	614.5	661.2	696.7	692.2
Gr.Mar. E.E	1054.14	153.5	744.2	504.68	1246.22	472.78	1246.26	735.38
Gr.Mar. O.L	596.11	-20.3	74.8	612.4	340.84	298.2	665.68	571.63
Gr.Mar. B.F	1099.1	114.34	683.8	374.76	698.12	866.66	523.53	441.9

Estimated Gross Margins for D. Wheat (with fertilization)* - Soc. Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	15.10	4.4	4.73	4.25	9.63	7.44	11.05	4.52
Yield O.L.	13.65	1.10	4.28	6.25	2.4	4.69	8.32	0.85
Yield B.F.	14.6	9.45	6.75	4.38	9.7	14.4	12.25	9.65
Price	87.2	101.2	121.2	126.2	126.2	141.2	141.2	161.2
Straw Yield	48	44	38	44	48	48	48	38
Straw Price	8	9	12	12	13.5	13.5	15.0	17.0
Gr.Inc. E.E	1700.72	841.28	1029.27	1064.35	1863.3	1692.88	2280.26	1374.62
Gr.Inc. O.L	1574.28	507.32	947.73	1316.75	950.88	1310.22	1894.78	802.02
Gr.Inc. B.F	1657.12	1352.34	1274.1	1080.75	1872.14	2681.28	2449.7	2220.58
Seed Costs	93.2	107.2	127.2	132.2	132.2	147.2	147.2	167.2
Mach. Costs**	415.8	409.2	433.2	486	524.4	554.4	604.8	574.8
Labor Costs	32.5	38.4	59	59	71.3	89	89	93
Variable Costs	541.5	554.8	619.4	677.2	727.9	790.6	840.8	835.0
Gr.Mar. E.E	1159.22	286.48	409.87	387.15	1135.4	902.2	1439.55	539.62
Gr.Mar. O.L	1032.78	-47.48	355.33	639.55	222.98	519.6	1053.98	-32.98
Gr.Mar. B.F	1115.62	797.54	654.7	403.55	1144.24	1890.68	1608.9	1385.58

* Yields are identical to those obtained without fertilization but inflated as follows:

Year	1	2	3	4	5	6	7	8
	30%	10%	-10%	25%	25%	25%	30%	-5%

** Machinery costs (fertilizers included) inflated by 20 percent.

Estimated Gross Margins for B. Wheat (with fertilization) - Soc. Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	17.5	3.75	5.63	5.44	8.94	8.63	15.21	6.18
Yield O.L.	17.92	1.6	3.9	8.75	4.19	6.0	12.61	1.35
Yield B.F.	19.65	2.98	9.55	6.57	10.53	10.2	23.4	4.38
Price	79.2	91.2	111.2	116.2	116.2	131.2	131.2	151.2
Straw Yield	48	44	38	44	48	48	48	38
Straw Price	8	9	12	12	13.5	13.5	15.0	17.0
Gr.Inc. E.E	1770	738.0	1082.05	1155.68	1686.92	1780.25	2715.55	1599.41
Gr.Inc. O.L	1803.26	541.92	889.68	1544.75	1134.87	1435.2	2374.43	868.85
Gr.Inc. B.F	1940.28	667.77	1517.96	1291.43	1883.2	1986.24	3790.08	1327.25
Seed Costs	85.2	97.2	117.2	122.2	122.2	137.2	137.2	115.2
Mach. Costs	415.8	409.2	433.2	486	524.4	554.4	604.8	574.8
Labor Costs	32.5	38.4	59	59	71.3	89	89	98
Var. Costs	533.5	544.8	609.4	667.2	717.9	780.5	831.0	830.2
Gr.Mar. E.E	1236.5	193.2	472.65	488.28	969.02	999.65	1884.5	769.41
Gr.Mar. O.L	1269.76	-2.98	290.28	877.55	416.97	654.6	1543.43	38.85
Gr.Mar. B.F	1406.78	122.97	908.56	624.23	1165.3	1205.64	2959.08	497.25

Estimated Gross Margins for Barley (with fertilization) - Soc. Sector

Years	76	77	78	79	80	81	82	83
Yield E.E.	26.91	4.78	9.68	9.25	19.5	8.32	20.54	7.98
Yield O.L.	16.32	1.65	2.25	10.0	5.57	5.63	11.25	6.45
Yield B.F.	28.0	4.07	9.0	7.25	11.10	14.45	9.0	5.25
Price	56.2	61.2	81.2	81.2	81.2	81.2	81.2	101.2
Straw Yield	52	48	40	48	52	52	52	40
Straw Price	8	9	12	12	13.5	13.5	15.0	17.0
Gr.Inc. E.E	1928.34	724.53	1266.01	1327.1	2285.4	1377.58	2447.85	1507.57
Gr.Inc. O.L	1333.18	532.98	662.7	1388.0	1154.28	1159.15	1693.5	1352.74
Gr.Inc. B.F	1989.6	681.08	1210.8	1164.7	1603.32	1875.34	1510.8	1231.3
Seed Costs	62.2	67.2	87.2	87.2	87.2	87.2	87.2	107.2
Mach. Costs	435.6	413.34	438	495.6	536.4	566.4	619.2	582
Labor Costs	32.5	38.4	59	59	71.3	89	89	98
Var. Costs	530.3	518.94	584.2	641.8	694.9	742.6	795.4	787.2
Gr.Mar. E.E	1398.04	205.59	681.81	685.3	1590.5	634.98	1652.66	720.37
Gr.Mar. O.L	802.88	14.04	78.5	746.2	459.38	416.55	898.1	565.54
Gr.Mar. B.F	1459.3	162.14	626.6	522.9	908.42	1132.74	715.4	444.10

Gr.Inc. = Gross Income; Gr.Mar. = Gross Margins.
Mach. Costs = Machinery costs; Var. Costs = Variable Costs.

Data Sources

-Labor costs (livestock) based on data from "Etude de l'Integration de l'Elevage Ovin a la Cerealiculture sur les Hautes Plaines Cerealieres: Synthese des travaux realises durant quatre campagnes agricoles" IGC-OIRD (Daira de Tissemsilt, Fevrier 1978).

-Machinery costs: Based on data from:

1- "Analyse Agronomique et Economique des Essais CIMMYT-IDGC 1979-1980" Nov. 1980. By Ambar. S; H. Bouzerzour; M. Chengell; and P. Masson.

2- Farmers' interviews.

3- CAPCS (E.Eulma; O.Ladjoul and B.Fouda).

-Cereal prices: Based on data from OAIC (Setif) and CAPCS (E.Eulma, O.Ladjoul and B.Fouda).

-Yields: Based on data provided by DAP (Setif) and SDA E.Eulma.

-Straw yields and prices: Based on data based on CAPCS (E.Eulma, O.Ladjoul and B.Fouda) and farmers' interviews.

APPENDIX C

REGRESSION DATA

	lns4	lns8	lns10	lns9	lns11	age	school
1	.17	.17	.17	.17	.17	50.00	.00
2	-.67	-.67	.17	.17	1.28	33.00	.00
3	-.67	-.67	-.67	-.67	-1.85	58.00	.00
4	.17	.17	1.28	1.28	1.28	43.00	.00
5	.17	.17	1.28	-.67	.17	37.00	5.00
6	1.28	-1.85	-1.85	-.67	-1.85	32.00	.00
7	-5.30	-.67	-1.85	-.67	-.67	62.00	.00
8	-5.30	1.28	1.28	1.28	1.28	54.00	.00
9	-.67	1.28	.17	-1.85	1.28	45.00	.00
10	-1.85	.17	.17	.17	-.67	38.00	.00
11	.17	-1.85	.17	.17	-.67	54.00	.00
12	1.28	2.11	.17	2.11	2.11	28.00	.00
13	.17	-.67	.17	.17	1.28	75.00	5.00
14	.17	.17	2.11	2.11	2.11	62.00	6.00
15	.17	1.28	1.28	.17	.17	60.00	3.00
16	1.29	.17	1.28	1.28	1.28	56.00	2.00
17	-.67	.17	.17	1.28	1.28	31.00	1.00
18	.17	-.67	.17	.17	.17	63.00	3.00
19	.17	-.67	.17	.17	.17	64.00	.00
20	2.11	.17	.17	.17	.17	54.00	.00
21	.17	-5.30	-.67	1.28	1.28	64.00	.00
22	-5.30	-5.30	-5.30	-5.30	-5.30	27.00	6.00
23	-5.30	.17	1.28	1.28	1.28	55.00	.00
24	-6.73	.17	1.28	.17	.17	66.00	.00
25	-.67	1.28	.17	1.28	2.11	75.00	.00
26	-.67	1.28	.17	2.11	2.11	47.00	.00
27	-.67	-.67	.17	.17	.17	40.00	.00
28	2.11	-.67	.17	.17	.17	23.00	.00
29	-.67	-1.85	-.67	-.67	-.67	27.00	13.00
30	.17	.17	.17	.17	.17	60.00	.00
31	2.11	2.11	2.11	2.11	2.11	54.00	.00
32	1.28	1.28	.17	.17	.17	74.00	.00
33	.17	.17	1.28	.17	.17	37.00	6.00
34	-.67	-.67	.17	.17	.17	65.00	.00
35	.17	.17	.17	.17	.17	45.00	.50
36	2.11	1.28	2.11	1.28	1.28	64.00	.00
37	.17	1.28	1.28	1.28	1.28	49.00	.00
38	.17	1.28	.17	1.28	1.28	35.00	.00
39	.17	-.67	.17	1.28	.17	31.00	.00
40	-.67	.17	.17	1.28	1.28	34.00	4.00
41	-5.30	.17	.17	1.28	.17	55.00	.00
42	-1.85	-.67	.17	1.28	1.28	49.00	4.00

	lns4	lns8	lns10	lns9	lns11	age	school
43	.17	1.28	1.28	.17	1.28	40.00	.00
44	-.67	.17	1.28	.17	.17	38.00	5.00
45	1.28	-1.85	-.67	-.67	-.67	51.00	1.00
46	.17	.17	.17	1.28	.17	55.00	.00
47	-.67	2.11	1.28	.17	1.28	26.00	.00
48	.67	-.67	.17	2.11	2.11	29.00	10.00
49	.17	.17	1.28	2.11	.17	58.00	2.00
50	.17	.17	.17	1.28	.17	73.00	.00
51	1.28	.17	.17	1.28	1.28	51.00	.00
52	-.67	-1.85	-.67	-.67	-.67	44.00	1.00
53	.17	.17	1.28	.17	.17	45.00	.00
54	2.11	2.11	2.11	2.11	2.11	45.00	.00
55	-.67	.17	1.28	.17	.17	48.00	.00
56	-.67	1.28	1.28	.17	1.28	52.00	.00
57	1.28	1.28	1.28	.17	1.28	56.00	.00
58	2.11	2.11	2.11	2.11	2.11	59.00	6.00
59	.17	-.67	.17	1.28	1.28	31.00	.00
60	.17	.17	2.11	-.67	.17	50.00	.00
61	.17	.17	.17	1.28	1.28	65.00	.00
62	-.67	.17	.17	1.28	2.11	54.00	.00
63	.17	.17	.17	.17	1.28	34.00	3.00
64	1.28	1.28	.17	2.11	2.11	59.00	.00
65	.17	.17	.17	1.28	.17	60.00	.00
66	2.11	1.28	1.28	1.28	1.28	30.00	.00
67	.17	1.28	2.11	.17	1.28	68.00	.00
68	-5.30	.17	.17	.17	.17	65.00	.00

REGRESSION DATA

	child	woagchil	herdsize	area	tractors	ofarminc	radio
1	7.00	.14	34.00	8.00	.00	.00	1.00
2	2.00	.00	.00	1.00	.00	80.00	.00
3	6.00	.17	.00	7.00	.00	70.00	1.00
4	10.00	.00	50.00	8.00	.00	.00	1.00
5	5.00	.00	42.00	8.00	.00	10.00	1.00
6	5.00	.00	16.00	2.00	.00	70.00	1.00
7	11.00	.55	19.00	9.00	.00	80.00	1.00
8	12.00	.08	122.00	38.00	1.00	.00	1.00
9	9.00	.11	30.00	13.00	1.00	20.00	1.00
10	6.00	.00	31.00	15.00	.00	.00	.00
11	2.00	.50	.00	12.00	.00	.00	.00
12	5.00	.00	57.00	5.00	.00	.00	1.00
13	6.00	.33	71.00	23.00	.00	.00	1.00
14	7.00	.29	.00	2.50	.00	40.00	1.00
15	5.00	.00	82.00	80.00	1.00	.00	.00
16	13.00	.23	71.00	20.00	2.00	40.00	1.00
17	5.00	.00	.00	1.50	.00	.00	.00
18	10.00	.20	74.00	27.50	.00	.00	1.00
19	8.00	.00	11.00	4.00	.00	20.00	1.00
20	9.00	.11	35.00	6.00	.00	10.00	1.00
21	6.00	.66	35.00	10.00	.00	.00	.00
22	.00	.00	40.00	47.00	1.00	.00	1.00
23	2.00	.00	20.00	4.50	.00	.00	1.00
24	12.00	.00	58.00	40.00	1.00	.00	1.00
25	2.00	.00	50.00	35.00	2.00	20.00	1.00
26	2.00	.00	37.00	1.00	.00	10.00	.00
27	7.00	.14	110.00	33.00	1.00	30.00	1.00
28	1.00	.00	61.00	20.00	1.00	.00	1.00
29	.00	.00	108.00	94.00	.00	.00	1.00
30	8.00	.38	21.00	15.00	.00	.00	1.00
31	7.00	.14	21.00	18.00	.00	70.00	1.00
32	4.00	.00	142.00	92.00	2.00	.00	.00
33	4.00	.00	72.00	30.00	1.00	30.00	1.00
34	5.00	.20	24.00	50.00	1.00	.00	1.00
35	5.00	.40	22.00	6.00	.00	30.00	1.00
36	9.00	.33	61.00	26.00	.00	50.00	1.00
37	2.00	.50	30.00	29.00	.00	.00	1.00
38	5.00	.00	10.00	20.00	.00	.00	.00
39	4.00	.00	5.00	15.00	.00	.00	1.00
40	5.00	.00	15.00	28.00	.00	.00	1.00
41	9.00	.33	31.00	8.00	.00	35.00	.00
42	7.00	.00	36.00	20.00	.00	.00	1.00

	child	woagchil	herdsize	area	tractors	ofarminc	radio
43	9.00	.11	72.00	18.00	.00	.00	.00
44	9.00	.11	143.00	30.00	1.00	.00	1.00
45	7.00	.14	42.00	45.00	1.00	20.00	1.00
46	9.00	.22	50.00	27.00	.00	.00	1.00
47	5.00	.00	9.00	.00	.00	90.00	1.00
48	3.00	.00	.00	4.00	.00	90.00	1.00
49	8.00	.38	25.00	23.50	.00	.00	1.00
50	11.00	.27	75.00	13.00	1.00	30.00	1.00
51	8.00	.13	.00	25.00	1.00	40.00	1.00
52	5.00	.00	.00	4.00	.00	.00	1.00
53	8.00	.00	.00	14.00	1.00	20.00	1.00
54	.00	.00	51.00	12.00	.00	.00	1.00
55	13.00	.31	70.00	22.00	.00	20.00	1.00
56	7.00	.14	61.00	35.00	1.00	20.00	1.00
57	7.00	.71	45.00	8.50	.00	20.00	1.00
58	11.00	.18	.00	22.00	.00	40.00	1.00
59	2.00	.00	.00	35.00	2.00	30.00	1.00
60	6.00	.67	140.00	19.00	.00	.00	1.00
61	7.00	.71	134.00	32.00	.00	20.00	1.00
62	7.00	.29	.00	7.00	.00	50.00	.00
63	4.00	.00	.00	5.50	.00	.00	1.00
64	8.00	.25	35.00	14.00	.00	.00	1.00
65	8.00	.25	.00	12.00	.00	.00	1.00
66	3.00	.00	.00	44.00	1.00	.00	1.00
67	8.00	.25	35.00	10.00	1.00	.00	.00
68	9.00	.56	.00	12.00	.00	.00	.00

REGRESSION DATA

	luck4	luck8	luck10	luck9	luck11	grosinc
1	1.00	-1.00	-1.00	-2.00	-2.00	20.00
2	1.00	-1.00	1.00	.00	.00	12.00
3	-1.00	1.00	1.00	.00	.00	30.00
4	-1.00	1.00	1.00	2.00	2.00	20.00
5	1.00	-3.00	-5.00	-4.00	-4.00	300.00
6	-1.00	-3.00	-1.00	-2.00	.00	25.00
7	-1.00	-1.00	-1.00	-2.00	.00	50.00
8	-3.00	-1.00	-1.00	.00	.00	80.00
9	3.00	-1.00	-3.00	-2.00	-4.00	25.00
10	1.00	-1.00	1.00	.00	2.00	12.00
11	-1.00	-3.00	-5.00	-4.00	-4.00	10.00
12	-1.00	-2.00	-2.00	-2.00	-1.00	7.00
13	1.00	1.00	-1.00	.00	.00	30.00
14	3.00	3.00	2.00	2.00	2.00	50.00
15	-1.00	-1.00	-1.00	-2.00	.00	40.00
16	-1.00	.00	2.00	1.00	1.00	210.00
17	-1.00	-1.00	-1.00	-2.00	.00	30.00
18	1.00	-1.00	-1.00	.00	.00	30.00
19	-1.00	1.00	3.00	2.00	4.00	9.00
20	2.00	3.00	5.00	4.00	4.00	20.00
21	-1.00	-1.00	1.00	.00	2.00	20.00
22	.00	-2.00	-2.00	-1.00	-1.00	50.00
23	3.00	1.00	1.00	.00	.00	10.00
24	1.00	1.00	-1.00	.00	.00	25.00
25	1.00	.00	.00	1.00	-1.00	25.00
26	1.00	-1.00	.00	.00	1.00	5.00
27	1.00	1.00	-1.00	.00	.00	30.00
28	1.00	.00	-2.00	-1.00	-3.00	25.00
29	.00	2.00	2.00	1.00	1.00	20.00
30	.00	-1.00	-1.00	.00	-2.00	20.00
31	.00	.00	.00	.00	.00	30.00
32	1.00	2.00	2.00	3.00	2.00	35.00
33	1.00	1.00	-2.00	-1.00	-1.00	40.00
34	-1.00	1.00	1.00	.00	.00	30.00
35	1.00	3.00	5.00	4.00	6.00	15.00
36	.00	1.00	3.00	2.00	3.00	100.00
37	-3.00	-5.00	-7.00	-6.00	-6.00	30.00
38	-1.00	1.00	-1.00	.00	.00	30.00
39	1.00	3.00	3.00	4.00	2.00	40.00
40	1.00	-1.00	1.00	.00	2.00	10.00
41	-3.00	-4.00	-4.00	-3.00	-5.00	25.00
42	1.00	5.00	5.00	4.00	6.00	30.00

	luck4	luck8	luck10	luck9	luck11	grosinc
43	1.00	-2.00	-2.00	-3.00	-1.00	20.00
44	2.00	2.00	.00	1.00	-1.00	40.00
45	-3.00	-1.00	-1.00	.00	.00	40.00
46	1.00	1.00	-1.00	.00	.00	20.00
47	-1.00	.00	-1.00	.00	.00	13.60
48	1.00	3.00	4.00	4.00	5.00	13.90
49	1.00	1.00	2.00	2.00	1.00	150.00
50	-1.00	.00	.00	-1.00	1.00	13.00
51	-3.00	-7.00	-7.00	-6.00	-8.00	30.00
52	1.00	-1.00	-1.00	.00	.00	3.00
53	-1.00	1.00	1.00	2.00	2.00	20.00
54	.00	.00	.00	.00	.00	25.00
55	-1.00	-1.00	-3.00	-2.00	-2.00	60.00
56	1.00	3.00	3.00	4.00	2.00	30.00
57	3.00	5.00	5.00	6.00	4.00	20.00
58	.00	.00	.00	.00	.00	30.00
59	-1.00	-3.00	-3.00	-4.00	-2.00	40.00
60	1.00	1.00	3.00	2.00	3.00	50.00
61	.00	2.00	.00	1.00	-1.00	120.00
62	-1.00	-1.00	1.00	.00	2.00	25.00
63	-1.00	-1.00	-1.00	-2.00	-2.00	40.00
64	-1.00	-1.00	.00	.00	-1.00	20.00
65	-1.00	-2.00	-2.00	-1.00	-3.00	20.00
66	-1.00	.00	2.00	1.00	1.00	60.00
67	-3.00	-1.00	-1.00	.00	-1.00	15.00
68	1.00	1.00	1.00	.00	.00	5.00

Note: Observations 1 through 22 refer to E.Eulma data.

Observations 23 through 48 refer to O.Ladjoul data.

Observations 49 through 68 refer to B.Fouda data.

APPENDIX D

EXPLANATION OF THE LETTER CODE OF THE LP

Explanation of the tableu activities.

1. Private sector.

DW = Durum Wheat; BW = Bread Wheat; B = Barley. L = Livestock; OFR = Own Fallow Leased; A = Area Cropped; F = Fallow; TC = Total Cereals; CAPF = Cereal Area Plowed in Fall; GF = Grazed Area; OF = Own Fallow; RF = Rented Fallow; OS = Own Straw; PS = Purchased Straw; AL = Annual Labor; AM = Annual Machinery; Y_k = Absolute Value of Negative Deviation in Gross Margins under State of Nature k (k = 1.....8) SD = Standard Deviation of Gross Margins; Z = Integer Variable <=1.

2. Socialist Sector.

D0 = Durum Wheat without fertilizer; D1 = Durum Wheat with fertilizer; BW0 = Bread Wheat without fertilizer; BW1 = Bread Wheat with fertilizer; B0 = Barley without fertilizer; B1 = Barley with fertilizer; TD = Total Durum Wheat; TBW = Total Bread wheat; Tb = Total Barley; TF = Total Fallow; F0 = Fallow without Phosphorus; F1 = Fallow with Phosphorus; CAPF0 =

Cereal Area Plowed in Fall without Phosphorus ; CAPF1 = Cereal Area Plowed in Fall with Phosphorus. FERT = Fertilizer; L; A; GF; OF; OS; AL; AM; Y_k; SD; as in Private Sector above.

LINDO Letter Code Used to Represent the LP Coefficients.

Z	.000000	thru	.000001
Y	.000001	thru	.000009
X	.000010	thru	.000099
W	.000100	thru	.000999
V	.001000	thru	.009999
U	.010000	thru	.099999
T	.100000	thru	.999999
A	1.000001	thru	10.000000
B	10.000001	thru	100.000000
C	100.000001	thru	1000.000000
D	1000.000001	thru	10000.000000
E	10000.000001	thru	100000.000000
F	100000.000001	thru	1000000.000000
G		>	1000000.000000