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DEMAND FOR RAINFALL-INDEX BASED INSURANCE: A CASE STUDY FROM MOROCCO

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ABSTRACT

In this paper, we derive estimates for willingness to pay for rainfall-index based insurance contracts. Surveys were undertaken in four regions in Morocco, representing different mean and variability of rainfall conditions. Results indicate that respondents in the high variability regions preferred contracts that paid out more often (had higher rainfall trigger levels), and which were more costly. In fact, a strong majority of respondents indicated they would purchase these contracts at the fair-value price; the estimated median willingness to pay for such contracts was between 12-20 percent above the fair value contract. However, in the lower rainfall variability regions, the cheaper contracts with lower trigger values were the only contracts for which the estimated median willingness to pay was greater than the fair-value of the contract. Finally, estimated coefficients for explanatory variables such as human and physical assets, debt levels, etc. did not have consistent impacts, either across or within regions.

KEYWORDS: agricultural insurance, dryland agriculture, willingness to pay

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DEMAND FOR RAINFALL-INDEX BASED INSURANCE: A CASE STUDY FROM MOROCCO

Nancy McCarthy[1]

1. INTRODUCTION

In this paper, we present results of a willingness to pay study, where respondents were asked to consider their demand for hypothetical rainfall-index based insurance contracts. With rainfall-index based insurance, payouts for those purchasing an insurance contract are based on how much rainfall is received at a specified rainfall station. It is not based on the individual's own yields. This type of contract reduces the potential for moral hazard and should also have lower administrative costs. On the other hand, to the extent that own yields and rainfall at the specified station are not perfectly correlated, the purchaser will still face residual, or basis, risk. In this paper, we examine the demand for this type of insurance contract in areas of Morocco where previous research indicates a fairly high degree of correlation between grain yields and rainfall recorded at local stations (Skees et al. 2001).

2. CASE STUDY AREA

Using the data presented in Skees et al. (2001), we chose four areas in which to undertake the survey. Two provinces, Settat and Meknes, have relatively high mean rainfall and crop yields; but farmers in Settat experience greater temporal variability in

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crop yields than do those in Meknes. On the other hand, Oujda and Essaouira have much lower mean rainfall and crop yields; here, Essaouira exhibits greater temporal variability.

Table 1--Average and coefficient of variation of soft and hard wheat yields

	Hard Wheat		Soft Wheat	
	Yield/ha	Coef. Variation	Yield/ha.	Coef. Variation
Settat	10.4	.79	12.6	.68
Meknes	8.9	.38	11.3	.37
Essaouira	6.5	.62	5.5	.64
Oujda	4.2	.54	5.2	.40

Rainfall data for the period 1970-1999 was used to estimate cumulative and probability density functions, on which the expected values of the contracts were based. For each rainfall data series, a third-order polynomial was fit to the data to generate the CDF's. In the higher rainfall areas, Settat and Meknes, the fit of the estimated distribution was quite high (.99), but the estimated distribution at the lower end was somewhat poor. Because the contracts are proportional, the highest payouts occur at very low rainfall, and the estimated distributions for these two areas tended to over-estimate the probability of very low rainfall and thus the expected value of the payout. This means that the estimated expected value of the contract was likely higher than the "true" expected value. We thus used a spline function to separately estimate the distribution at very low rainfall realizations and the estimated distribution at higher levels. Graphs of the cumulative density function are presented in Appendix 1, along with the equations used to estimate the CDF's and PDF's and thus the contract parameters for different rainfall trigger levels. The rainfall trigger level is that level below which a payout occurs;

in the contracts specified in the survey, payouts were proportional to the rainfall deficit below a given trigger. In the survey, we based contracts on three different trigger levels. The 50 percent trigger is based on median rainfall, with an expected payout every other year, the 33 percent trigger is the rainfall corresponding to an expected payout every third year, and the 25 percent trigger, rainfall corresponding to an expected payout every fourth year. Furthermore, we used data on revenue per hectare provided in Skees et al. on which to base coverage levels; average revenue per hectare was used for the 100 percent coverage level, and 80 percent of average revenue was used to generate values for the 80 percent coverage contracts.

3. SURVEY IMPLEMENTATION AND DESCRIPTIVE STATISTICS

Only those households within a 20 km radius of a rainfall station were included in the sampling framework. Also, we restricted attention to households considered to have sufficient landholdings to be net sellers in general; thus, in Meknes and Settat, only farmers with landholdings exceeding 5 has. were considered[2], minimum landholdings in Oujda and Essaouira were 10 has.

As shown above, six different soft wheat contracts were drawn up for each region, with three different trigger values and two coverage levels. Given that this was a single round survey, a wide range of contracts were developed to check that responses were consistent and that respondents understood the hypothetical contracts being offered to them. Internal consistency was checked by varying the coverage level; lower coverage for the trigger should result in a lower willingness to pay. Similarly, external consistency

[2] Though, we note that all farmers in Settat actually had landholdings exceeding 15 has.

was checked by varying the trigger; lower rainfall trigger levels should result in a lower willingness to pay. Responses were generally both internally and externally consistent in three of the four areas, but neither internally nor externally consistent for most contracts offered in Meknes. We discuss these issues more fully in section 4 below.

Each contract had a lower and upper bound value, the lower bound coincided with the expected – or fair – value of the contract, and the upper bound was equal to the expected value plus 15 percent. Respondents were told that contracts would be offered at the beginning of the cropping season. They were then asked to consider four contracts, which corresponded to two coverage levels for each of two trigger levels. The respondent was instructed to consider each contract as if it were the only option available. In Table 2, we present the bid values used in the willingness to pay questions.

The willingness to pay questions followed a 1 ½ bound design, where those who were offered an upper bound contract were only asked a follow-up question if they responded “no”, and those offered a lower bound contract were only asked a follow-up question if they responded “yes”. The follow-up question was open-ended; if the respondent answered “no” to the upper bound contract, he was then asked how much he would pay for the contract, if the respondent answered “yes” to the lower bound contract, he was then asked what was the most he would pay for the contract.

Table 2--Contract Parameters

	Lower Bound Bid Value (Dh)	Upper Bound Bid Value (Dh)
Settat		
50% Trigger, 100% Coverage	390	450
50% Trigger, 80% Coverage	310355	
33% Trigger, 100% Coverage	195	225
33% Trigger, 80% Coverage	160	185
25% Trigger, 100% Coverage	110	130
25% Trigger, 80% Coverage	90105	
Meknes		
50% Trigger, 100% Coverage	300	345
50% Trigger, 80% Coverage	240	275
33% Trigger, 100% Coverage	170	195
33% Trigger, 80% Coverage	135	155
25% Trigger, 100% Coverage	105	120
25% Trigger, 80% Coverage	85	100
Essaouira		
50% Trigger, 100% Coverage	230	265
50% Trigger, 80% Coverage	180	205
33% Trigger, 100% Coverage	140	160
33% Trigger, 80% Coverage	110	125
25% Trigger, 100% Coverage	95	110
25% Trigger, 80% Coverage	75	85
Oujda		
50% Trigger, 100% Coverage	200	230
50% Trigger, 80% Coverage	160	185
33% Trigger, 100% Coverage	115	130
33% Trigger, 80% Coverage	95	110
25% Trigger, 100% Coverage	75	85
25% Trigger, 80% Coverage	60	70

Interestingly, in almost all cases where the respondent answered "yes" to the lower bound contract, the follow-up response to the open-ended question was less than the contract value that the respondent just said he would pay. DeShazo (2002) gives a review of studies that find bias in follow-up questions[3], and presents a theoretical basis for downward bias in follow-up responses where the starting point is the lower bound and the

[3] In many of the implemented surveys, the follow-up questions are dichotomous choice (a new premium is offered, and the person responds "yes, I would purchase it" or "no, I would not purchase it"; whereas our follow-up was an open-ended question.

follow up question asks about a willingness to pay for a higher amount. Essentially, after having said “yes” to the first dichotomous choice question, the respondent uses the first bid offered as a reference point, and engages in “loss averting” behavior, usually by restating that the initial bid is the highest amount he/she would have paid. This can also be considered a type of protest bid. Because our follow-up was open-ended, it is quite possible that respondents’ engaged in loss-averting behavior when responding to the open-ended follow-up, giving a lower value in the belief that this might influence actual contracts offered in the future. Given that our data clearly reflect this predicted pattern of bias in the second-stage responses, we restrict analysis to the first-stage dichotomous choice responses.

Before proceeding to the analysis, below we present some basic statistics on demographics, landholdings and crop diversification patterns, asset holdings, income sources, and formal credit. We expect that rainfall index-based insurance will be more valuable in regions with greater rainfall variability of course, but demand should also be higher where risk management and/or coping mechanisms are relatively more costly. Practically, it is difficult to obtain a measure of the costliness of alternative management and coping mechanisms, however. Skees et al. (2001) note that in the Moroccan context, current risk coping and management strategies include diversifying labor allocation into the off-farm wage sector, using fewer inputs, using less risky but less productive local seeds, and holding livestock – particularly sheep – to sell when needed. The authors note, however, that livestock is itself risky, and its output price is likely to be positively correlated with rainfall (and reduced livestock production), so it is likely to be a very inefficient risk management tool. The authors note that other factors likely to influence the decision to use insurance are variables that enable the farmer to understand the insurance product, i.e. education levels and technical assistance; higher coverage levels; and perhaps most importantly, enough cash on hand at the beginning of the season to actually purchase the insurance.

Another variable that might capture "costs" of current risk management strategies is crop diversity patterns, though it is problematic to interpret what this variable actually reflects. For instance, to the extent that crop diversity reflects a risk management strategy, then we expect the demand for insurance to be greater the greater is crop diversity. However, to the extent that crop diversity is undertaken to take advantage of different soil characteristics and/or in response to seasonal marketing opportunities, then crop diversity should have little if any impact on the demand for insurance. Access to irrigated land, on the other hand, should reduce demand for insurance – except to the extent that availability of irrigation water is itself a function of rainfall, in which case there may be no additional impact on demand for insurance. To capture risk preferences, we have included a dummy variable that takes a value of 1 if the respondent holds improved-breed cattle; we hypothesize that engaging in this activity proxies a greater willingness to take risks, *ceteris paribus*.

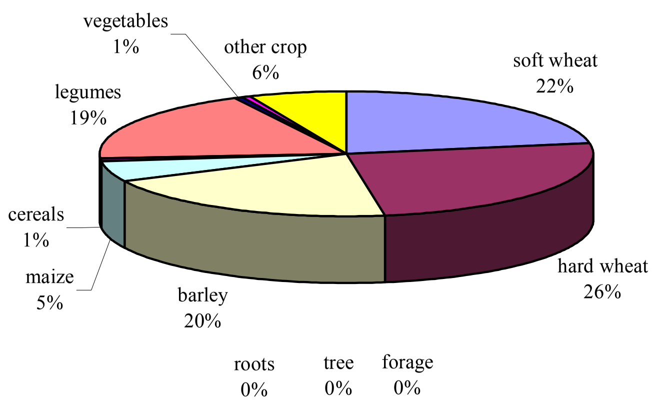
Greater stocks of human capital are expected to reduce the demand for insurance, since those with greater education and/or number of working-age adults are hypothesized to have more flexibility in the labor market and thus to bear lower relative costs of current risk management and coping strategies. Asset ownership, both land and physical assets, are included as wealth proxies, and are thus hypothesized to reduce demand for insurance. The respondent's debt level, on the other hand, is hypothesized to increase the demand for insurance (Vandeveer and Loehman 1994).

Though the above hypotheses regarding demand for insurance are quite standard, they may not adequately account for missing markets in more than just risk. To the extent that credit markets are imperfect and households often find themselves cash constrained – at the very least, seasonally – higher relative asset holdings may instead capture the capacity of the household to purchase insurance contracts at the beginning of the planting season, when cash flows are generally tightest. If so, the hypothesized impacts of asset variables would be opposite to that predicted when considering asset holdings as a proxy for wealth and lower relative costs to current risk management and coping strategies.

LAND

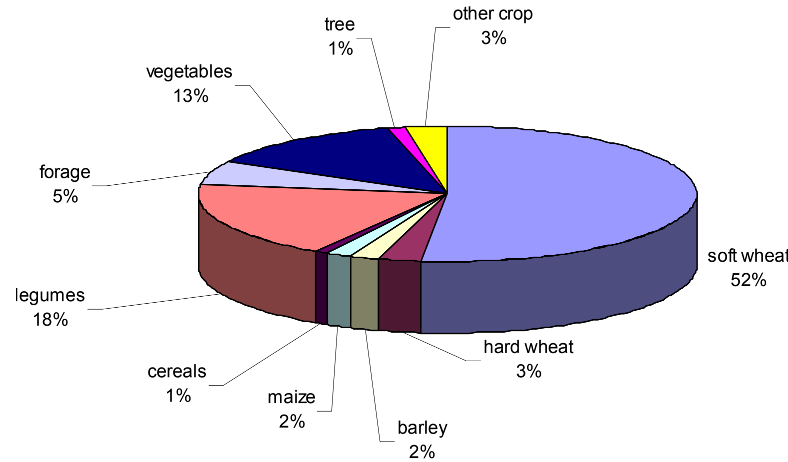
Average cropped land in Settat is the largest, with a mean of 28 has., but only a tiny fraction (less than one percent) is irrigated. In Meknes, average landholding is about 9 has., with 13 percent irrigated. In Oujda, average landholding is 17 has, with 10 percent irrigated. Total cropped land in Essaouira is 21 has, but like Settat, none of the farmers had irrigated land. It is interesting to note at the outset that it is precisely in the two less variable areas – Meknes and Oujda – where at least some land is irrigated; even though the two differ substantially in terms of average rainfall. In fact, crop diversification patterns appear to be more closely related to variation in rainfall, rather than to mean rainfall, as illustrated in charts 1-4, below.

Chart 1--Cropland allocation, Settat



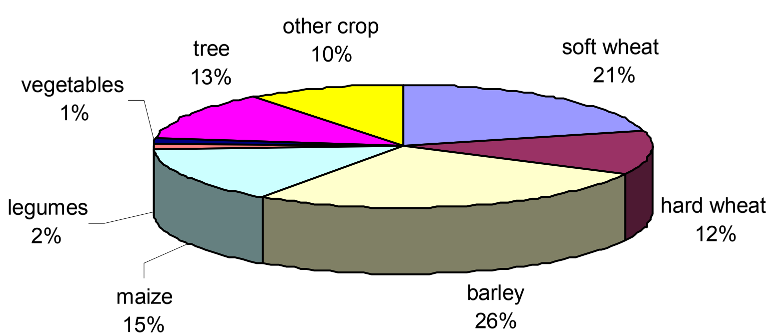
Grains=73%, Crop Diversity Index=.63

Chart 2: Cropland allocation, Meknes



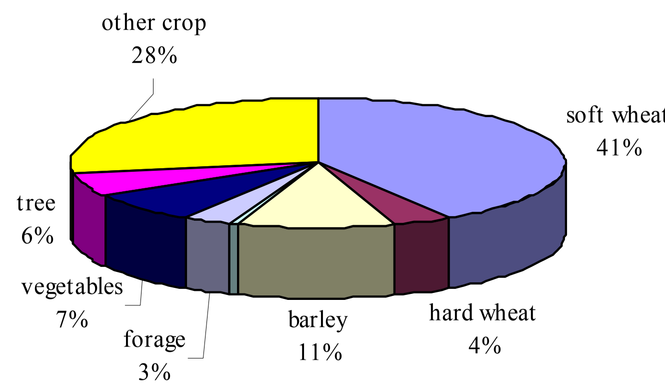
Grains=60%, Crop Diversity Index=.38

Chart 3-- Cropland allocation, Essaouira



Grains=74%, Crop Diversity Index=.62

Chart 4--Cropland allocation, Oujda



Grains=56%, Crop Diversity Index=.52

As clearly highlighted in the charts above, lands allocated to grain and crop diversity indices are almost identical in the two high variability environments; nearly 75 percent of the land is allocated to grains, and the crop diversity indices are just over .6. In the low variability areas, both the land allocated to grains and the crop diversity indices are significantly lower, though diversity is then higher in the low-rainfall vs. high rainfall area. In general, then, land allocation and diversification patterns accord well with general hypotheses.

In Table 3 below, we present descriptive statistics for human and physical capital. We include the number of teenaged and adult males per household and a density of education variable constructed as an unweighted average of the years of schooling by household males over 12, times the number of males over 12[4]. Physical capital includes the number of agricultural buildings, the number of pieces of agricultural equipment, the number of large ruminants (cattle and camel) and the number of small ruminants (goats and sheep). In the final column, we report an index of physical capital constructed using scoring coefficients from a factor analysis; this index is used in the regression analysis primarily to reduce collinearity and preserve degrees of freedom.

[4] From the data, it seems apparent that full data on females in the household was not obtained by the enumerators. We thus include only information on males over 12 in the household, as this data appears to be complete, and consistent with other demographic sources.

Table 3--Human and physical capital, descriptive statistics

	Settat	Meknes	Essaouira	Oujda
Human Capital				
Number of Males>12	1.9	3.1	2.1	3.2
Average Years School	2.5	2.9	2.8	2.7
Physical Capital				
Number of Buildings	3.1	1.5	2.7	1.6
Number of Equipment	3.2	2.3	2.6	2.7
Number Large Ruminants	2.4	1.5	2.2	1.4
% Households with Large Ruminants	71%	50%	80%	48%
Number Small Ruminants	34.2	8.1	40.0	30.3
% Households with Small Ruminants	85%	41%	98%	94%
Physical Asset Index	1.74	.30	1.50	.46

Somewhat surprisingly, there are fewer male adults in the high variability regions of Settat and Essouaira, but in general, greater stocks of physical capital precisely in those regions. Schooling, on the other hand, is fairly uniform and low across regions. Livestock assets are quite important in all regions, but large ruminants (predominantly cattle) are more important in high variability regions. Small ruminant holdings, on the other hand, appear to be driven more by average rainfall rather than variability; they are held by almost all households in the low rainfall regions.

Finally, we present descriptive statistics on the number of households with formal credit, debt levels, and the number of households that hold improved breeds of cattle. This data is presented in Table 4 below

Table 4--Household Debt and Improved Breeds

	Settat	Meknes	Essaouira	Oujda
Number of Households, Formal Credit	24	34	12	7
Avg. Debt, those with Credit (1000 Dh)	11	11	1.5	8.1
Number of Households, Improved Breeds	19	17	15	17

In terms of borrowing and debt levels, respondents in the high rainfall regions appear to be more able to access formal credit; more than half of the respondents in Settat and Meknes received formal credit, and the average amount was nearly the same, about Dh11,000. Fewer than one quarter of the households received credit in Essaouira and Oujda, and the amount per loan was significantly lower in Essaouira. The proportion of households holding improved breeds is quite similar across regions, with more than a third of households doing so in all regions.

4. WILLINGNESS TO PAY

Sarris (2002) discusses the producers' valuation of insurance under three different assumptions about the optimization problem. He first considers the case where the insurance contract offered is a "one-shot" offer made after planting decisions have already been made; in this case the value of insurance is entirely composed of its impact on reducing variability in returns that period, given that production decisions have already been made. In the second case, producers are similarly asked to consider an insurance contract that is made available to them before production decisions are fixed; in this case the value of the insurance is hypothesized to be higher since the producer may then reallocate variable inputs. Finally, producers are presented with an insurance scheme which they are assured will be available each year forever; in this case, the value of insurance should be greatest, since this would enable the farmer to fully adjust cropping patterns and input use to new long-term equilibrium conditions. In the case studied here, the respondents were asked to consider insurance contracts that would be available at the start of the next growing season, but no particular statements were made as to whether they would only be available once or would "always" be available (and it is not clear how respondents would view such information). There is no way of knowing whether respondents thought through the long-term adjustment implications that would arise if this type of insurance were made available forever. Nonetheless, we consider that the responses were consistent with short-term valuations of insurance, representing a lower bound estimate of their value.

One of the key aspects of rainfall index based insurance is the extent to which farmers feel that rainfall at the station is correlated with rainfall realized on their own plots. The difference represents basis risk. In the survey, we asked respondents to describe how closely they felt rainfall at the station represented rainfall they receive, where they were asked to say if station rainfall was: very similar, fairly similar, little similar or not at all similar, with rainfall received on their own farms. Table 5 below summarizes these responses across areas.

Table 5--Subjective Assessments of Yield:Rainfall Co-Variation

	Settat	Meknes	Essaouira	Oujda
Very Similar	4	0	1	0
Fairly Similar	18	8	27	5
A Little Similar	20	18	16	21
Not at all Similar	5	14	1	20

In general, it appears as if respondents believe that there will be a good deal of basis risk remaining even if rainfall index based insurance were available. It is also interesting to note that in the areas with higher temporal variability in rainfall, Settat and Essaouira, respondents consider the station rainfall to be better correlated with their own rainfall than respondents who live in the two areas with relatively low temporal rainfall variability. The expected value of payouts for the insurer are only a function of the temporal variation at each station, but spatial variability will reduce the value of any contract for the insurance purchaser. We do not have access to plot-level rainfall on which to construct measures of spatial variability, but we do have information on soft wheat yields in 2000/01 and 2001/02. While some of the variability is certainly due farmers' using different inputs, we present these yields for 2000/01 and 2001/02 for each province, on the assumption that overall yield variability observed for a given year is an adequate proxy for yield variability induced by spatial rainfall patterns. Average yields per hectare, the standard deviation and coefficient of variation are presented for the two years in Table 6 below.

Table 6--Yields per hectare

	Settat	Meknes	Essaouria	Oujda
Yields per Ha. 2000/01	2.97	5.00	2.70	1.67
Standard Deviation	1.69	3.78	2.68	1.50
Coefficient of Variation	.57	.76	.56	1.60
Yields per Ha. 2001/02	3.07	4.58	.43	2.47
Standard Deviation	2.25	6.50	.63	1.51
Coefficient of Variation	.73	1.42	.61	1.47

First, we note that yields per hectare are uniformly lower in all communities than those reported in Skees et al., but quite a very large margin, capturing the fact that rainfall during the preceding two years was very low across much of the country. Given our sample data, revenues ware approximately ½ to $\frac{2}{3}'s$ lower than those on which contract parameters were based.

Returning to Table 6, we note that the two regions with lower temporal variability appear to suffer greater spatial variability in yields; this result is consistent with the perceptions about correlation between rainfall on-farm vs. at the station. Next, we consider the role of information about rainfall. In particular, we asked farmer's what source(s) were used to access information about rainfall. On the survey, sources included radio, television, workplace (for those who had salaried jobs), a friend, "other", and "did not access rainfall information"; a summary table of information sources is given below in Table 7.

Table 7--Sources of Weather Information

	Settat	Meknes	Essaouira	Oujda
Radio/Television	13	22	19	5
Workplace	14	1	13	5
Friend	7	5	1	5
Other	4	1	0	0
No Source	10	19	15	33

As can be seen, in the areas with higher spatial variability, fewer people access any source of information regarding rainfall, though this is particularly true for farmers in Oujda.

Next we present a table of responses to each bid in each community, captured in Table 8 below. As noted above, 12 contracts were developed for each community. Because of a typing error, however, information is only available for contracts 1-9, 11; thus, we only have sufficient data to report on results for the 50 percent Trigger at 100 percent and 80 percent Coverage, 33 percent Trigger at 100 percent Coverage, and the 25 percent Trigger at 100 percent Coverage. For the 50 percent Trigger, there were 24 responses in each community for each bid (48 in total), for the 33 percent and 25 percent Trigger levels, there were 12 responses for each bid (24 in total). Finally, due to problems with the Meknes data, we dropped this community and in the remainder of the report, present results for Settat, Essaouira and Oujda.

Table 8--Household Responses to Offered Contracts

	Lower Bound Bid Value (Dh)		Upper Bound Bid Value (Dh)	
	Yes	No	Yes	No
Settat				
50% Trigger, 100% Coverage	23	1	13	11
50% Trigger, 80% Coverage	19	4	8	16
33% Trigger, 100% Coverage	3	8	7	5
25% Trigger, 100% Coverage	4	8	4	8
Essaouira				
50% Trigger, 100% Coverage	22	2	14	10
50% Trigger, 80% Coverage	18	6	9	15
33% Trigger, 100% Coverage	4	8	5	7
25% Trigger, 100% Coverage	3	9	1	11
Oujda				
50% Trigger, 100% Coverage	14	10	8	16
50% Trigger, 80% Coverage	7	17	6	18
33% Trigger, 100% Coverage	7	5	6	6
25% Trigger, 100% Coverage	8	4	7	5

First we note that in each of the three areas, the 50 percent contracts perform as expected; the number of yes responses is uniformly higher at the lower bid level than at the higher. The proportion of yes values is quite high for all communities for both 100 percent and 80 percent contracts, but slightly lower for 80 percent coverage. This latter result mirrors those obtained in Vandeveer & Loehman (1994) where farmers preferred higher to lower coverage. The proportion of yes values is also relatively higher in the two areas with high temporal variability, Settat and Essaouira, vs. Oujda, where temporal variability is lower but spatial variability may be higher. Results for the 33 percent and 25 percent contracts are less striking, though demand appears to drop off considerably compared to the 50 percent trigger contracts. In Essaouira, the 33 percent contracts attract a greater proportion of yes responses than the 25 percent contracts, but not by much; whereas in Oujda, the 25 percent contract attracts slightly more yes responses. The responses in bold are those that correspond to theory; that is, where the proportion of yes responses is greater at the lower bid value. Responses not in bold indicate a higher proportion of yes values for the higher bid value, meaning that the estimated coefficient on the bid value will be positive, or very close to zero (as in the case for the 25 percent trigger in Settat). We thus estimated bid value results only for contracts in bold.

Estimation of Willingness to Pay

Following standard procedures to recover willingness to pay (c.f. Hanemann & Kanninnen 2001), we first run probits and logits to recover an estimate of mean and median willingness to pay using only the "bid" value (the premium) as an explanatory variable. A priori, we have little theoretical reason to select a distribution for the error term, and we ran both logit and probits. Because the probit and logit results are similar, we present the probit results here. Also, because the mean and median are very close to the same, we present results for the median WTP only.

Settat:

50% Trigger, 100% Coverage:12.6-.028*Bid, Pseudo R^2= .23
Median WTP: 454 Dh.

50% Trigger, 80% Coverage: 8.63-.025*Bid, Psuedo R^2= .19
Median WTP 341 Dh.

Essaouira:

50% Trigger, 100% Coverage: 9.09-.034*Bid, Psuedo R^2= .14
Median WTP: 272 Dh.

50% Trigger, 80% Coverage: 7.07-.036*Bid, Psuedo R^2= .11
Median WTP : 196 Dh.

25% Trigger, 100% Coverage : 3.81-.047*Bid, Psuedo R^2= .06
Median WTP : 81 Dh.

Oujda :

50% Trigger, 100% Coverage:	4.48-.021*Bid,	Psuedo R^2= .05
Median WTP:	210 Dh.	
50% Trigger, 80% Coverage:	.26-.005*Bid,	Psuedo R^2= .001
Median WTP :	50 Dh.	
33% Trigger, 100% Coverage :	1.82-.014*Bid,	Psuedo R^2=.01
Median WTP :	130 Dh.	
25% Trigger, 100% Coverage :	2.08-.022*Bid,	Psuedo R^2=.01
Median WTP :	94 Dh.	

Next, we consider other variables that may affect an individual's demand for insurance at different levels. As discussed above, it is hypothesized that other factors will affect the willingness to pay across households. To quickly summarize, we hypothesize that human and physical capital reduce demand for insurance to the extent they proxy wealth and capacity to manage/cope with risk more cheaply; the alternative hypothesis being that such assets proxy for better seasonal cash flow and thus capacity to actually purchase insurance. Irrigation is hypothesized to reduce the demand for insurance, whereas higher crop diversity indices are hypothesized to increase demand for insurance to the extent that they reflect costly risk management strategies. A dummy for holding improved breeds, on the other hand, should reflect lower risk aversion and thus a lower demand for insurance. Finally, the greater the respondent feels is the co-variation between own yields and rainfall occurring at the specified rainfall station should increase demand for insurance, as should access to formal sources for weather information.

In Table 9 below, we present results for each equation run separately. We also determined that, in general, observations could not be pooled across communities (even after suitably transforming the variables)[5]. As shown in Table 9, coefficients on explanatory variables differed both within and between communities and we thus reject the hypothesis that observations could be pooled. This means that for some of the regressions, only 24 observations were available. In some cases, we could not include all potential explanatory variables in certain equations, since this led to perfect predictions. Variables that led to perfect predictions were then simply dropped from the regression.

The explanatory power of the multivariate regressions improves compared to the bivariate case, as would be expected. This is particularly true in Oujda, where the bid value itself is negative but not significant in any of the equations. The coefficients on bid values are negative across all equations, and significant in all but one equation for Settat and Essaouira. Besides the bid value, however, coefficients on other explanatory variables generally differ across the three regions, and in some cases, across different contracts within the same region.

[5] We tested whether Settat and Oujda, Settat and Essaouira, and Essaouira and Oujda data could be pooled by constructing community dummies interacted with each explanatory variable, and jointly tested the significance of all interaction terms, in each of the community pairs, for each of the three contracts for which we run regressions (50%T, 100%C; 50%T, 80%C; and, 25%T, 100%C). Of the nine tests performed, we could not reject that Settat and Essaouira data could be pooled for the 50%T, 80%C, or that Essaouira and Oujda data could not be pooled for the 25%T, 100%C equation. Nonetheless, because we did reject pooling observations for the seven other pairs, in Table 9 we report only results for each equation estimated separately.

Table 9--Results of multivariate probits

	Settat						**Essaouira**						**Oujda**					
	50% T, 100% C		50% T, 80% C		25% T, 100% C		50% T, 100% C		50% T, 80% C		25% T, 100% C		50% T, 100% C		50% T, 80% C		25% T, 100% C	
	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.	Coef.	z-val.
Bid	**-0.04**	-2.62	**-0.07**	-3.41	-0.04	-1.10	**-0.05**	-3.23	**-0.05**	-2.19	**-0.16**	-2.04	-0.01	-0.43	-0.01	-0.58	-0.02	-1.29
Human Capital																		
# Sons over 12					0.43	0.92	0.02	0.06	-0.03	-0.10			-0.40	-1.10	-0.07	-0.25	**-0.82**	-1.69
Education index	-1.15	-1.57	-0.50	-1.26	-0.30	-0.46	0.09	0.61	**-0.18**	-1.83	0.20	0.73	**0.99**	2.34	-0.45	-1.08	**-2.65**	-2.21
Physical Assets																		
Asset Index	-1.04	-1.54	**1.51**	2.93	-0.99	-1.19	**-0.81**	-1.73	0.39	.94	-0.27	-0.59	**0.60**	1.67	0.07	0.34	**-0.70**	1.71
Total landholdings	**1.21**	1.71	**-0.04**	-2.60			**-0.04**	-3.08	**-0.02**	-1.78			-1.16	-1.09	-.59	-.62	-0.05	-0.09
Risk Management																		
Improved Breeds	**-1.24**	-2.33	**-1.61**	-2.59	**2.08**	2.05	-0.03	-.06	-0.43	-1.05			**1.69**	3.19	**0.90**	2.17	**1.67**	2.26
Amount in Debt	1.86	.98	**3.23**	1.77	-3.23	-0.79	3.08	0.37	-2.80	-0.41	-1.70	-0.49	1.12	1.06	**2.34**	2.08	1.36	.88
Irrigation													**1.80**	2.65	**-1.08**	-1.95	-1.15	-1.38
Crop Diversity Index	**5.66**	1.62	-2.27	-0.83	0.17	0.06	**-7.67**	-1.62	-3.32	-1.16	**18.61**	2.10	**-3.89**	-1.64	1.55	.55	.38	1.03
Rainfall																		
Subj. Corr., Own Yields: Rainfall Sta.	0.12	0.19	**1.54**	1.76			-0.43	-0.72	0.36	0.70			-0.15	-.29	-0.05	-.06	.71	.58
Information from formal sources	.47	.70	-0.05	-0.07			**-1.71**	-2.35	**-1.09**	-2.08								
Constant	**16.97**	2.02	**26.45**	4.03	3.94	0.90	**21.50**	4.13	**12.59**	2.56	2.90	0.52	1.94	0.38	1.79	0.45	1.12	0.26
Number of Observations	47.00		48.00		47.00		48.00		48.00		24.00		48.00		48.00		24.00	
Psuedo-R2	0.45		0.50		0.26		0.37		0.31		0.34		0.46		0.21		0.41	

Of the human capital variables, number of males in a household is only significant in the low rainfall, low variability region of Oujda; the coefficient is negative as hypothesized. The education index is never significant in Settat, is negative and significant in one equation each in Essaouira and Oujda, and positive in one equation in Oujda. The only conclusion to be drawn is that education appears to affect household choices differently on different contract structures, both within and between regions. Like the education index, the coefficient on the index of physical assets is both positive and negative. Total landholdings has a positive impact on the WTP for the 50 percent T, 100 percent C contract in Settat, but a negative and significant impact in the same region for the 50 percent T, 80 percent C contract. On the other hand, total landholdings have a negative and significant impact on both coverage levels for the 50 percent T contracts in Essaouira.

Considering the risk management variables, the dummy variable for whether or not the farmer owned improved breeds was intended to capture a willingness to engage in risky activities, and the coefficient is negative for both the 50 percent T contracts in Settat, but is positive and significant for the low trigger contract in Settat, and for all contracts in Oujda. As with other assets, holding improved breeds may reflect the capacity of the farmer to pay for the insurance rather than reflect a lower degree of risk aversion, at least for some households. The amount of credit is always positive when significant as expected, but is only significant in two of the nine regressions. The impact of irrigation in the only region included where it is important, Oujda, differs across contracts. Irrigation is associated with a greater demand for the most expensive insurance contract, but has a negative impact on demand for the lower value contracts. Finally, the crop diversity index has a statistically significant and positive impact in Settat for the 50 percent T, 100 percent C contract. However, in Essaouira, the impact is negative for the 50 percent T, 100 percent C, but positive for the 25 percent T, 100 percent C.

As for information and subjective assessment of correlation of own yields with the rainfall station, these appear to have little impact on the demand for insurance in general. This is particularly odd for the subjective assessment; though in the one equation in which the coefficient is statistically significant, the impact is positive, as expected. Information from more formal sources (radio, television) in fact has a negative sign in Essaouira, indicating that those who keep better informed of rainfall at the station are less likely to prefer any insurance contract.

To summarize, explanatory variables had ambiguous impacts on the probability of accepting an insurance contract, and significant impacts differed both quantitatively and qualitatively across and within regions.

Returning to the estimates of WTP, in Table 10, we present the median willingness to pay for both the simple and multivariate probits, as well as the expected value of the contract and willingness to pay as a percentage of the expected value.

As can readily be seen, estimated WTP is greater than the expected value for the 50 percent contracts in Settat in Essaouira. In fact, the two regions exhibit very similar WTP as a percent of the expected value, which is about 17 percent with 100 percent coverage and about 10 percent with 80 percent coverage. Similarly, in both areas, the WTP estimate of the 25 percent contract is below the expected value, by about 5 percent .

Table 10--Estimated WTP

	WTPWTP Simple	Expected Multivariate	% of EV Value(EV)	(WTP-MV)
Settat				
50% Trigger, 100% Coverage	454	451	390	116%
50% Trigger, 80% Coverage	351	339	310	109%
25% Trigger, 100% Coverage		51	110	46%
Essaouira				
50% Trigger, 100% Coverage	272	270	230	117%
50% Trigger, 80% Coverage	196	200	180	111%
25% Trigger, 100% Coverage	81	91	95	96%
Oujda				
50% Trigger, 100% Coverage	210	188	200	94%
50% Trigger, 80% Coverage	50	131	160	82%
33% Trigger, 100% Coverage	130	123	115	107%
25% Trigger, 100% Coverage	94	86	75	115%

On the other hand, in Oujda – where WTP's for the 50 percent trigger contracts are both less than the expected value –it appears as if median willingness to pay is higher than the expected value for both the 33 percent and 25 percent contracts. Again, there appears to be a distinct difference between the high vs. low variability environments; farmers in the high variability areas much prefer contracts with higher triggers, whereas those in the low variability areas prefer contracts with low premiums that pay out much less frequently.

5. CONCLUSIONS

First, results are generally quite consistent with the hypotheses that insurance will be preferred in the areas with higher temporal rainfall variability, and where limited evidence suggests that farmers may be subject to less basis risk. Both higher triggers and coverage levels are preferred, as expected. Demand for insurance, however, appears to be quite distinct across the different areas, which indicates the need for larger data sets to satisfactorily estimate the determinants of the willingness to pay.

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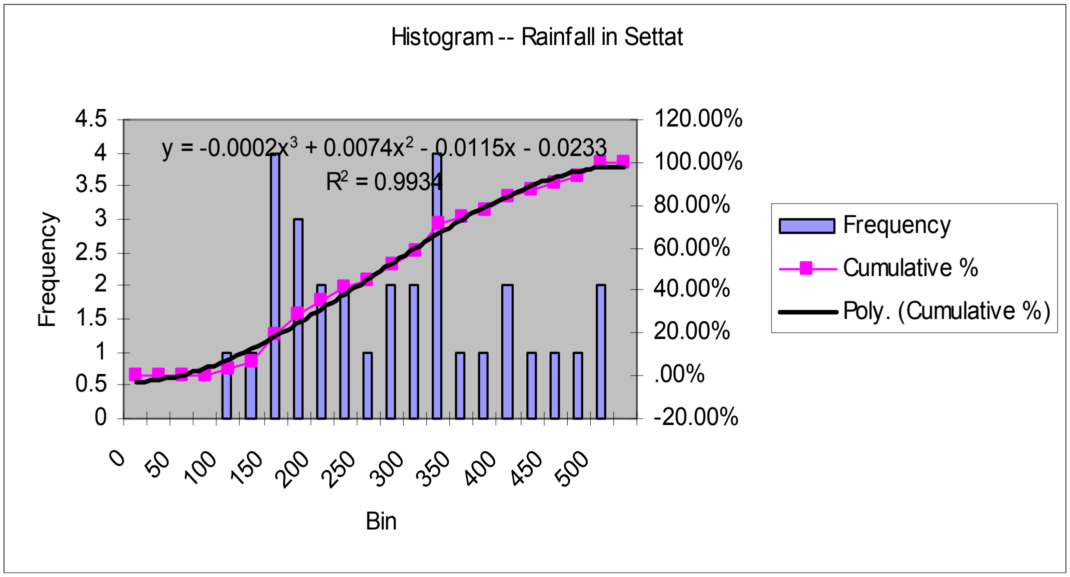
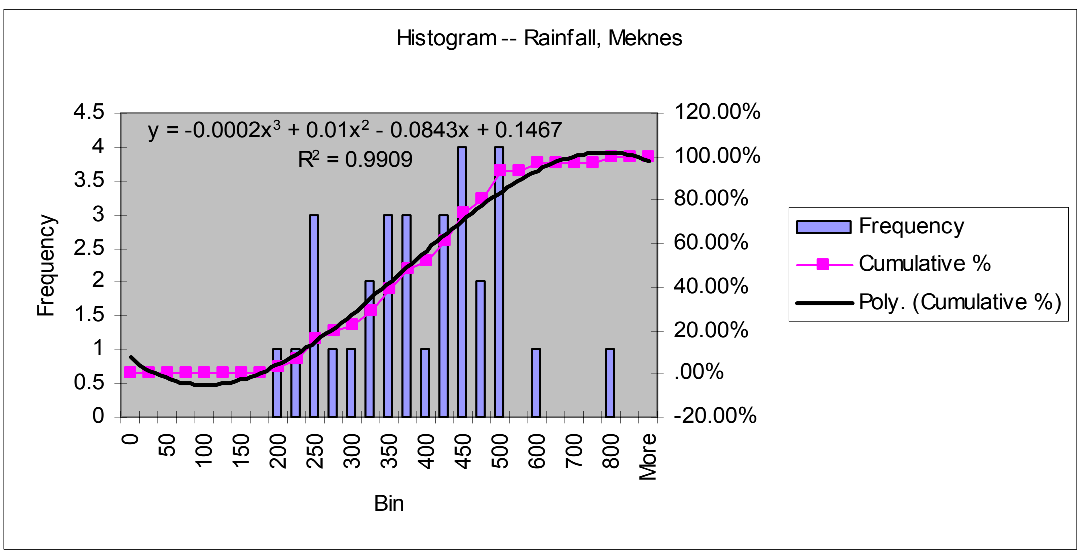
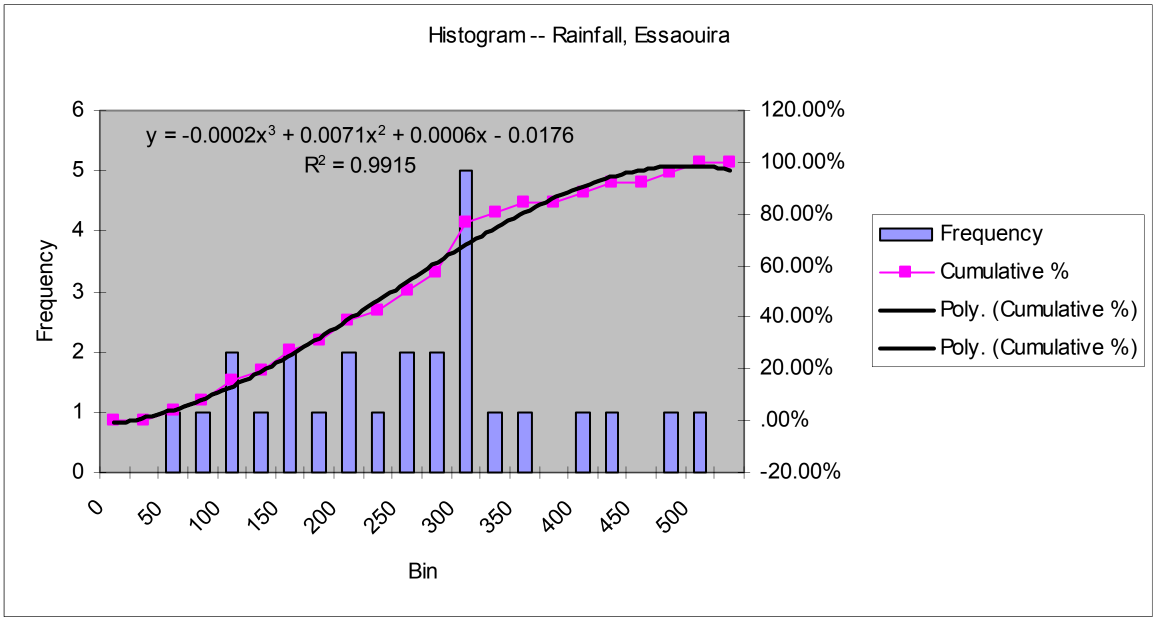
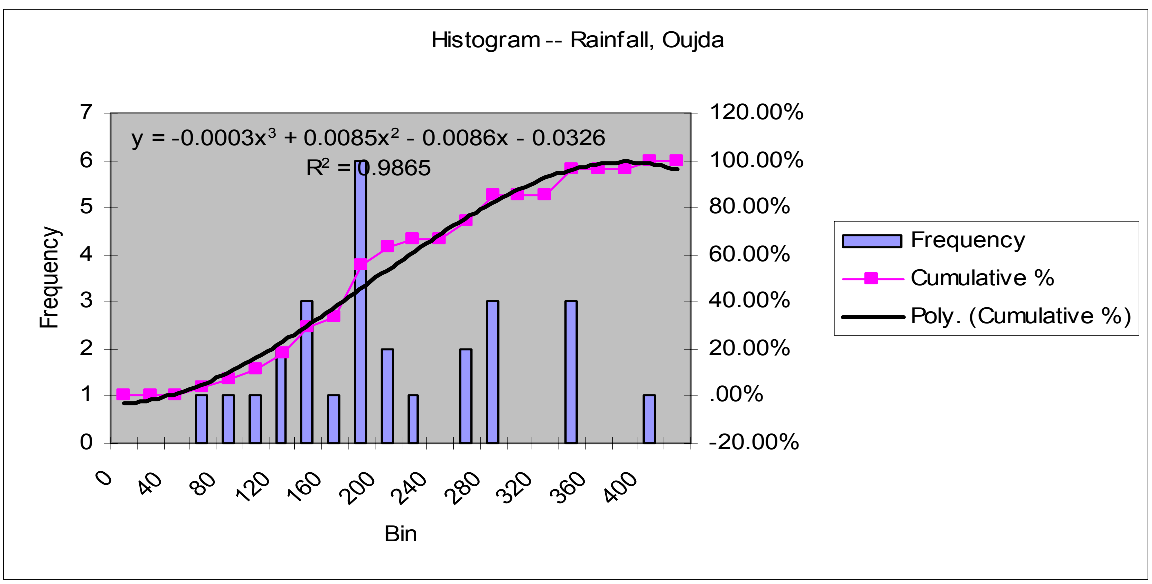
Appendix 1--Cumulative density functions, rainfall






Histogram -- Rainfall, Essaouira
y = -0.0002x3 + 0.0071x2 + 0.0006x - 0.0176
R2 = 0.9915
Frequency
Bin
0
1
2
3
4
5
6
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
-20.00%
0
50
100
150
200
250
300
350
400
450
500
Frequency
Cumulative %
Poly. (Cumulative %)
Poly. (Cumulative %)


Histogram -- Rainfall, Oujda
y = -0.0003x3 + 0.0085x2 - 0.0086x - 0.0326
R2 = 0.9865
Frequency
Bin
0
1
2
3
4
5
6
7
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
-20.00%
0
40
80
120
160
200
240
280
320
360
400
Frequency
Cumulative %
Poly. (Cumulative %)

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