Farmers' risk attitudes to influence the productivity and planting decision: A case of rice and maize cultivation in rural Uganda

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Abstract

The effects of Ugandan farmers' attitudes toward risk on their decisions about rice production are closely analysed and discussed. A three-step procedure is proposed: 1) farmers' characteristics determine farmers' risk attitudes, 2) their risk attitudes influence yield, and 3) yield affects decisions on acreage. This procedure is based on the assumption that acreage decisions are a reflection of farmers' actual yields, which are associated with risk-averting farming practices. The estimation results show that age and religion are significantly correlated with farmers' risk attitude, that risk-averse farmers perform better in terms of yield, and that higher yields subsequently increase acreage for production. These attitudes partly account for the diminishing increase in rice production. The results imply that effective ways to increase rice acreage are to increase the potential yield of rice and to promote rice cultivation for lands that are suited to rice cultivation.

Key words: risk attitude; yield function; acreage function; rice; Uganda

1. Introduction

Rice is a relatively new crop to many farmers in Uganda outside of the eastern part of the country where, thanks to the better availability of water, lowland rice cultivation has been practised for several decades now (Kikuchi *et al*. 2013). In the mid-2000s, due to the introduction of upland NERICA varieties, rice started to be produced in other parts of the country, such as the Northwest and West. However, the pace of rice diffusion within the country has started to decelerate in recent years. Some previous studies report that, while many farmers opted for rice production, others abandoned production after several seasons of cultivation (Kijima *et al*. 2011). The reasons behind this slowdown must be identified if the country wishes to keep pace with the increasing consumption demand for the crop.

To grasp the factors that decelerate the expansion of rice cultivation, analyses should focus on the factors that influence a) the number of new farmers taking up rice cultivation; b) the number of farmers dropping out of rice farming; and c) the area cultivated to rice. Research on the first aspect has often been attempted through the framework of farmers' behaviour to adopt new technologies, which normally involves farmers' risk preferences. Many studies suggest that the risk-averse nature of farmers either negatively affects or slows down the pace of adoption of new technology (Abadi Ghadim *et al*. 2005; Dercon & Christiaensen 2012). On the other hand, some studies show the opposite relationship, with risk-averse farmers actively adopting new technologies, such as double cropping (Shapiro *et al*. 1990) and fertiliser use (Babcock 1992; Paulson & Babcock 2010). More empirical evidence has been accumulated for the former cases than for the latter. The second aspect, the deceleration of rice production increase, was examined by Fujiie *et al*. (2010), who conducted a survival duration analysis of upland rice farmers in Uganda. Their results reveal that the duration of remaining in rice production was negatively influenced by the experience of crop farming and distance to rice mills. The third aspect has been addressed by many researchers through the framework of acreage response or supply response against uncertain yield or output price levels, e.g. Chavas and Holt (1990) for corn and soybeans, and Weersink *et al*. (2010) for corn, soybeans and wheat. These studies deal with the effects of farmers' risk preferences on acreage decisions by estimating a model based on expected utility maximisation, and find that risk preferences actually play an important role in the decisions. The risk is measured by the variance of yield and output price, as in most other similar studies, and it is rare to adopt farmers' directly elicited attitudes to risk.

We approach the last aspect above, acreage expansion, by incorporating farmers' directly elicited risk attitudes and the impact thereof on yield. As mentioned above, risk attitudes are often discussed in relation to the issues of technology choice, but such discussions are not limited only to the mere adoption or choice, but also extended to relationships between attitudes to risk and use of inputs, that is fertiliser and labour (Antle 1987; Paulson & Babcock 2010) and between risk attitudes and technical efficiency in production (Kumbhakar 2002).

2. Analytical framework

2.1 Analysis of the role of risk attitudes in production decisions

This study proposes a three-step linked-functions approach to test the hypothesis that risk attitudes influence farmers' decisions on expanding the area planted:

Risk attitude function:	Risk attitudes (r) are determined by individual farmers' exogenous characteristics (z)
Yield function:	Yield per acre (Y) is determined by the variable of risk attitudes predicted by the risk attitude function (rh) and other farm characteristics (s)
Acreage function:	Area planted (A) is determined by yield per acre predicted by the yield function (yh) and other variables constraining the expansion of area (c)

Risk attitude may directly influence a farmer's decision regarding area planted. However, this study considers it more reasonable that the acreage decision is based on yield and/or output price levels, which are assumed to be influenced by risk attitude. A similar approach is used in Weersink *et al*. (2010), who estimated an expected yield by using forecasted climate conditions and included the predicted expected yield and its variance, along with output price-related variables, in their acreage function.

Predicted values are used in the second- and third-step regression in order to minimise the difficulty associated with endogeneity.[1]

2.2 Risk attitude function

First, a regression of farmers' characteristics against their risk attitudes was conducted in order to know the characteristics of farmers who tend to be risk averse. Farmers were first categorised into either risk averters or otherwise. Using data on farmers' risk attitudes collected from a risk experiment, which will be explained later, the first step was to obtain a set of binary data by labelling those farmers considered to be risk averse as 1, and the rest 0. Therefore, the equation to be estimated is as follows:

$$\begin{aligned} \mathrm{r} &= 1 \quad \text{if } \mathrm{r}^* > 0 \\ &= 0 \quad \text{otherwise} \\ \mathrm{r}^* &= a + \sum b_i z_i + \varepsilon \end{aligned}$$

where r is a binary of risk averse or not, r^* is a latent variable that represents the probability of being a risk-averse farmer, z_i's are variables of farmers' characteristics, a and b_i are parameters to be estimated, and ε is the error term. Possible explanatory variables are exogenous individual characteristics such as age, education level, and the location where farmers reside.

Once the regression was done, we predicted the probability of $\mathrm{r} = 1$ using the estimated equation, and used it as the variable "rh" for the following yield function.

2.3 Yield function

Second, we looked at the relationship between rh, the predicted propensity of being risk averse, and yield per acre, Y. Our hypothesis was that the yield levels the farmers had attained in the past were a reflection of their risk attitudes, since whatever decisions they made on production should be influenced by their risk attitudes.

$$\mathrm{Y}_{mean} = a^Y + b_1^Y \mathrm{rh} + \sum b_i^Y \mathrm{s}_i + \varepsilon^Y$$

$$\mathrm{Y}_{min} = a^{Y'} + b_1^{Y'} \mathrm{rh} + \sum b_i^{Y'} s_i + \varepsilon^{Y'}$$

$$\mathrm{Y}_{max} = a^{Y''} + b_1^{Y''} \mathrm{rh} + \sum b_i^{Y''} \mathrm{s}_i + \varepsilon^{Y''}$$

where Y is farmer's yield; rh is the farmer's risk preference; s_i's are explanatory variables, a^Y, b_1^Y and b_i^Y are parameters to be estimated; and ε^Y is the error term. Possible explanatory variables are household characteristics such as family size, farm size, income from crop agriculture, and years of experience in cultivating particular crops.

Many of the past studies on this issue assumed that farmers behave in a manner to minimise yield variance if they are risk averse (Antle & Crissman 1999). However, the yield-variance minimisation principle will not hold under certain conditions: while the maximum yield is higher for risk averters, with their prudent on-farm management, the minimum yield could unavoidably be attained due to

[1] Although we estimated price functions as well as yield functions in the preliminary analysis, the estimated results were not statistically significant at any conventional levels. Therefore, our model focuses only on the effects of yield on the acreage decision.

natural causes such as weather events, predators or crop diseases, regardless of the farmers' abilities or risk attitudes. In this case, actual variance of the yield is larger for risk averters compared to risk seekers. Therefore, the variance or the range between maximum and minimum yields may not be correlated to the level of risk attitude under such an extremely risky situation. Agriculture in Uganda faces high uncertainty stemming from such damage. In order to avoid a misleading result, and also to know the real response of farmers against downside and upside risks, minimum and maximum yields were used separately as variables for analysis instead of yield variance.

In estimating the yield function, a seemingly unrelated regression was used over different crops to consider the error-term correlation, because farmers typically cultivate these crops at the same time, using the same level of techniques under the same climate conditions. Using the parameter obtained in this estimation, we also predicted yields (yh) of all levels for the crops, which were used for the following acreage function.

2.4 Acreage function

Lastly, the third function was set to discover factors that determine the size of area to be planted, using the predicted yields, yh. It is straightforward that the higher the yield farmers obtain for a particular crop, the more the acreage they allocate toward that crop. The regression at this third step was, on one hand, to confirm this for rice farmers in Uganda and, on the other, to see how and to what extent other variables could affect the extent of the cultivated area. The equation used is as follows:

$$\mathrm{A} = a^A + b_1^A \mathrm{yh} + \sum b_i^A c_i + \varepsilon^A$$

where A is area planted, c_i's are explanatory variables limiting area expansion; a^A, b_1^A and b_i^A are parameters to be estimated; and ε^A is the error term.

Although farmers plant many crops, this study focused on two of them, rice and maize, which are major crops competing with each other for land to be planted. All statistical analysis was carried out by STATA version 12 (STATA Corp. 2012).

3. Data collection

The farmers' risk attitudes are revealed by means of the well-known lottery game developed by Holt and Laury (2002), with slight changes to the amount of payoff; the payoff of lottery A (the less risky option) is UGX 2 000 or UGX 1 600, while that of lottery B (the risky option) is UGX 4 000 or UGX 100 (UGX 2 500 = USD 1). The game offers both lotteries, from which farmers are to select one, while the probabilities attached to each payoff vary. Normally, a subject in this game starts by choosing Lottery A and, as probabilities change, moves to Lottery B. The point (or row) at which the subject moves to Lottery B is a reference point for his/her risk averseness. The amounts of the payoffs were chosen based on the results of our pre-tests and earlier studies that employed lottery games. In addition, we fixed the experimental design with hypothetical payoffs, referring to Holt and Laury (2002), who find that although high stakes make subjects more risk-averse, there is not much difference in their responses between low real payoffs and high hypothetical payoffs. Our preliminary survey on time preference shows that Ugandan farmers' discount rate is extremely high, at 315.5% on average, which implies a reasonable possibility that if a real payoff is offered, farmers' responses will not vary with risk levels due to their high discount rate. In order to see risk-averting reactions against losses, which are said to be different from those for gains, the games for both the gain version and the loss version were conducted.

The questionnaire also included questions about farm-level characteristics such as engagement in off-farm activity, income from each source, asset level, group membership, distances to rice mills and financial institutions, years of experience of rice and maize cultivation, and farm size. Farmers' ability to devote their resources to farm production was measured by their asset level as well as farm size. Farm size is known as a factor that is positively correlated with good access to capital (Dorward 1999) and with large crop income (Haneishi *et al*. 2013a). It has also been noticed, however, that farm size can negatively affect yields if the labour market is not functioning well, creating labour constraints. Which effect dominates (positive or negative) is an empirical question.

The two proxy variables, asset level and farm size, possibly are correlated, and this are a source of multi-collinearity. Transforming continuous data into a dummy variable is a way to avoid this. Therefore, a farm-size dummy was introduced, the value of which was 1, indicating "2 ha and above", or 0, indicating "less than 2 ha". The demarcation size of 2 ha comes from the average cultivated area of rain-fed rice farms in Uganda (Haneishi *et al*. 2013b).

Farm characteristics, such as land size devoted to each crop, location of plots and weather recall and forecasts, were collected for the acreage function. Location of plot was used to identify whether plots were in a suitable condition in terms of water availability. Weather recall and forecasts represent climatic conditions on the farms; we asked farmers to judge whether the weather in the last three seasons was good, fair or bad, and to estimate the coming season's weather in terms of rainfall.

Interview surveys using a structured questionnaire were conducted in two districts, namely Kyankwanzi and Iganga, from September to October 2012. The two districts, known as rice-growing areas, are in western and eastern Uganda respectively. Both are located an almost equal distance from Kampala, the capital, providing a sample of farmers from two regions with a similar setting in terms of exposure to the cash economy. Rice cultivation in both regions is purely rain-fed. Within the districts, sub-counties where rice production was popular were first selected with support from the respective district agriculture offices. Then, parishes, villages and farmers were selected randomly. A total of 280 farmers, 140 in each district, were drawn from a total of 12 villages. Of these, five villages were in Kyankwanzi and seven were in Iganga. For the analysis we used only 110 observations, which consisted of the farmers who produced both rice and maize in the same season during the years 2011/2012 and who responded rationally to the risk experiment.

While the risk experiment was thoroughly explained to the sample farmers, some of them exhibited an insufficient understanding of the rules of the game. Farmers were omitted from the sample for analysis if they either crossed from Lottery A to Lottery B (or B to A) more than twice, or did not cross at all, even at the 10^{th} row of the experiments, as these are regarded as irrational responses.

The characteristics of the selected farmers are summarised in Table 1.

Table 1: Sample characteristics (N=110)

Variables	Unit	Mean	Standard deviation
Age of respondent	yrs.	38.9	11.5
Education of respondent [a]	-	6.1	3.1
No. of adult in family	no.	3.5	1.5
Being Muslims	%	40.9	49.4
Total income	000 UGX	1404.9	1453.9
Crop income	000 UGX	1145.2	1123.7
Asset level [b]	-	160.0	625.5
Distance to rice mill	km	9.5	11.6
Distance to maize mill	km	7.6	10.8
Experience of rice cultivation	yrs.	5.5	4.2
Experience of maize cultivation	yrs.	10.2	6.5
Risk averse (gain domain)	-	6.2	1.2
Risk averse (loss domain)	-	6.3	1.0
Experienced min. rice yield	kg/ac	460.0	330.5
Experienced mean rice yield	kg/ac	834.4	597.8
Experienced max. rice yield	kg/ac	1422.6	1201.3
Experienced min. maize yield	kg/ac	680.7	689.0
Experienced mean maize yield	kg/ac	1183.4	1070.3
Experienced max. maize yield	kg/ac	2080.4	2135.7
Weather judge [c]	-	8.7	1.6
Total land size	ac	4.9	5.0
Land size for crops	ac	3.4	2.6
%age of land suitable for cultivation	%	85.2	31.8
Size of rice planted	ac	1.3	0.8
Size of maize planted	ac	1.5	1.7

[a] Education level: 1-6: primary, 7-11: secondary, 12 or above: tertiary.
[b] Asset level: calculated using current market value.
[c] Summation of farmers' judgement of the past three seasons' weather and current season, good = 3, fair = 2, bad = 1.

4. Results

4.1 Risk measurement

In eliciting the farmers' risk attitudes, this study revealed that the sample farmers were risk averse in general terms. About 60% of the farmers switched from Lottery A to Lottery B at the 6th row for both domains – Gain and Loss. There is not much difference between the farmers' responses between the two domains. For estimating the risk function, the data for each farmer's risk averseness (scale from 1 to 10 scale; these correspond to the row at which they switched from A to B) was converted into binary form (risk averter = 1, the rest = 0) in order to identify a switchover point statistically that can distinguish risk averters from risk seekers.

4.2 Risk attitude function

To consider the error correlation between the two equations, one for the Gain domain and the other for the Loss domain, bivariate probit was used first. However, since the χ^2 test does not reject the null hypothesis that the correlation of the error terms equals zero, which means that bivariate probit is not necessarily required, a regression for each equation was performed independently. The switchover point to distinguish the risk averters from the rest was estimated to be at the 7th level of the risk scale, according to the minimum AIC standard. This study categorises risk averters as those farmers with a switchover point at the 7th level or above (28 samples out of 110).

The regression results in Table 2 indicate that, for the Gain domain, age, religion and village dummy (Kikonda village) explain farmers' risk-averse attitudes at the 5%, 10% and 1% levels of significance respectively. Age is correlated negatively with risk-averse attitudes. This means that the older the farmers, the more risks they can take. This result is compatible with the findings of Dadzie and Acquah (2012) in Ghana, and Aye and Oji (2007) in Nigeria, but opposite to the finding of Yesuf and Bluffstone (2007) in Ethiopia. The inverse relationship between age and risk aversion in Uganda could be associated with the current socioeconomic conditions of the nation: the high youth unemployment rate is an increasing concern and may influence younger generations to become more hesitant to take risky actions. Religion is highly and positively correlated, meaning that Muslims are more risk averse than Christians in the study area. This is also in line with the findings of Bartke and Schwarze (2008) for Germany. The village dummy of Kikonda, a village in Iganda, was highly significant for risk attitudes. We failed to identify why farmers in this village were more risk averse, as other economic and social characteristics did not vary much among the sample villages. This difference is not due to an enumerator effect, because the same enumerators covered all the surveyed villages in Iganga. For the Loss domain, only age and the Kikonda village dummy were significant. This domain showed essentially the same structure as the Gain domain. For the following analysis, the predicted probability of being risk averse was used, hereafter called risk-averse propensity, from the model in the better fitting Gain domain (Table 2).

Table 2: Estimation results of risk attitude functions, using Probit regression (N=110) [a]

	Regression models			
	(1) Gain domain		**(2) Loss domain**	
Variables	Co-eff.	P > z	Co-eff.	P > z
Sex (Female = 1)	0.463	0.283	0.729	0.103
Age	-0.029	0.048	-0.031	0.005
Education	0.043	0.358	0.059	0.335
District dummy (Iganga = 1)	-0.531	0.122	0.247	0.522
Village dummy (Kikonda = 1)	1.086	0.003	1.463	0.000
Religion (Muslim = 1)	0.588	0.078	-0.560	0.146
Constant	-1.243	0.244	-0.422	0.699
Wald chi^2 ($P > chi^2$)	21.14	(0.0017)	25.51	(0.0003)
Log likelihood	-51.82		-45.91	
Pseudo R-squared	0.17		0.24	

Note: [a] The values of dependent variables are 1 for risk averter and 0 otherwise.

4.3 Yield function

All three measures of yield – minimum, average and maximum – were regressed separately, but the two crops – rice and maize – were regressed together by using bivariate seemingly unrelated regression. Table 3 shows that the average rice yield was positively correlated with risk-averse propensity, farm size and years of experience in rice cultivation, and that the average maize yield was positively correlated with risk-averse propensity, asset level and farm size.[2] For maize, unlike rice,

[2] Varieties and land types (upland or lowland) were also included in the regression but did not show any significant difference.

asset level had some effect on improving maize yield, while experience did not.[3] For the minimum yield, only risk-averse propensity and years of rice experience influenced the rice yield, while the risk attitude and farm size did so in the case of the maize yield. For the maximum yield, all four variables regressed had significant impacts on the rice yield, but only three variables (with experience the exception) significantly affected maize yield.[4]

Table 3: Estimation results of yield response functions, using seemingly unrelated regression (N=110)

	Regression models					
	(1) Minimum yield		(2) Average yield		(3) Maximum yield	
Variables	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
Rice						
rh (predicted risk attitude)	0.636	0.067	0.728	0.016	0.937	0.003
ln (asset level)	-0.001	0.967	0.021	0.101	0.029	0.026
Farm size dummy (large = 1: total holding > 5 acres)	0.155	0.248	0.282	0.016	0.272	0.023
Experience with rice	0.053	0.000	0.053	0.000	0.048	0.000
Constant	5.407	0.000	5.938	0.000	6.400	0.000
Maize						
rh (predicted risk attitude)	1.124	0.003	0.968	0.008	0.955	0.016
ln (asset level)	0.021	0.194	0.031	0.045	0.044	0.007
Farm size dummy (Large = 1: total holding > 5 acres)	0.611	0.000	0.595	0.000	0.619	0.000
Experience with maize	0.014	0.161	0.006	0.54	0.009	0.357
Constant	5.518	0.000	6.213	0.000	6.660	0.000
R^2 (rice)	0.099		0.200		0.231	
R^2 (maize)	0.270		0.272		0.288	
chi^2 (rice) (p-value)	16.41	(0.003)	34.73	(0.000)	38.75	(0.000)
chi^2 (maize) (p-value)	39.65	(0.000)	40.80	(0.000)	43.58	(0.000)
Max. VIF (rice)	1.210					
Max. VIF (maize)	1,240					
Condition number (rice)	5.349					
Condition number (maize)	5.843					

[3] Risk attitude may be correlated with wealth level and also asset level. However, multi-correlation indexes, variance inflation factor (VIF) and condition number (CN), indicated otherwise for our sample. Moreover, estimation results were confirmed to be robust if asset level was excluded from the regression.

[4] When the yield range (difference between maximum and minimum yields) was used instead of the minimum and the maximum yields, the regression result showed that risk-averse farmers had wider yield ranges than non-risk averters, for both rice and maize. This is quite different from the notion of risk averseness and the results of previous studies. However, a close look at how the yield range was determined by decomposing the yield range to the minimum and maximum yields shows that the yield range widened because the rate of increase of the maximum yield was greater than that of the minimum yield.

A positive correlation between risk-averse propensity and yields, which implies that risk-averse farmers achieve higher yields, was found at all the yield measures, regardless of crops. Farm size was positively correlated at all three yield measures for both crops, except for the minimum yield of rice. While this result conflicts with the inverse relationship between farm size and yield found by Kimhi (2006) and Barrett (1996), it is in line with the findings of Dorward (1999) and Eswaran and Kotwal (1986). The latter two studies explain the positive relationship in terms of economic and market restrictions: large farmers may have better access to the capital market because of their better asset position, so that they would use more inputs and therefore attain higher yields. In our model, asset level was expected to explain such capital market restrictions.

On the other hand, farm size may have a negative impact on yield if large farmers find it difficult to hire sufficient numbers of workers in the labour market. The regression parameter of farm size, therefore, reflects the two opposite effects on the yield. The result shows that the positive effect of farm size on yield dominates.

4.4 Acreage function

The possible determinants of area planted, that is availability of family labour, percentage of suitable land and favourable weather, together with the predicted yield for each yield measure, were regressed using the ordinary least squares method for rice, maize and the relative acreage between them (Table 4).

Table 4: Estimation results of acreage function, using OLS regression (N = 110)

Variables	[1] Rice acreage (log form)		[2] Maize acreage (log form)		[3] Relative acreage [a] (ratio form)	
Minimum yield	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
ln (average yield)	0.497	0.060	1.049	0.000		
ln (average yield) ratio [b]					0.413	0.189
Family labour	0.025	0.410	0.087	0.036	-0.063	0.517
Weather judge [c]	0.377	0.007	-0.022	0.887	0.471	0.120
% of suitable land [d]	-0.040	0.816	0.276	0.170	-0.024	0.946
Constant	-3.721	0.017	-6.918	0.000	-0.988	0.514
R^2	0.14		0.33		0.14	
Average yield	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
ln (average yield)	0.540	0.008	1.059	0.000		
ln (average yield) ratio [b]					0.901	0.014
Family labour	0.026	0.397	0.100	0.017	-0.080	0.327
Weather judge [c]	0.341	0.014	-0.030	0.846	0.559	0.076
% of suitable land [d]	-0.004	0.983	0.264	0.187	0.074	0.837
Constant	-4.270	0.001	-7.609	0.000	0.692	0.275
R^2	0.17		0.33		0.19	
Maximum yield	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
ln (average yield)	0.471	0.007	0.962	0.000		
ln (average yield) ratio [b]					0.908	0.004
Family labour	0.032	0.296	0.975	0.017	-0.067	0.411
Weather judge [c]	0.334	0.016	-0.004	0.976	0.669	0.040
% of suitable land [d]	-0.169	0.919	0.260	0.190	-0.118	0.722
Constant	-4.047	0.001	-7.486	0.000	0.586	0.356
R^2	0.17		0.34		0.19	

[a] Dependent variable for regression [3] is the relative acreage of rice to maize.
[b] Defined as ln (rice yield/maize yield).
[c] Summation of farmers' judgement of the past three seasons' weather, good = 3, fair = 2, bad = 1.
[d] % of land categorised as suitable for crop planting out of total lands devoted to crop production.

The results for rice indicate that only the predicted rice yield and weather judgement affected the area planted to rice. It is reasonable that farmers with a higher predicted yield and better weather in the recent past tend to produce more. Availability of family labour and percentage of suitable land do not have any significant effect on area planted to rice. On the other hand, the maize planting area was influenced by its predicted yield and the number of family members older than 15 years for all yield measures. Contrary to the case of rice, weather judgement did not play a role in deciding the maize area. This suggests that the farmers in the sample recognise that rice requires more water than maize.

With regard to labour requirements, rice requires more labour for land preparation, weeding and bird scaring than maize. However, the results show that availability of family labour increased maize area significantly, but not rice area. This might result from the fact that our sample was basically selected from rice farmers. If they already employed as much family labour as possible in rice production in relation to other necessary inputs such as suitable land, additional family labour would not be allocated to rice but to other crops, in our case maize. Finally, the fact that the percentage of suitable land was not statistically significant in acreages for both crops may be because differences in the availability of suitable land among the sample farmers were small and almost all suitable lands were already utilised for both crops.

5. Discussion

5.1 Influence of risk attitudes on yield and acreage

The estimation results of the three linked functions indicate that farmers' risk attitudes significantly affected the yield levels attained, and consequently their crop acreages. It was also found that risk attitudes positively influenced yield variance: risk-averse characteristics broaden yield variance. This is because the increase in the maximum yield is larger than that in the minimum yield. For all the three yield measures, especially for the maximum yield, the risk-averse farmers performed better than their risk-neutral or risk-seeking counterparts. Two possible explanations are: first, the risk averters use more inputs, and second, they also exercise better on-farm management than the non-averters. The latter may be a more important reason in rice-growing areas in Uganda, where small-scale rice farmers seldom use purchased farm inputs such as fertilisers and chemicals (Haneishi *et al*. 2013b). This result is consistent with a finding by Antle and Crissman (1999) that the higher the degree of farmers' risk aversion, the higher the output they achieve. It has also been shown that risk-averse farmers tend to be more technically efficient compared to risk-neutral or risk-seeking farmers, although the difference is not statistically significant. Our results reinforce their finding.

5.2 Competition for resources between rice and maize

The sampled farmers considered maize to be much more risky than rice. Many of them pointed out strong sunshine as the largest risk for maize production. This may cause farmers to shift their production from maize to rice, although this is not yet happening on a large scale. Our study gives plausible explanations for this slow shift. First, rice yield is affected by farmers' years of experience in rice farming, but maize yield is not. This suggests that there are technical difficulties inherent in rice production that can be overcome only by experience. Second, as seen in Table 3, the yield elasticity of risk attitudes for all three yield measures is higher for maize than for rice. Considering the vulnerable economic situation farmers face, it is understandable that they prefer maize to rice. Third, the acreage function shows a significant impact of the weather variable (rainfall) on the acreage decision only for rice. The target areas of this study were selected from rice-producing districts, and the sample farmers were without formal irrigation, as are most farmers in Uganda. Our results emphasise the importance of rainfall for rice production: its yield and acreage are highly dependent on rainfall.

We now look at some elasticity measures calculated from the coefficients estimated in the yield and acreage functions in order to further investigate the issue of competition regarding areas planted and resources between the two crops. Table 5 shows the acreage elasticity for variables whose estimated coefficients were statistically significant.

Table 5: Calculated acreage elasticity[a]

	Rice	Maize	Ratio [b]
Minimum yield			
Yield [c]	0.497	1.049	0.284
No. of adults in family	-	0.303	-
Weather judge	0.793	-	-
Risk attitudes	0.079	0.295	-
Average yield			
Yield [c]	0.540	1.059	0.620
No. of adults in family	-	0.348	-
Weather judge	0.717	-	0.809
Risk attitudes	0.099	0.257	-
Maximum yield			
Yield [c]	0.471	0.962	0.625
No. of adults in family	-	0.341	-
Weather judge	0.702	-	0.968
Risk attitudes	0.110	0.230	-

[a] Elasticity of each item relative to acreage, at each yield measure, and for rice, maize and ratio of rice over maize, are transferred or calculated using the average figures from Tables 3 and 4.
[b] Ratio means relative acreage of rice to maize.
[c] Yields are own yield for rice and maize, and the relative yield of rice to maize for ratio.

The acreage elasticity of yield was larger for maize than for rice, which means that the rate of increase in area planted as yield increased was larger for maize than for rice. An increase in number of family members of working age is a factor to increase maize acreage, but not as much as an increase in maize yield. Better weather is influential for rice acreage slightly more than rice yield. Both weather and yield are of course interrelated and therefore these two factors are important when considering the expansion of rice acreage. The acreage elasticity of risk attitude was smaller for rice than for maize: risk-averse characteristics have a greater influence on maize acreage than on rice acreage. For rice, the elasticity of risk attitude was largest for the maximum yield, while, for maize it was largest for the minimum yield. Moreover, the fact that the elasticity of risk attitude for rice (both in Tables 3 and 5) was largest for the maximum yield among the three yield measures suggests that improving the maximum yield of rice is important for increasing rice acreage in Uganda.

To obtain another elasticity measure, we regressed the relative acreage of rice to maize on the relative average yield of rice to maize and other variables used in the acreage function using the simple OLS method. The result is presented in the last column of Table 4. The acreage elasticity of yield was measured at 0.28, 0.62 and 0.63 for the relative minimum yield, the relative average yield and the relative maximum yield respectively (see the ratio column in Table 5). On the other hand, the acreage elasticity of weather judgement indicated that weather judgement affected the relative acreage more elastically than yield, except for the minimum yield. These results imply that effective ways to promote a shift in production from maize to rice are to increase the potential yield of rice and to make weather favourable. In the current situation of agriculture in Uganda, the latter can only be attained by selecting appropriate land for rice cultivation, that is land with adequate moisture, such as valley bottoms.

6. Conclusions

Our estimation reveals that farmers' risk attitudes significantly affect their yield levels and, consequently, their crop acreages. Risk-averse farmers perform better than their risk-neutral or risk-seeking counterparts, most likely by exercising better on-farm management. We find that their risk attitudes also have some effects on the slowing down of rice production increase in the country. Our investigation of the comparison between rice and maize, the country's most widely cultivated crop, shows that the application of appropriate on-farm management, prompted by being risk averse, can improve maize yield a little more easily than rice yield. This could explain partly why farmers tend to select maize rather than rice. Other reasons are the inherent difficulty and water dependency of rice production compared to maize production. An increase in rice production therefore depends on an improvement of rice yield, especially its potential yield, and the selection of appropriate land with adequate moisture.

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