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Farmers' risk management in maize production in northern Vietnam: determinants of variety choice and area allocation

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Introduction and Research Objectives

In Vietnam, maize has become the second most important crop after rice due to its importance as feed for the country's rapidly growing livestock industry. In Yen Chau district in north-western Vietnam, 97% of farmers grew maize in 2007; maize covered 84% of the upland area and accounted for an average of 65% of total cash income (Keil et al., 2008). Given the considerable input and output price fluctuations, dramatic soil erosion on steep maize plots, and adverse climatic conditions observed in recent years, this specialization on maize production must be viewed as a relatively risky livelihood strategy, especially for the poorest. The level of risk depends – among other factors - on the yield potential, yield variability, and input requirements of the maize varieties used. Understanding farmers' decision-making with respect to maize production is a crucial prerequisite to enhancing both its economic and ecological sustainability in the area. In particular, this study tests the hypothesis that poorer farmers are more risk averse (cf. Morduch, 1995) and that this is reflected in their maize management.

The specific objectives of this research are (1) to identify the most important maize varieties used and their characteristics; (2) to empirically investigate differences in maize management between poorer and wealthier farmers using data from a random sample of farm households; (3) to identify determinants of farmers' choice between relatively risky HYV and less risky varieties; and (4) to identify determinants of area allocation to maize, accounting for the possible effect of variety choice and unobserved characteristics affecting both variety choice and area allocation.

Description of the Research Area

The research was conducted in the mountainous Yen Chau district in Son La province in north-western Vietnam, which is among the poorest provinces in the country (Minot et al., 2006). Agricultural production is dominated by two major crops, irrigated rice mainly cultivated in the valley bottoms and intensive maize production on sloping upland plots. Rice is grown mainly for home consumption, whereas maize is produced almost exclusively as a cash crop (Keil et al., 2008).

Methodology

Analytical framework: To address objective (2) we construct a linear composite wealth index by principal component analysis (cf. Dunteman, 1994) to classify households into wealth terciles (poorest third, middle third, and wealthiest third of sample households). Twelve indicators feed into the wealth index, which are related to households' asset endowment, housing condition, consumption expenditures, demography, and the official poverty rating[1] from the previous year. With respect to objectives (3) and (4) we estimate a two-stage regression model, consisting of a probit model to identify determinants of variety choice (1. stage) and an OLS regression on factors influencing area allocation to maize (2.stage). The latter may also be influenced by variety choice; for example, farmers who opt for a higher-yielding variety may in turn systematically devote a smaller area to maize. Since there may be unobserved factors that influence both the choice of maize variety and the area allocation to the crop (e.g., risk preferences, innovativeness), the second-stage regression corrects for possible selection bias by including the Inverse Mills Ratio (IMR) derived from the first-stage probit model (cf. Heckman, 1979). Drawing on the concept of livelihood resources as laid out in the sustainable livelihoods framework (cf. Scoones, 1998), we hypothesize the determinants of maize variety choice and area allocation to the crop to be determined by households' resource endowment and access to relevant services and commodity markets. These resources we subsume under four types of capital, namely natural capital, human capital, economic/financial capital, as well as market access/infrastructure.

Data collection: Structured interviews were conducted in a random sample of 300 households representative for Yen Chau district between March and July 2007. For household selection a two-stage cluster sampling procedure was followed. In the first stage 20 villages were randomly selected using the Probability Proportionate to Size (PPS) method and in the second stage 15 households were randomly selected in each of these villages, resulting in a self-weighing sample (Carletto, 1999).

Results and Discussion

Maize varieties used: In 2007, five hybrid varieties accounted for 94% of maize plantings, namely LVN 10 (59%), NK 54/4300 (19%), and CP 888/999 (16%). Based on their characteristics these can be further aggregated into two groups (Table 1), in the following referred to as LVN 10 and NK 54, respectively. Table 1 implies that growing the higher-yielding NK 54 varieties entails a higher level of risk than growing LVN 10 (higher yield potential, but also higher input requirements and poorer insect tolerance and storage quality).

Table 1. Characteristics of the major maize variety groups grown in Yen Chau district, northern Vietnam

	LVN 10 and CP 888/999	NK 54/4300
Yield potential	~ 6 Mg ha^{-1}	7 – 8 Mg ha^{-1}
Input requirements	Moderate	high
Seed price	relatively cheap	expensive
Insect tolerance	relatively high	relatively low
Storage quality	good	fair

Source: Agricultural extension service, Yen Chau

Differences in maize management between poorer and wealthier farmers: The share of households growing the higher-yielding NK 54 variety group is 20.5%; there is no significant difference in variety choice between wealth terciles. The same is true for the portion of land allocated to maize, which amounts to 77%, 76% and 72% of the total farmed area in the poorest, middle, and wealthiest terciles of our sample households, respectively. Table 2 explores differences in the management of the two maize variety groups between wealth terciles. On both variety groups, the wealthiest third of households apply significantly larger amounts of fertilizer and achieve higher yields and gross margins than the poorest third. Investigating the management of different maize varieties within wealth groups finds the wealthiest tercile applying larger

[1] Once a year, the local government classifies households into poor (i.e., below the official rural poverty line) and non-poor based on a set of criteria developed by the Ministry of Labor, Invalids, and Social Affairs (MOLISA).

amounts of urea to NK 54 and achieving higher yields than with LVN 10 (difference of 534 kg ha-1, on the average). Due to higher input costs, there is no significant difference in gross margins, however. On the contrary, the poorest tercile apply the same amount of fertilizer to both variety groups and do not achieve a yield difference. The gross margin is significantly lower for LVN 10 growers as they obtain a significantly lower output price.

Table 2. Mean levels of inputs, outputs, and gross margins in maize production in Yen Chau district in 2007, differentiated by variety (LVN 10/NK 54) and households' wealth status

	Poorest tercile[1] (N = 105)			Wealthiest tercile (N = 112)		
	LVN 10 (n = 73)	NK 54 (n = 32)	Sig.	LVN 10 (n = 81)	NK 54 (n = 31)	Sig.
Inputs:						
Seeds (kg ha^{-1})	22.6[a]	20.3[a]	n.s.	22.4[a]	25.4[a]	n.s.
Seed costs (million VND ha^{-1})[2]	0.49[a]	0.75[a]	***	0.49[a]	0.94[a]	***
NPK (kg ha^{-1})	389.7[aaa]	349.3[aaa]	n.s.	550.2[bbb]	787.3[bbb]	n.s.
Urea (kg ha^{-1})	120.0[aaa]	142.6[aaa]	n.s.	202.1[bbb]	266.2[bbb]	***
Total input costs (million VND ha^{-1})	1.93[aaa]	2.26[aaa]	n.s.	2.71[bbb]	3.76[bbb]	**
Output:						
Maize yield (kg ha^{-1})	5865[aaa]	5945[aaa]	n.s.	6935[bbb]	7469[bbb]	*
Maize price received (VND kg^{-1})	2896[aaa]	3391[a]	***	3240[bbb]	3336[a]	**
Maize revenue (million VND ha^{-1})	17.22[aaa]	20.20[aaa]	**	22.49[bbb]	24.90[bbb]	**
Gross margin (million VND ha^{-1})[3]	15.29[aaa]	17.94[aa]	**	19.78[bbb]	21.15[bb]	n.s.

*(**)[***] Difference in means between varieties within wealth groups statistically significant at the 10% (5%) [1%] level of error probability based on Mann-Whitney test.

a,b (aa, bb)[aaa, bbb] Difference in means between wealth groups within varieties statistically significant at the 10% (5%) [1%] level of error probability based on Mann-Whitney test.

[1] Wealth terciles are based on a relative wealth index constructed by principal component analysis from twelve indicators capturing multiple dimensions of poverty.

[2] Vietnamese Dong. 1 US$ = 16,000 VND (June 2007).

[3] Gross margins are based on household-level output prices and means of village-level input prices.

Determinants of maize variety choice: The results of the first-stage probit regression model are presented in the fourth column of Table 3. Residing in a relatively wealthy village increases the probability of growing the higher-yielding NK 54 variety group by 17 percentage points and is therefore an important influencing factor. Female household heads, literate household heads and those located at higher elevations are also more likely to use NK 54, whereby the marginal effects are considerably smaller. Distance to the road and distance between the homestead and the household's upland plots negatively influence its use, whereby especially the marginal effect of the latter is small. The more expensive NK 54 seed is relative to LVN 10 seed, the less likely its use. For an increase of the price ratio from the observed 1.64 to 2.64 the model predicts a decrease in the propensity to grow NK 54 by 12.4 percentage points. However, the marginal effect differs between wealth groups: for the poorest tercile, at 6.2 percentage points, it is much *less* pronounced than for the middle tercile; for the wealthiest group the effect is even smaller at 1.9 percentage points. Interestingly, there is a positive relationship between the price of urea and the choice of NK 54 in the poorest and the middle wealth terciles whereby the effect is more pronounced in the latter; this may indicate an attempt to compensate (expensive) urea fertilizer by a higher-yielding variety, which, however, is unlikely to be successful (cf. Table 2).

Determinants of area allocation to maize: The last column of Table 3 presents the coefficients of the second-stage OLS regression. Per-capita land availability and good extension access positively influence the area share allocated to maize. Interestingly, the portion of land allocated to the cash crop maize *increases* with increasing distance to the road, and the distance to the closest fertilizer outlet is not found to have a statistically significant (negative) impact. This can be explained by the fact that maize traders also service remote villages and frequently supply the necessary inputs to farmers on credit. Due to these arrangements maize may be the only viable cash crop in remote places. The price of urea has a pronounced negative effect while the output price received the previous year is not found to influence farmers land allocation decision. Supplementary off-farm income appears to have a positive effect on the area share allocated to maize (it can be used to finance the necessary inputs), but if the share of off-farm income in total household income exceeds 57%[2] its effect becomes increasingly negative. An explanation may be that these households give priority to food crops for home consumption and/or to crops with low labor requirements to free up labor resources for their off-farm activities. Finally, we find that growing NK 54 is associated with a 17 percentage points larger area allocation to maize. Hereby, statistically significant negative selection bias is corrected for by including the IMR in the second-stage regression, i.e., we find that there are unobserved characteristics of NK 54 growers that pre-dispose them to allocating an almost 10 percentage points smaller area share to maize.

Table 3. Regression results on influencing factors of maize variety choice (1. stage) and area allocation to maize (2. stage) in Yen Chau district, Northern Vietnam (N = 268)

Variable name		Definition	Mean	Coefficients 1. stage (probit)[1]	Coefficients 2. stage (OLS)
Dependent variables					
HYV	=	Dummy, = 1 if high-yielding maize variety NK 54 was used in 2007, 0 otherwise	0.21	Dependent variable	17.1080***[2]
Maize share	=	Share of cultivable area devoted to maize in 2007 (%)	74.86	-	Dependent variable
Independent variables					
Natural capital					
Land availability	=	Per capita cultivable area in the main growing season 2007 (ha)	0.36	0.0250	11.2354***
Upland share	=	Share of land classified as 'upland' within the total cultivable area (%)	78.97	-	0.3488***
Paddy share	=	Share of paddy land (%)	12.28	-	- 0.4126***
Plot distance	=	Mean distance to the households' upland plots (walking minutes)	32.57	- 0.0004*	- 0.0082
Red Book area	=	Total cultivable area under a formal land use certificate ('Red Book') (ha)	1.44	- 0.0122***	-
Red Book share	=	Share of total cultivable area under a Red Book (%)	73.10	-	0.1150
Elevation		Elevation of village centre above sea level ('00 m)	5.18	0.0271***	- 2.3989*
Human capital					
Age HH head	=	Age of the household head	43.11	- 0.0002	- 0.0993*
Literacy HH head	=	Dummy, = 1 if HH head is literate, 0 otherwise	0.79	0.0169***	- 4.8219***
Sex HH head	=	Dummy, = 1 if HH head is female, 0 otherwise	0.07	0.0632*	6.2138**
H'mong	=	Dummy, = 1 if HH head belongs to the ethnic group of the H'mong, 0 otherwise	0.15	- 0.0346***	- 2.4613
Kinh	=	Dummy, = 1 if HH head belongs to the ethnic group of the Kinh, 0 otherwise	0.07	0.0115	13.0137**
Dependency ratio	=	Share of HH members aged < 15 or > 64	0.32	0.0280	- 4.2464

(continued)

[2] This is calculated from the regression coefficients on the variable *Off-farm income* and its squared term. Note that these coefficients are statistically significant at an alpha-error probability level of 13% only.

Table 3. (continued)

Economic/financial capital					
Off-farm income	=	Share of off-farm income in total HH income (%)	13.46	- 0.0007**	0.2120[5]
Off inc. square	=	Off-farm income squared		-	- 0.0037[5]
Credit limit	=	Logged maximum amount of credit available to the HH ('000 VND)[3]	10.33	0.0116	2.0690
Wealthy village	=	Dummy, = 1 if village head assesses village to be wealthier than average in the commune, 0 otherwise	0.29	0.1682***	- 3.4830
Infrastructure/market access					
Maize price	=	Maize price received in 2006 ('000 VND kg^{-1})	2.10	0.0284	3.0311
Seed price ratio	=	Price ratio NK 54/LVN 10 seed in 2007	1.64	- 0.1242***	-
Seed price ratio x poor	=	Interaction seed price ratio x poorest tercile[4] of HHs	0.50	0.0621***	-
Seed price ratio x wealthy	=	Interaction seed price ratio x wealthiest tercile of HHs	0.59	0.1050***	-
Urea price	=	Mean vill. level price of urea in 2007 ('000 VND kg^{-1})	5.09	0.0301**	- 5.8040***
Urea price x poor	=	Interaction urea price ratio x poorest tercile[d] of HHs	1.70	- 0.0229***	0.8409
Urea price x rich	=	Interaction urea price ratio x wealthiest tercile of HHs	1.76	- 0.0342***	- 0.5652
Input distance	=	Distance to the closest fertilizer store (km)	0.70	- 0.0020	- 0.4872
Road distance	=	Distance to the closest paved road (walking min.)	16.62	- 0.0031***	0.3041***
Good extension access	=	Dummy, = 1 if perceived access to agr. extension on a scale from 1 (= very poor) to 5 (= very good) is above the median score of 3	0.43	0.0130	3.3100**
IMR	=	Inverse Mills Ratio derived from 1.stage	0.00	-	- 9.6232**
Constant				-	60.9987**
Model diagnostics				Log-likelihood = - 67.246 Pseudo-R^2 = 0.506 Cases correctly classified: Overall: 88.8% Non-HYV growers: 94.8% HYV growers: 65.5%	F = 7.64*** $R^2_{adj.}$ = 0.383 VIF: Mean = 2.97 Max = 8.56

*(**)[***] Statistically significant at the 10% (5%) [1%] level of alpha-error probability. Significance levels are based on heteroskedasticity-consistent standard errors and account for cluster sampling procedure applied in selecting the households.

[1] Coefficients are marginal effects evaluated at the means of the independent variables.

[2] HYV is used as an independent variable in the 2. stage OLS regression; potential selection bias is accounted for by inclusion of the Inverse Mills Ratio derived from the 1. stage probit regression.

[3] Vietnamese Dong. 1 US$ = 16,000 VND (June 2007); unlogged mean equals 30.496 million VND.

[4] Based on a relative wealth index constructed by principal component analysis.

[5] Not statistically significant in the strict sense, but the alpha-error probability < 13% indicates a likely effect.

Conclusions

In maize production in Yen Chau district there is a high degree of concentration on just a few hybrid varieties. Groups of potentially riskier and less risky varieties can be identified. Regarding variety choice and area allocation to maize, the hypothesis of a higher level of risk aversion of the poor is *not* confirmed: neither do the poorest tercile of farm households allocate a smaller portion of land to the cash crop maize to reduce their exposure to market related risks, nor do they tend to grow varieties belonging to the less risky LVN 10 group. However, the poorest tercile do not apply more inputs to the riskier HYV and do not achieve higher yields than with other varieties. We hence conclude that they do not exploit their higher yield potential. A new research question emanating from this finding is whether this is an attempt to reduce risk or whether it is caused by lacking knowledge or lacking ability to increase input use, for example due to inadequate access to credit. The regression model shows that while the use of NK 54 is less likely in more remote locations, the portion of land allocated to maize increases with increasing distance to the next paved road. Due to arrangements with maize traders who also supply the necessary inputs on credit, maize is particularly attractive to farmers in remote villages. We find, however, that the poorest farmers - who often reside in more remote locations - obtain significantly lower prices for

LVN 10 maize than the wealthiest farmers, indicating that the poorest may have limited choices in marketing their produce (dependence on few maize traders). From this we conclude that maize market integration should be enhanced by improving the road network leading to the more remote upland villages and by enhancing the price information system; price information could be transferred to remote villages by the agricultural extension service and be channelled to individual farmers through mass organisations that are in place in every village.

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