# The Influence of Market Barriers and Farm Income Risk on Non-Farm Income Diversification

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**Abstract**

Empirical evidence shows that non-farm income diversification is associated with higher welfare among farm households. However, most studies have ignored market barriers and farm income risk in explaining income diversification behaviour. This study develops an analytical framework that includes both market barriers and farm income risk, in addition to other factors, in explaining income diversification behaviour. The analytical framework is used to test the hypotheses that: market barriers reduce the intensity of non-farm income diversification; and farm income risk increases the intensity of non-farm income diversification. The results confirm the hypotheses, suggesting that market barriers and farm income risk are key factors in explaining income diversification behaviour of farm households. Future studies should, therefore, consider the two factors in the analysis of income diversification behaviour.

*Key words:* market barriers, farm income risk, income diversification

## 1. INTRODUCTION

There is emerging evidence that non-farm income diversification is associated with higher income and food consumption as well as more stable income and consumption over time (Reardon *et al.,* 1992; Dercon and Krishnan, 1996; Reardon, 1997; Reardon *et al.,* 1998, Barrett *et al.,* 2000; Block and Webb, 2001; Canagarajah *et al.,* 2001). Nonfarm income sources are also effective in combating poverty and inequality (De Janvry and Sadoulet, 2001). As a result, most studies have investigated the factors that influence non-farm income diversification, especially in developing countries (e.g., Ellis, 2000; Barrett *et al.*, 2001a; Abdulai and CroleRees, 2001; Woldenhanna and Oskam, 2001; De Janvry and Sadoulet, 2001; Reardon *et al.*, 2007). These factors can be grouped into five categories, namely: (1) individual and household characteristics; (2) farm characteristics; (3) locational factors; (4) barriers to income diversification; and (5) risk factors.

Individual and household characteristics comprise age, gender, education, marital status and household size among other characteristics (Reardon, 1997; De Janvry and Sadoulet, 2001; Deininger and Olinto, 2001; Lanjouw *et al.,* 2001; Abdulai and CroleRees, 2001; Escobal 2001; Woldenhanna and Oskam, 2001; Barrett *et al.*, 2001a; Yunez-Naude and Taylor, 2001; Wouterse and Taylor 2008). Farm characteristics consist of characteristics such as amount of land cultivated, number of crops grown, value of farm implements, membership in a farm organization and access to agricultural extension (Woldenhanna and Oskam, 2001; De Janvry and Sadoulet, 2001). Locational factors may include the nature of the roads, availability of electricity and distance from towns (Lanjouw *et al.,* 2001; Barrett *et al.*, 2001b; De Janvry and Sadoulet, 2001; Escobal, 2001; Joshi *et al.,* 2002; Winters *et al.*, 2002). Barriers to income diversification may consist of factors such as inaccessibility to credit and market information,

which may discourage non-farm income diversification (Escobal, 2001; Winters *et al.,* 2002; Schwarze and Zeller, 2005). Risk factors capture the impact of the variability of returns from various activities (Mishra and Goodwin 1997; Abdulai and CroleRees, 2001).

Although most of the studies in the non-farm income diversification literature have included individual and household characteristics, farm characteristics and locational factors in assessing income diversification behaviour, only a few studies have included market barriers and farm income risk. As a result, the influences of market barriers and farm income risk on non-farm income diversification have been inadequately researched. In addition, the models developed to explain non-farm income diversification behaviour have ignored the joint influence of market barriers and farm income risk. Based on the Mean-Variance utility approach, this study develops an analytical framework that includes both market barriers and farm income risk, in addition to other factors (household characteristics, farm characteristics and locational factors) in explaining income diversification behaviour. The analytical framework is used to test the hypotheses that: (1) market barriers reduce the intensity of non-farm income diversification; and (2) farm income risk increases the intensity of non-farm income diversification. Cross-sectional data collected in 2004 in the semi-arid areas of Eastern Kenya is used to test the hypotheses. The Kenyan data is chosen for the tests because of its availability. The paper is organized into five sections. The second and third sections give the analytical framework and the data used, respectively. On the other hand, the fourth and the fifth sections discuss the results and provide the conclusion and recommendations, respectively.

## 2. ANALYTICAL FRAMEWORK

*Assumptions*

The model is based on the following assumptions: a household as the unit of analysis; mean-variance utility function; two source of income, farm and non-farm; farming comprises crop and livestock production; farm production function is quasi-concave and twice differentiable; constant absolute risk aversion; fixed leisure; income risk comes from farming, while non-farm work is not risky; and farm income risk comes from fluctuations in weather.

*The model structure*

Let $M_{farm}$, $M_{nonfarm}$ and $M_{total}$ represent farm income, non-farm income and total household income, respectively, with $\overline{M}_{farm}$ and $\overline{M}_{nonfarm}$ denoting the expected farm and non-farm incomes. Also let $R$ be the absolute risk aversion coefficient and $\sigma^2_{M_{farm}}$ be the variance of farm income. The Mean-Variance utility function [ $EU(M)$ ] is specified as:

$$Max\ EU(M) = \overline{M}_{farm} + \overline{M}_{nonfarm} - \frac{R}{2}\sigma^2_{M_{farm}} \tag{2.1}$$

Now let the amount of time spent by a household in leisure, farming, non-farm work, and the total time available for work, be represented by $\overline{T}_{leis}$, $T_{farm}$, $T_{nonfarm}$ and $T_A$ , respectively. Likewise, let $Q$ be farm output, $P_q$ be price of farm output, $K$ be cost per unit farm output, $e_{farm}$ be the random variable for weather, $\sigma^2_{e_{farm}}$ be the variance of farm output, $W$ be non-farm wage and $\theta$ be the proportion of time spent in non-farm work (the choice variable). Also denote household characteristics, farm work characteristics and locational factors by $Z$ , $F_C$ and $L_C$ ,

respectively. In addition, let $B$ represent the proportion of non-farm income lost as a result of barriers to income diversification. Equation (2.1) can be expanded as:

$$\underset{\theta}{Max}\ EU(M) = (P_q - K)Q((1-\theta)T_A; Z, F_C, L_C) + W\theta T_A(1-B) - \frac{R}{2}\left((P_q - K)^2 Q^2 \sigma^2_{e_{farm}}\right) \quad (2.2a)$$

Where,

$$0 \le \theta < 1;\ \ 0 \le B \le 1 \quad (2.2b)$$

$$T = T_A + \overline{T}_{leis} \quad (2.2c)$$

$$T_{farm} = (1-\theta)T_A;\quad T_{nonfarm} = \theta T_A \quad (2.2d)$$

$$M_{farm} = (P_q - K)Q((1-\theta)T_A; Z, F_C, L_C)(1 + e_{farm}) \quad (2.2e)$$

$$E(M_{farm}) = \overline{M}_{farm} = (P_q - K)Q((1-\theta)T_A; Z, F_C, L_C) \quad (2.2f)$$

$$E(M_{nonfarm}) = \overline{M}_{nonfarm} = W\theta T_A(1-B) \quad (2.2g)$$

$$\sigma^2_{M_{farm}} = (P_q - K)^2 Q^2 \sigma^2_{e_{farm}} \quad (2.2h)$$

$$Ee_{farm} = 0 \quad (2.2i)$$

Differentiating Equation (2.2a) with respect to $\theta$ gives the first order conditions (F.O.C.s) as:

$$\frac{dEU(M)}{d\theta} = -(P_q - K)\frac{dQ(.)}{dT_{farm}}T_A + WT_A(1-B) + R(P_q - K)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A\sigma^2_{e_{farm}} \le 0 \quad (2.3a)$$

$$\theta * \frac{dEU(M)}{d\theta} = 0 \quad (2.3b)$$

The second order condition (S.O.C.) is given as:

$$\frac{d^2EU(M)}{d\theta^2} = H = (P_q - K)\frac{d^2Q(.)}{dT^2_{farm}}T_A^2 - R(P_q - K)^2\left(\frac{dQ(.)}{dT_{farm}}\right)^2 T_A^2\sigma^2_{e_{farm}}$$
$$- R(P_q - K)^2 Q(.)\frac{d^2Q(.)}{dT^2_{farm}}T_A^2\sigma^2_{e_{farm}} < 0 \quad (2.4)$$

Let the expected utility as a result of specializing in farm work be $EU(M)_{spec}$. Similarly, let the expected utility as a result of diversifying income into non-farm work be $EU(M)_{div}$. A utility maximizing household will only diversify income into non-farm work (i.e., $\theta > 0$) if $EU(M)_{div} > U(M)_{spec}$. If the household decides to diversify income, then from the F.O.C.s, the optimal proportion of time spent in non-farm work is given as:

$$\theta^* = \theta^*((P_q - K), B, \sigma^2_{e_{farm}}; Z, F_C, L_C) \tag{2.5}$$

Where $P_q - K$ represents the farm profit per unit output. Now substitute $\theta^*$ in the farm income, non-farm income and total household income functions and denote $P_q - K$ as $\pi_q$. The optimal income functions are gives as:

$$M^*_{farm} = M^*_{farm}\left(\theta^*(\pi_q, B, \sigma^2_{e_{farm}}; Z, F_C, L_C)\right) \tag{2.6a}$$

$$M^*_{nonfarm} = M^*_{nonfarm}\left(\theta^*(\pi_q, B, \sigma^2_{e_{farm}}; Z, F_C, L_C)\right) \tag{2.6b}$$

$$M^*_{total} = M^*_{total}\left(\theta^*(\pi_q, B, \sigma^2_{e_{farm}}; Z, F_C, L_C)\right) \tag{2.6c}$$

The intensity of non-farm income diversification is defined as the proportion of non-farm income in total income ($\lambda$). The optimum $\lambda$ (i.e., $\lambda^*$) is specified as:

$$\lambda^* = \frac{M^*_{nonfarm}(\theta^*)}{M^*_{Total}(\theta^*)} = \lambda^*\left(\theta^*(\pi_q, B, \sigma^2_{e_{farm}}; Z, F_C, L_C)\right) \tag{2.7}$$

*Comparative statics*

The aim of the comparative statics is to obtain $\partial\lambda^*/\partial B$ and $\partial\lambda^*/\partial\sigma^2_{e_{farm}}$, assuming interior solutions for $\theta$. Using chain rule, the two derivatives can be specified as:

$$\frac{\partial\lambda^*}{\partial B} = \frac{d\lambda^*}{d\theta^*} * \frac{\partial\theta^*}{\partial B} \tag{2.8a}$$

$$\frac{\partial\lambda^*}{\partial\sigma^2_{e_{farm}}} = \frac{d\lambda^*}{d\theta^*} * \frac{\partial\theta^*}{\partial\sigma^2_{e_{farm}}} \tag{2.8b}$$

Deriving $d\lambda^*/d\theta^*$, $\partial\theta^*/\partial B$ and $\partial\theta^*/\partial\sigma^2_{e_{farm}}$ gives[1]:

$$\frac{d\lambda^*}{d\theta^*} = \frac{M^*_{Total}(.)\frac{dM^*_{nonfarm}(.)}{d\theta^*} - M^*_{nonfarm}(.)\frac{dM^*_{Total}(.)}{d\theta^*}}{\left[M^*_{Total}(.)\right]^2} > 0 \tag{2.9a}$$

$$\frac{\partial\theta^*}{\partial B} = \frac{WT_A}{H} < 0 \tag{2.9b}$$

$$\frac{\partial\theta^*}{\partial\sigma^2_{e_{farm}}} = \left(-R(\pi_q)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A\right)\frac{1}{H} > 0 \quad \text{if } R > 0 \tag{2.9c}$$

Substituting Equations (2.9a-c) in Equations (2.8a) and (2.8b) gives:

$$\frac{\partial\lambda^*}{\partial B} = \frac{M^*_{Total}(.)\frac{dM^*_{nonfarm}(.)}{d\theta^*} - M^*_{nonfarm}(.)\frac{dM^*_{Total}(.)}{d\theta^*}}{\left[M^*_{Total}(.)\right]^2} * \frac{WT_A}{H} < 0 \tag{2.10a}$$

$$\frac{\partial\lambda^*}{\partial\sigma^2_{e_{farm}}} = \frac{M^*_{Total}(.)\frac{dM^*_{nonfarm}(.)}{d\theta^*} - M^*_{nonfarm}(.)\frac{dM^*_{Total}(.)}{d\theta^*}}{\left[M^*_{Total}(.)\right]^2} * \frac{-R(\pi_q)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A}{H} > 0 \quad \text{if } R > 0 \tag{2.10b}$$

[1] See the technical appendix for derivations of $\partial\theta^*/\partial B$ and $\partial\theta^*/\partial\sigma^2_{e_{farm}}$.

In sum, the study tests the hypotheses that: (1) market barriers (measured by inaccessibility to credit) reduce the intensity of non-farm income diversification (Equation 2.10a); and (2) farm income risk (measured by the coefficient of variation of farm income) increases the intensity of non-farm income diversification (Equation 2.10b).

*Econometric model specification and estimation*

Following Mishra and Goodwin (1997), a Tobit regression model is used to estimate the determinants of the intensity of non-farm income diversification (Equation 2.7). The Tobit model is specified as follows:

$$\lambda = \begin{cases} \lambda^* = X\beta + \varepsilon \quad if \;\; EU(M)_{div} > U(M)_{spec}; 0 < \lambda^* < 1 \\ 0 \quad\;\; if \;\; EU(M)_{div} \leq U(M)_{spec} \end{cases} \tag{2.11}$$

Where $\lambda$ is the observed proportion of non-farm income in total income, $\beta$ are the parameter estimates and $\varepsilon$ is the error term. In addition, $X$ comprises farm profit per unit output ($\pi_q$), household characteristics ($Z$), farm work characteristics ($F_C$), locational factors ($L_C$), barriers to participation in non-farm work ($B$) and farm income risk ($\sigma^2_{e_{farm}}$). Since there is no data on farm profit per unit output, a perception variable on the cost of farm inputs is used as a proxy for farm profit per unit output. Household characteristics are captured by the age of the household head, age squared, gender of the household head, education (i.e., primary education or secondary education) and family size. Farm characteristics are captured by farm size, value of farm implements, access to agricultural extension and membership of a farmers' group. Locational factors are captured by dummy variables for Machakos and Makueni districts. Barriers to income diversification are captured by inaccessibility to credit. Farm income risk is captured by the

coefficient of variation (CV) of farm income, measured in terms of the standard deviation of two season (short and long rain) farm income expressed as a percentage of the mean seasonal farm income. In addition to the hypotheses on the influence of barriers to income diversification and farm income risk, it is expected that education, family size, value of farm implements and the locational dummies positively influence the intensity of income diversification, while perception of the cost of farm inputs, farm size, access to agricultural extension and membership of a farmer's group negatively influence the intensity of income diversification. The directions of influence of age and gender cannot be anticipated *a priori*.

## 3. DATA

The data was collected from 228 farmers in the semi-arid areas of Eastern Kenya, by means of semi-structured questionnaires. The survey was undertaken jointly by the Kenya Agricultural Research Institute (KARI-Katumani) and the University of Nairobi, under the Collaboration on Agricultural/Resource Modeling and Applications in Semi-Arid Kenya (CAMASAK) project. The area covered was a catchment of about 5000 $Km^2$ that encompasses three districts, namely: Machakos, Makueni and Kitui. Machakos district houses Machakos town which is capital town of Eastern Province. Of the three districts, Machakos district is the most developed district in terms of infrastructure and other social amenities, followed by Makueni and Kitui in that order. According to the 1999 Kenyan census, Machakos district had a population of 906,644, Makueni district had a population of 771,545, while Kitui district had a population of 515,422.

Geographical Information System (GIS) guided random sampling procedure was used to select farmers to be interviewed. Using this procedure, 30 blocks (1 $km^2$ each) were randomly selected

from the catchment. Farmers were then randomly interviewed in these blocks. The survey was based on long-rain and short-rain seasons of the year 2003. Questions asked include: household characteristics; farm characteristics; locational factors, marketing and institutional support and non-farm income diversification. A summary of descriptive statistics of the variables is given in Table 1.

[Table 1 here]

## 4. RESULTS AND DISCUSSION

Table 2 reports the parameter estimates and marginal effects for the Tobit model of the intensity of non-farm income diversification. The model fit is satisfactory. This evaluation is based on the likelihood ratio statistic which is statistically significant at the one percent level. This means that all 15 variables included in the model are jointly able to explain the variations in the proportion of non-farm income. All the parameter estimates and marginal effects have expected signs.

The results show that nine out of 15 variables are statistically significant at the 10 percent level or better. Secondary education, family size, district dummies and CV of farm income positively and significantly influence the proportion of non-farm income. This means that household heads that have at least secondary education, have larger family sizes, live in Machakos or Makueni districts and experience a higher variation in farm income have a higher proportion of non-farm income. The results also indicate that farm size, access to agricultural extension, membership of a farmers' group and inaccessibility to credit negatively and significantly influence the proportion of non-farm income. This means that households with larger farms, who have access

to agricultural extension, are members of a farmers' group and do not have access to credit have a lower proportion of non-farm income.

[Table 2 here]

The results confirm our first hypothesis that market barriers reduce the intensity of non-farm income diversification. This interpretation is based on the negative and significant influence of inaccessibility to credit on the proportion of non-farm income. In addition, the marginal effect shows that inaccessibility to credit reduces the proportion of non-farm income by 14 percent. The results also confirm our second hypothesis that farm income risk increases the intensity of non-farm income diversification. This is based on the positive and significant influence of CV of farm income on the proportion of non-farm income. The marginal effect shows that a 10 percent increase in the CV of farm income results into a 1.4 percent increase in the proportion of non-farm income. The confirmation of the hypotheses on market barriers and farm income risk shows that these factors, which have generally been ignored by past studies, are key in explaining income diversification behaviour of farm households.

## 5. CONCLUSION AND RECOMMENDATIONS

Empirical evidence shows that non-farm income diversification is associated with higher welfare among farm households. However, most studies have ignored market barriers and farm income risk in explaining income diversification behaviour. The present study develops an analytical framework that includes both market barriers and farm income risk, in addition to other factors, in explaining income diversification behaviour. The analytical framework is used to test the

hypotheses that: (1) market barriers reduce the intensity of non-farm income diversification; and (2) farm income risk increases the intensity of non-farm income diversification.

Tobit regression results confirm the hypothesis that market barriers reduce the intensity of non-farm income diversification. This interpretation is based on the negative and significant influence of inaccessibility to credit on the proportion of non-farm income. Similarly, the regression results confirm the hypothesis that farm income risk increases the intensity of non-farm income diversification. This is based on the positive and significant influence of CV of farm income on the proportion of non-farm income. These results show that market barriers and farm income risk are key factors in explaining income diversification behaviour of farm households. Future studies should, therefore, consider these two factors in the analysis of income diversification behaviour.

**REFERENCES**

Abdulai, A., CroleRees, A., 2001. Determinants of income diversification amongst rural households in southern Mali. *Food Policy* 26, 437-452.

Barrett, C. B., Bezuneh, M., Aboud, A., 2001b. Income diversification, poverty traps and policy shocks in Cote d'Ivoire and Kenya. *Food Policy* 26, 367-384.

Barrett, C.B., Bezuneh, M., Clay, D., Reardon, T., 2000. Heterogeneous constraints, incentives and income diversification strategies in rural Africa. Mimeo.

Barrett, C. B., Reardon, T., Webb, P., 2001a. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy* 26, 315-331.

Block, S., Webb, P., 2001. The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy* 26, 333-350.

Canagarajah, S, Newman, C., Bhattamishra, R., 2001. Non-farm income, gender, and inequality: evidence from rural Ghana and Uganda. *Food Policy* 26, 405-420.

De Janvry, A., Sadoulet, E., 2001. Income strategies among rural households in Mexico: the role of off-farm activities. *World Development* 29, 467-480.

Deininger, K., Olinto, P., 2001. Rural non-farm employment and income diversification in Columbia. *World Development* 29, 455-465.

Dercon, S., Krishnan, P., 1996. Income portfolios in rural Ethiopia and Tanzania: choices and constraints. *Journal of Development Studies* 32, 850-875.

Ellis, F., 2000. Rural livelihoods and diversity in developing countries. Oxford University Press. New York, USA.

Escobal, J., 2001. The determinants of nonfarm income diversification in rural Peru. *World Development* 29, 497-508.

Joshi, P. K., Gulati, A., Birthal, P. S., Twari, L., 2002. Agricultural diversification in South Asia: patterns, determinants and policy implications. Discussion paper no. 57. Markets and Structural Studies Division. International Food Policy Research Institute. Washington, D.C.

Lanjouw, P., Quizon, J., Sparrow, R., 2001. Non-agricultural earnings in peri-urban areas of Tanzania: evidence from household survey data. *Food Policy* 26, 385-403.

Mishra, A.K., Goodwin, B.K., 1997. Farm income variability and the supply of off-farm labour. *American Journal of Agricultural Economics* 79, 880-887.

Reardon, T, Delgado, C., Matlon, P., 1992. Determinants and effects of income diversification amongst farm households in Burkina Faso. *Journal of Development Studies* 28, 264-296.

Reardon, T., Berdegue, J., Barrett, C. B., Stamoulis, K., 2007. Household income diversification into rural nonfarm activities. In: Haggblade, S., Hazell, P. B. R., Reardon, T., (Eds.). Transforming the rural nonfarm economy: opportunities and threats in the developing world, p. 115-140. The John Hopkins University Press. Baltimore, Maryland, USA.

Reardon, T., Stamoulis, K., Balisacan, A., Cruz, M.E., Berdegue, J., Banks, B., 1998. Rural nonfarm income in developing countries. Special chapter in The State of Food And Agriculture 1998. Rome: Food and Agricultural Organization of the United Nations.

Schwarze, S., Zeller, M., 2005. Income diversification of rural households in Central Sulawesi, Indonesia. *Quarterly Journal of International Agriculture* 44, 61-73.

Winters, P., Davis, B., Corral, L., 2002. Assets, activities and income generation in rural Mexico: factoring in social and public capital. *Agricultural Economics* 27, 139-156.

Woldenhanna, T., Oskam, A., 2001. Income diversification and entry barriers: evidence from the Tigray region of Northern Ethiopia. *Food Policy* 26, 351-365.

Wouterse, F., Taylor, J.E., 2008. Migration and income diversification: evidence from Burkina Faso. *World Development* 36, 625-640.

Yunez-Naude, A., Taylor, J.E., 2001. The determinants of nonfarm activities and incomes of rural households in Mexico, with emphasis on education. *World Development* 29, 561-572.

**Technical Appendix**

The comparative statics are undertaken assuming interior solutions for $\theta$. In order to derive $\partial\theta^* / \partial B$, totally differentiate the F.O.C. (Equation 2.3a) with respect to $B$ which gives:

$$\begin{aligned}&(P_q - K)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2\frac{\partial\theta^*}{\partial B} - WT_A - R(P_q - K)^2\left(\frac{dQ(.)}{dT_{farm}}\right)^2 T_A^2\sigma_{e_{farm}}^2\frac{\partial\theta^*}{\partial B}\\&- R(P_q - K)^2 Q(.)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2\sigma_{e_{farm}}^2\frac{\partial\theta^*}{\partial B} = 0\end{aligned} \tag{A.1}$$

And hence:

$$\frac{\partial\theta^*}{\partial B} = \frac{WT_A}{(P_q - K)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2 - R(P_q - K)^2\left(\frac{dQ(.)}{dT_{farm}}\right)^2 T_A^2\sigma_{e_{farm}}^2 - R(P_q - K)^2 Q(.)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2\sigma_{e_{farm}}^2} \tag{A.2}$$

$$= \frac{WT_A}{H} < 0 \tag{A.3}$$

In order to derive $\partial\theta^* / \partial\sigma_{e_{farm}}^2$, totally differentiate the F.O.C. (Equation 2.3a) with respect $\sigma_{e_{farm}}^2$ which gives:

$$\begin{aligned}&(P_q - K)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2\frac{\partial\theta^*}{\partial\sigma_{e_{farm}}^2} - R(P_q - K)^2\left(\frac{dQ(.)}{dT_{farm}}\right)^2 T_A^2\sigma_{e_{farm}}^2\frac{\partial\theta^*}{\partial\sigma_{e_{farm}}^2}\\&- R(P_q - K)^2 Q(.)\frac{d^2Q(.)}{dT_{farm}^2}T_A^2\sigma_{e_{farm}}^2\frac{\partial\theta^*}{\partial\sigma_{e_{farm}}^2} + R(P_q - K)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A = 0\end{aligned} \tag{A.4}$$

And hence:

$$\frac{\partial\theta^*}{\partial\sigma_{e_{farm}}^2} = \frac{-R(P_q - K)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A}{H} = \frac{-R(\pi_q)^2 Q(.)\frac{dQ(.)}{dT_{farm}}T_A}{H} > 0 \quad \text{if } R > 0 \tag{A.5}$$

Table 1: Variable definitions and summary statistics

| Variable | Definition | Mean | Std. deviation |
|---|---|---|---|
| *Income diversification* | | | |
| Total income | Annual household total income in Kenyan Shillings (Kshs) | 37,532 | 63,041 |
| Farm income | Annual household farm income in Kshs | 13,251 | 17,815 |
| Non-farm income | Annual household non-farm income in Kshs | 24,282 | 58,018 |
| Income diversification intensity | Proportion of non-farm income in total income | 0.4260 | 0.3497 |
| *Farm profitability* | | | |
| Perception of the cost of farm inputs | Dummy variable; 1= inexpensive, 0 = expensive | 0.899 | 0.302 |
| *Household characteristics* | | | |
| Age of household head | Continuous variable; in years | 48.3904 | 14.7476 |
| Gender | Dummy variable; 1 = male, 0 = female | 0.6974 | 0.4604 |
| Education | | | |
| Primary | Dummy variable; 1= primary education, 0=otherwise | 0.5658 | 0.4967 |
| Secondary | Dummy variable; 1= secondary and above, 0=otherwise | 0.2544 | 0.4365 |
| Family size | Continuous variable; number of family members | 5.4518 | 3.1219 |
| *Farm characteristics* | | | |
| Farm size | Continuous variable; size of farm in acres | 3.9526 | 3.2830 |
| Value of farm implements | Continuous variable; value of farm implements in '000' Kshs | 7.3135 | 10.3009 |
| Access to agricultural extension | Dummy variable; 1= if received extension, 0=otherwise | 0.1886 | 0.3920 |
| Membership of farmers' group | Dummy variable; 1= if member, 0=otherwise | 0.3947 | 0.4899 |
| *Locational factors* | | | |
| Machakos district | Dummy variable; 1= if in Machakos district, 0=otherwise | 0.5921 | 0.4925 |
| Makueni district | Dummy variable; 1= if in Makueni district, 0=otherwise | 0.3772 | 0.4858 |
| *Barriers to income diversification* | | | |
| Inaccessibility to credit | Dummy variable; 1= if no access to credit, 0=otherwise | 0.8158 | 0.3885 |
| *Farm income risk* | | | |
| CV of farm income | Continuous variable; coefficient of variation of farm income; in percentage | 48.4153 | 32.3122 |

Table 2: Tobit regression results for the intensity of non-farm income diversification

| Variable | Parameter estimate | Marginal effect |
|---|---|---|
| *Farm profitability* | | |
| Perception of the cost of farm inputs | -0.1188 | -0.0869 |
| (1 = inexpensive) | (-1.2023) | (-1.1910) |
| *Household characteristics* | | |
| Age of household head | 0.0014 | 0.0010 |
| | (0.1024) | (0.1024) |
| Age squared | 0.00004 | 0.00003 |
| | (0.3194) | (0.3178) |
| Gender | -0.0897 | -0.0648 |
| (1 = male) | (-1.2492) | (-1.2395) |
| Education | | |
| Primary | 0.0765 | 0.0547 |
| | (0.7417) | (0.7429) |
| Secondary | 0.2157* | 0.1574* |
| | (1.6673) | (1.6454) |
| Family size | 0.0200* | 0.0143* |
| | (1.7014) | (1.7106) |
| *Farm characteristics* | | |
| Farm size | -0.0208* | -0.0149* |
| | (-1.6871) | (-1.6800) |
| Value of farm implements | 0.0021 | 0.0015 |
| | (0.5403) | (0.5399) |
| Access to agricultural extension | -0.1929** | -0.1327** |
| | (-2.0720) | (-2.1908) |
| Membership of farmers' group | -0.1227* | -0.0873* |
| | (-1.8054) | (-1.8169) |
| *Locational factors* | | |
| Machakos district | 0.4106* | 0.2823* |
| | (1.7753) | (1.8993) |
| Makueni district | 0.5503** | 0.3900** |
| | (2.3625) | (2.5167) |
| *Barriers to income diversification* | | |
| Inaccessibility to credit | -0.1892** | -0.1386** |
| | (-2.2714) | (-2.2528) |
| *Farm income risk* | | |
| CV of farm income | 0.0019** | 0.0014** |
| | (2.0161) | (2.0109) |
| Constant | -0.1026 | |
| | (-0.2168) | |
| Sigma | 0.4365*** | |
| | (18.4707) | |
| *Model statistics* | | |
| Number of observations | 228 | |
| Likelihood ratio test (df=15) | 35.3350*** | |

* **, **, * indicates significance at one, five and 10 percent levels, respectively; t-values in parenthesis.
Dependent variable is proportion of non-farm income in total income.