Economic analysis of farmers' preferences for coffee variety traits: lessons for on-farm conservation and technology adoption in Ethiopia

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Abstract

On top of its role in the national economy, Ethiopia's coffee diversity is important not only nationally but also in international research and conservation centers. Despite a tremendous attention to salvage its diversity loss through on-farm conservation, there is no attempt to link on-farm conservation, variety adoption, farmers' preferences for variety traits. This paper aims to study coffee farmers' preferences for variety traits and their implications using a multinomial logit model derived from Lancaster's characteristic model. The model is estimated using the data collected from 266 coffee growing farmers in South Western Ethiopia. The results have shown the factors inducing farmers' preference for certain variety traits. Based on the empirical results, the paper derives policy implications in the areas of on-farm conservation, improved variety adoption, and coffee breeding priority setting.

Keywords: Coffee diversity, Ethiopia, multi-nomial logit, on-farm conservation, variety adoption

1. General background

Coffea Arabica is said to originate in Ethiopia where its genetic diversity is high. Many studies have shown that this diversity plays an important role not only for the country but also for the world at large (Sylvain, 1958). Ethiopian coffee genetic materials are represented in world collections with numerous samples exchanged among gene-banks and breeders and the country is the only region where *arabica* coffee is found as wild forest species (Worede, 1988; Berthaud and Charrier, 1988).

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This paper focuses on farmers' variety attribute preferences and concerns. Understanding attribute preferences serves as an input to both on-farm conservation and technology development and diffusion. For on-farm conservation, it assists in identifying farmers to be targeted, varieties maintained *de facto* and those requiring external incentives. Contextual variety development / breeding, breeding priority setting, targeted diffusion, and better potential of success are the benefits from the technology side (Adesina and Baidu-Forson, 1995; Adesina and Zinnah 1993). Thus, for a successful intervention (be it adoption or on-farm conservation), policy has to be informed on: 'who prefers what kinds of variety attributes most?'

The supply of attributes in the varieties from which farmers choose is constrained by the genetic diversity of the crop in their community (Smale *et.al*, 2001). Even though the choice set (coffee varieties) that farmers have are the same within a PA, the data described else where (Edilegnaw, 2003) shows that some farmers give most priority to yield, others to yield stability and still others to marketability. What explains such differences across farmers? What can policy learn from the results of this exercise?

Having these points in mind, this paper examines farmers' preferences for coffee variety attributes and identifies the varieties that will be conserved *de facto* and those that need policy incentives.

2. Farmers' concerns and variety attribute preferences

When local variety attributes satisfy farmers' concerns, their *de facto* conservation is the outcome of the harmony of variety attributes and farmers' concerns. Thus, the level of *de facto* conservation that occurs in an area is mainly a function of the capacity of farmers' variety (ies) (FVs) to satisfy farmers' economic and non-economic concerns. In essence, farm household characteristics and variety characteristics translate to varietal preferences and land allocation decisions.

Farmers have multiple concerns and no single variety satisfies their concerns (Brush, 2000). A critical issue that remains to be studied is how farmers rank their concerns and how they may trade-off one against another (Bellon, 1996). Their varietal preferences are the reflections of their concerns.

There is a profound relationship among farmers' concerns, farmers' contextual characteristics, their working environment and variety attribute preferemnce. Farmers' concerns are the outcomes of their features, the policy environment and environmental characteristics. Addressing concerns requires matching variety attributes with farmers' concerns. This conditions farmers' variety management that includes selection among the available choice set and use decisions.

The probability of existence of a variety on farmers' fields is a function of the extent to which it embeds the most important attributes playing a key role to the household. Thus the question boils down to the fitness of the variety characteristics with household concerns. The survival of a variety is contingent on its capacity to supply the variety attributes which receive more weight by the farm household.

3. The theoretical framework

The theory presented here draws from Lancaster's (1966) characteristic model, Roy's (1952) safety first model, and the random utility theory (McFadden, 1974).

Suppose Q_p, Q_p-Q_s, Y_f and $C_1 \ldots C_n$ denote quantity of coffee produced, quantity of coffee consumed, farm income and household consumption of other on-farm produced or purchased goods, respectively. Assuming a well behaved utility function, the farmers' utility maximization problem can be set as:

$$Max: \ U = U(Q_p - Q_s, C_1, \ldots, C_n / \varpi_1) \quad (1)$$

where ϖ_1 refers to the vector of household level contextual factors affecting farmers' utility maximization. The utility is subject to cash, labor, land, and production technology constraints.

From the optimum level of production inputs used, farmers' varietal preferences can be derived by tracing the attributes of varieties in use or preferred. Farmers' coffee varietal preferences are, thus, the derived outcomes of farmers' *revealed preferences*. The point of interest is having 'n' varieties of coffee in a given locality with 'n' or more attributes, which of the desirable variety attributes the village is endowed with will be ingredients of the household utility maximization.

Missing markets bring additional input and output constraints by forcing farmers to be self-sufficient. Given that different varieties have different input requirement and marketability, the input and output market constraints will induce farmers to adjust their *revealed preferences* for variety attributes. Depending on the suitability of the variety attributes to the market, it can be hypothesized that while yield stability and environmental adaptability are important for farmers with little access to markets, yield and marketability are the preferred attributes for farmers with better access to markets.

The next important variable worth considering is risk. To study the linkage between farmers' demand for variety attributes and risk, the notion of *Roy's safety first* model is integrated into the utility-based derivation of farmers' preference for variety attributes. Farmers' safety-first strategy is making a *lexicographic optimizer i.e.* a farm household who aims at meeting the target minimum survival level as first priority objective and maximizes expected returns as second priority.

For the purpose at hand, FN_{income} (subsistent level of income) for each farm household is computed as the sum of the value of livestock (V_{live}) and annual estimated income from non-farm, off-farm and unearned income sources (Y_{NF}) *i.e.*

$$V_{live} + Y_{NF} = FN_{income} \quad (2)$$

The decision of the farmer considering survival first depends on the extent to which the household is able to fulfill basic household needs ($Basic_{req}$) from its internal endowment (wealth plus expected risk free income) denoted as FN_{income}. The farmer's objective is thus to minimize the probability that FN_{income} falls short of $Basic_{req}$ *i.e.*

$$\text{Min P}(FN_{income} < Basic_{req}) \Rightarrow \text{P}(FN_{income} - Basic_{req} < 0) \qquad \text{Farmers' 'survival first' motive (3)}$$

Accordinly, farmers will gamble with nature (take high yielding and marketable varieties) if $FN_{income} > Basic_{req}$ and they will take more cautionary measures (opt for environmentally adaptable and stable varieties) if $FN_{income} < Basic_{req}$. Thus, it can be hypothesized that yield stability and environmental adaptability are important for income shock vulnerable farmers and yield and marketability are the most important variety traits for income shock tolerating ones.

4. The multinomial logit model

Suppose ϖ_1 is the vector of characteristics of farmers reflecting their endowments, concerns and preferences and Z_{ji} is a vector of attributes of coffee varieties in the choice set. Then utility from coffee is given by:

$$U_{coffee\ production} = f(Z_{FV}^{1} \ldots Z_{FV}^{n}, Z_{IV}^{1} \ldots Z_{IV}^{n} / \varpi_1) \quad (4)$$

Let the probability that the i^{th} farmer chooses the j^{th} variety attribute be P_{ij} and denote the choice of the i^{th} farmer by $Y_i^{'} = (Y_{i1}, Y_{i2}, \ldots, Y_{ij})$ where $Y_{ij} = 1$ if the j^{th} attribute is selected and all other elements of $Y_i^{'}$ are zero. If each farmer is observed only a single time, the likelihood function of the sample of values $Y_{i1}, \ldots, Y_{ij}$ is:

$$L = \prod_{i=1}^{T} P_{i1}^{Yi1} P_{i2}^{Yi2} \ldots P_{iJ}^{YiJ} \quad (5)$$

Assuming that the errors across the variety traits (ε_{ij}) are independent and identically distributed leads us to the following multinomial logit (MNL) model:-

$$P\{y_i = t\} = \frac{\exp\{x_{it}^{'}\beta\}}{1 + \exp\{x_{i2}^{'}\beta_2\} + \ldots + \exp\{x_{ij}^{'}\beta_j\}} = \frac{\exp\{x_{ij}^{'}\beta\}}{1 + \sum_{k=1}^{M-1} \exp\{x_{ij}^{'}\beta_j\}}, j = 1,2,\ldots., z. \quad (7)$$

The MNL model is used to predict the probability that a farmer prefers a certain variety attribute and how that preference is conditioned by different household and environmental related factors. This exercise has enabled us to answer a pertinent question '*What kind of farmers are looking for what types of varieties?*'

The sign of the marginal effects and the sign of the coefficients is not the same because the sign of the marginal effects will depend not only on the respective coefficients but also on the relative size of the expected value of the coefficients across the choices and the value of the coefficient in the choice set (Greene, 2000) *i.e.*

$$\frac{\partial P_j}{\partial X_j} = P_j\left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P\left[\beta_j - \overline{\beta}\right]. \qquad (8)$$

Thus, in the case of MNL model, one can't for sure tell the sign of the relationship based on the coefficients until the marginal effects are computed. For this reason, we are also reporting the marginal effects in Section 6.

5. Description of variables

To address the empirical objectives, primary data were collected from 266 coffee growing farm households in Jimma Zone of South Western Ethiopia. Farm households were sampled using a *stratified random sampling technique*. The data generation process and coffee farmers' variety choice behavior have been described more in detail elsewhere (Edilegnaw, 2003).

To elucidate farmers' derived demand for variety attributes, they were requested to make a choice among alternative variety attributes (yield, yield stability, environmental stability, marketability, and disease resistance). These variety traits were identified based on the key informal interview undertaken before the data collection using a structured questionnaire. This is the variable used as a response variable. The descriptive statistics show that 29.3%, 29.3%, 21.8%, 13.9% and 5.64% of the farmers had opted for yield, yield stability, environmental adaptability, marketability, and disease resistance, respectively.

The variables considered to explain variety attribute preference (ϖ_1) are described in Tables 1 below along with the expected signs based on the theoretical predictions.

Table 1. Variable definitions and expected signs

Variable	Description	Mean	SD	Expected sign
Dependent variables				
Attribute	0 –Yield; 3 – marketability	NI	NI	NI
Explanatory variables				
Age	Age of the household head	46.3	13.7	-
Agesqur	The square of '*age*'	2332.5	1383.5	-
Educathh	Education level of the household head	2.98	3.20	+
Anyincom	Does the household have any income source outside agriculture? (1 – yes; 0 – no)	0.25	0.43	UN
Locattribute	Number of local variety attributes mentioned to be important to the HH	5.17	1.86	-
Timarket	The average of walking time needed to reach the nearest market (in minutes)	44.67	33.03	-
Cofland	Proportion of land allocated for coffee as a percentage of total land holding	0.54	0.30	UN
Labor14	Farmers' ranking of the importance labor shortage as a production constraint (the lower the better)	5.4	2.9	-
Land14	Farmers' ranking of the importance of land shortage as a production constraint (the lower the better)	3.3	2.7	-
Regular	Do you buy improved seeds regularly? (0 – not at all, 1 - only one time, and 2 – frequently)	0.996	0.66	+
Gappc1	Risk proxy as defined in equation 16	-546.24	659.46	+
Capita14	Farmers' ranking of the importance of working capital as a production constraint (the lower the better)	2.41	1.75	-
Govrank	Farmers' ranking of the importance of extension, input supply, and farm implements as production constraints (the lower the better)	5.78	2.14	-
Naturank	Farmers' ranking of the importance of natural factors (pests, disease, weather, and drought) as a production constraint (the lower the better)	3.91	1.64	UN
Harro[2]	Village dummy (for Harro)	0.14	0.35	UN
Kelaguda	Village dummy (for Kela Guda)	0.13	0.33	UN
Kelokiri	Village dummy (for Kilole Kirkir)	0.13	0.33	UN
Gibeboso	Village dummy (for Gibe Boso)	0.11	0.31	UN
Halosebe	Village dummy (for Halo Sebeka)	0.15	0.35	UN
Sebekdeb	Village dummy (for Sebeka Debiye)	0.14	0.34	UN

Notes: NI = Not important; UN = unpredictable. **Source**: Own 2001/2002 survey data

As given above, the dependent variable '*attribute*' takes five discrete values (0 – yield, 1 – yield stability, 2 – environmental adaptability, 3 - marketability, and 4 – disease resitance). Disease resitance is taken as a reference in the regression. The values of '*attribute*' designiated by 1 and 2 are hypothesized to have the opposite sign unless it happens to be unpredictable.

[2] Villages – Bulbulo and Yachi Urechi – are left as a reference.

6. Regression results and discussions

When we take the most preferred attribute (in the MNL model), it should not imply that farmers are exclusively looking for a single variety attribute. Rather, the motivation is to find the factors that could motivate farmers to have better preference for specific variety attributes. Tables 2 and 3 report the MNL model estimation results.

Table 2. MNL regression results to explain farmers' demand for variety attributes

Variable	Coefficient for yield	Coeff. for yield stability	Coeff. for environmental adaptability	Coeff. for marketability
Age	0.33* (1.33)	0.236 (1.07)	0.213 (0.96)	0.175 (0.64)
Agesqur	-0.004* (-1.63)	-0.002 (-1.04)	-0.0025 (-1.16)	-0.0024 (-0.86)
Educathh	-0.241 (-1.17)	0.239 (1.25)	0.165 (0.84)	-0.067 (-0.31)
Anyincom	0.399 (0.34)	-0.23 (-0.21)	0.222 (0.20)	0.420 (0.32)
Timarket	-0.045** (-1.95)	-0.031* (-1.41)	-0.03* (-1.37)	-0.059** (-2.40)
Locattribute	-0.017 (-0.05)	0.1036 (0.35)	0.263 (0.85)	0.269 (0.67)
Cofland	0.262 (0.12)	0.619 (0.29)	1.2453 (0.57)	-0.81 (-0.33)
Labor14	-0.556** (-2.08)	-0.385* (-1.51)	-0.562** (-2.16)	-0.702** (-2.56)
Land14	-0.689** (-2.16)	-0.536* (-1.78)	-0.537* (-1.75)	-0.511* (-1.58)
Regular	0.773 (0.90)	0.244 (0.32)	0.460 (0.58)	0.875 (0.91)
Gappc1	0.006*** (3.30)	-0.003** (-2.23)	-0.0028** (-1.97)	0.0063*** (3.36)
Govrank	0.563** (2.10)	0.065 (0.28)	0.088 (0.37)	0.698** (2.26)
Capita14	-0.22 (-0.71)	-0.095 (-0.32)	-0.019 (-0.06)	-0.293 (-0.85)
Naturank	0.742* (1.39)	0.640 (1.30)	0.314 (0.61)	0.2104 (0.37)
Harro	-4.13** (-2.06)	-3.48* (-1.82)	-3.72** (-1.90)	-47.39 (-0.00)
Kelaguda	21.48*** (15.06)	21.35*** (13.02)	21.72*** (13.34)	20.17
Kelokiri	0.955 (0.46)	1.529 (0.86)	0.843 (0.46)	0.495 (0.22)
Gibeboso	25.96*** (16.0)	22.06*** (10.9)	22.52*** (11.02)	24.15
Halosebe	23.14*** (18.8)	20.38*** (12.66)	20.98*** (13.03)	23.85
Sebekdeb	26.49	21.75*** (13.95)	22.37*** (14.04)	28.05*** (21.72)
Constant	-0.53 (-0.07	-3.62 (-0.55)	-1.427 (-0.21)	2.64 (0.32)
Dependent variable is Attribute		Number of obs = 230		
LR $\chi^2(80)$ = 309.19		Prob > χ^2 = 0.00		
Pseudo R^2 = 0.454		Log likelihood = -186.02		
Disease resistance is left as a reference				

NOTES: ***-Significant at 1%; **- Significant at 5% and *- Significant at 10%. Two-tailed test is used for those variables the sign of the relationship is not predictable *a priori* and one-tailed test for those variables whose sign of relationship is predicted *a priori.* Figures in parentheses are the ratio of the coefficient to the estimated asymptotic standard error.

Source: Own 2001/2002 survey data

Table 3: Marginal effects of the MNL regression model

Variable	Dy/dx: yield	Dy/Dx: yield stability	Dy/Dx: environmental adaptability	Dy/Dx: marketability
Age	0.016	-0.005	-0.012	-0.00001
Agesqur	-0.00027	0.0002	0.000055	4.50e-08
Educathh	-0.070	0.054	0.0163	-0.00003
Anyincom	0.067	-0.13	0.0602	0.00006
Timarket	-0.0023	0.0012	0.00113	-3.9e-06
Locattribute	-0.0299	-0.015	0.0449	0.00002
Cofland	-0.099	-0.069	0.1687	-0.00024
Labor14	-0.014	0.043	-0.029	-0.000033
Land14	-0.024	0.013	0.0105	8.34e-06
Regular	0.068	-0.081	0.0129	0.00007
Gappc1	0.0014	-0.0009	-0.001	1.13e-06
Govrank	0.076	-0.047	-0.030	0.00008
Capita14	-0.025	-0.0015	0.0261	-0.00003
Naturank	0.039	0.0434	-0.082	-0.00005
Harro*	-0.063	0.1191	0.0058	-0.062
Kelaguda*	-0.0071	-0.07	0.0769	-0.00013
Kelokiri*	-0.045	0.160	-0.11	-0.00008
Gibeboso*	0.726	-0.430	-0.296	5.22e-06
Halosebe*	0.516	-0.351	-0.166	0.00083
Sebekdeb*	0.800	-0.480	-0.324	0.00259

Notes: (*) Dy/Dx is for discrete change of dummy variable from 0 to 1. **Source**: Own 2001/2002 survey data

Overall, the estimated MNL model is highly significant in explaining farmers' variety attribute preference. The χ^2 value is 309 which is statistically significant at 0.00 level. Another indicator was the Psedo-R^2 which was equal to 0.45. To see the predictive power of the model, the actual preferences and the ones predicted by the model were compared. The model correctly predicted about 74 percent of the yield preference, 80 percent of the yield stability preference, 96 percent of the environmental adaptability preference and 60 percent of the marketability preference. The over all prediction was 77 percent.

The results all in all confirm that factors inducing higher demand for yield are different from those factors leading to higher demand for yield stability. More over, the relative importance of the different variety attributes varies across farm households depending on their constraints, endowments and working environment.

For the most part, farmers' vulnerability to potential income shocks, market access, farm household concerns (input supply, extension and natural constraints), experience in growing IVs, and the opportunity cost of resources (mainly land and labor) have been influential in determining variety attribute preferences.

The results suggest that farmers in more accessible areas and those who are less concerned with satisfying subsistence income prefer yield and marketability. On the contrary, farmers in less accessible areas and those more concerned with potential future income shocks (or survival) have more propensities for adaptability and yield stability.

More over, farmers who are less concerned with natural problems (disease, drought, and pests) have been found to have higher demand for yield. Farmers who expect good prospect for availability of rural development services (input supply, farm implements, markets and extension services) have higher demand for yield and marketability.

Because of their effect on farmers' utility, rural development interventions in the areas of infrastructure development, poverty reduction, and market access will change the relative importance of the different variety attributes to households and thereby affect farmers' varietal preferences, demand for local varieties, and on-farm coffee diversity. For instance, if irrigation is made accessible to most small scale farmers, they will be less concerned with traits like drought resistance and environmental adaptability. Hence, those varieties having these traits will be replaced by new varieties.

7. Policy recommendations

The results of this paper have implications not only for on-farm conservation but also for improved variety adoption and breeding priority setting. Since conservation of crop diversity is not an end in itself, this paper will pinpoint the relevance of the results to both of these policy concerns. There are four major policy directions that we would like to emphasize.

The first policy implication is in the area of identifying the varieties conservaed de facto and those that need external incentives. Once policy is informed on the types of varieties preferred by different farm household types, on-farm conservation costs can be optimized. For instance, de facto conservation of high yielding varieties by more accessible and income-shock tolerant farmers implies that there is no need to design external incentives for these varieties to deal with their maintainers. On the contrary, in an area where the demand for a certain variety trait (say, marketability) is low, the variey (ies) embedding that trait should be targeted for conservation. For instance, for farming systems failing to satisfy their current consumption requirement and those found in less-accessible areas, conservation should be targeted to varieties which do not satisfy yield stability and environmental adaptability.

The second policy implication is in the area of opportunity cost compensation. One of the issues to be dealt with in on-farm conservation is the opportunity cost that farmers are facing when the policy is in place. To this end, understanding farmers' variety trait preferences will enable policy makers to identify the variety attributes that have to be compensated. For instance, famers who fail to satisfy their current consumption requirement are most affected when they have to abandon varieties (for the purpose of on-farm conservation) with better yield stability and environmental adaptability.

The third policy implication is in the area of variety adoption. For the success of agricultural technologies, their attributes should address farmers' concerns. Thus understanding farmers' variety trait preferences is an input to this end. For instance, according to the results, to target and address variety demand for income shock vulnerable and segmented farmers, the priority variety attributes are yield stability and environmental adaptation.

The fourth policy implication is in breeding priority setting. Given that farmers' variety attribute preferences are determining both their propensity to use IVs and the chance of using them successfully, breeding should target to satisfy demands of different farm household types classified by their resource endowments, preferences and constraints. To this end, analyzing farmers' variety attribute preferences will help to inculcate farmers' demands in the making of the technology. The research priority setting should, therefore, ask '*breeding for whom?*' not just only '*breeding for which environment?*', as it is mostly the case.

References

Adesina, A.A. and J.Baidu-Forson (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. Agricultural Economics, vol.13: 1-9.

Adesina, A.A. and M.E. Zinnah (1993). Technology characteristics, farmers' perceptions and adoption decisions: a tobit model application in Sierra Leone. Agricultural Economics, vol.9: 297-311.

Berthaud, J. and A. Charrier (1988). 'Genetic resources of coffea Arabica.' In: Clarke, R.J. and R. Macrae, Eds. Coffee, Agronomy, Volume 4. Elsevier applied sciences: London.

Bellon, M.R. (1996). The dynamics of crop infraspecific diversity: a conceptual framework at the farmer level. Economic Botany, vol. 50 (1): 26-39.

Brush, S.B. (2000). 'The issues of in situ conservation of CGRs.' In: Brush, S.B., Ed. Genes in the field: on-farm conservation of crop diversity. Lewis publishers: IDRC and IPGRI, PP. 3-26.

Edilegnaw, W. (2003). The economics of on farm conservation of crop diversity in Ethiopia: incentives, attribute preferences and opportunity costs of maintaining local varieties of crops. Ph.D. dissertation, submitted to the Faculty of agriculture, University of Bonn.

Greene, W. (2000). Econometric Analysis. Fourth Ed., Prentice-Hall: New Jersey.

Lancaster, K.J. (1966). A new approach to consumer theory. Journal of political economy, vol.74: 132-57.

McFadden, D.L. (1974). The measurement of urban travel demand. Journal of public economics, vol.3: 303-328.

Roy, A.D. (1952). Safety first and the holding of assets. Econometrica, vol. 20: 431- 449.

Smale, M., M. Bellon, and J.A.A. Gömez (2001). Maize diversity, variety attributes and farmers' choices in Southeastern Guanajuato, Mexico. Economic development and cultural change, vol. 50 (1): 201-225.

Sylvain, P.G. (1958). Ethiopian coffee – its significance to world coffee problems. Economic botany, vol.12: 111-139.

Worede, M. (1988). Diversity and the genetic resource base. Ethiopian journal of agricultural sciences, vol.10 (1-2): 39-52.