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A Test of Separability of Consumption and Production Decisions of Farm Households in Ethiopia*

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Abstract: In this paper, I test and reject the separability of production and consumption decisions of agricultural households in Ethiopia, using data from a rural household survey conducted in 1994 and an estimated labor demand equation. I also elicit socio-demographic and asset variables that are positively linked with agricultural labor demand.

These results reflect the limited development of fully organized labor markets in rural Ethiopia. They also imply that price subsidies, taxes and other purely market-driven agricultural policies may have only limited or perverse impacts. They should be complemented by policies directly affecting household decisions, such as food aid, technology transfer, free supply of fertilizers and so on.

Keywords: Agricultural Household, Separability, Ethiopia

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Because of the proximity of households to subsistence thresholds in very poor countries, survival considerations may be dominating household decisions. In such situations, own-produced consumption strategies may be preferred to commercialization combined with consumption purchases by agricultural households. In such a context, the separability of production and consumption decisions of agricultural households, a well-known property under perfect market situations, may be broken.

In this paper, I test the separability of agricultural household decisions in Ethiopia using data from a rural household survey conducted in 1994. First, I present the data and the agricultural technology model. Then, I discuss the estimation and test results.

Data and Context

At the time of the survey, the agricultural sector in Ethiopia corresponded to about 48 percent of GDP.[1] Rural areas represented nearly 87 percent of the population, which implies that agriculture was the basis of most household livelihoods. However, over the period 1970–1992, agricultural growth was sluggish at rates between 0.7 and 0.4 percent. Combined with steady demographic growth, this stagnation of agricultural output generated a general decline in living standards in rural areas. Indeed, population growth rates reached 2.6 percent over the period 1970–1980 period, and 3.1 percent over the period 1980–1992.

The bulk of the agricultural output was, and is still, made up of cereal products. The main cereals grown are teff, wheat, barley, maize, sorghum and millet. At the time of the survey, cereals accounted for 83 percent of the cultivated area (Central Statistical Authority 1995). Farmers contributed 90 percent of agricultural output, mostly in the form of cereals corresponding to 75 percent of the cultivated area. This

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1 The aggregate indicators for which the source is not specified are extracted from the World Bank's World Development Report (1993, 1994, 1995).

justifies my focus on this type of producers. Yao (1990), who studies aggregate productivity in cereal crops in Ethiopia, and Croppenstedt and Muller (2000), who use this household survey data, show that land and labor are the dominating production factors in explaining agricultural productivity for cereal products in Ethiopia.

However, cereal output dropped by 5 percent between 1980 and 1994 due to adverse weather conditions, violent conflicts and poor policies, whereas population had increased by 40 percent. Such a fragile food balance is not rare in Ethiopia. Notably, two large scale famines (1973–1974 and 1983–1985) struck Ethiopia at the end of the last century, and there continues to be a significant risk of famine (see for example AP 2011). Even in years of normal rainfall, malnutrition is common and food security remains precarious in rural areas (Diriba 1995; Webb and von Braun 1994). At the time of the survey, 64 percent of children below 5 years old were observed suffering from stunting, and 8 percent from wasting (Central Statistical Authority 1993; Pelletier et al. 1995).

The data I use are taken from the Ethiopian Rural Household Survey conducted in 1995 by the University of Addis Ababa, in collaboration with IFPRI and the University of Oxford.[2] 1477 households were interviewed in 18 peasant associations in 15 weredas (districts) and 6 regions across the country. Records on crops, production factors and socio-demographic characteristics are available in these data.

The initial sample of surveyed households corresponded to sites that had been chosen by the organization conducting the survey for their easy access from the road and their "interesting" characteristics. From this initial sample, I retained observations that correspond to typical production processes for cereal growers and eliminated missing values. This implies that the studied sample may differ from the average

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2 These data have been used in many applied studies of Ethiopian agricultural households, such as Dercon and Christensen (2011) and Mani, Hoddinott and Strauss (2012).

Ethiopian agricultural households by some of their production or socio-demographic characteristics, though this is not blatant in the descriptive statistics. In these conditions, the interpretation of some effects elicited in the regressions may be affected by selection or sampling effects. Since I cannot correct for these deficiencies in the data, I assume that it is not the case.

Specifically, to avoid excessive heterogeneity in agricultural technology affecting the results, I focus on sites where farmers grow cereals by using ox-plough techniques. Croppenstedt and Muller (2000) discuss these data in detail. Moreover, I exclusively include households cultivating at least 0.2 hectares. Indeed, families cultivating almost no land are not likely to be agricultural households, and consequently the question of separability of consumption and production decisions may not make sense for them.

After dropping observations because of missing values, outliers and erroneous values, we are left with 430 households. Table 1 shows the corresponding descriptive statistics, which roughly fit the commonly known features of this part of Ethiopia. Land is scarce with an average holding area of 1.5 hectare per household. Land quality is described by a multinomial variable (1 = best quality, 2 = average, 3 = worst quality), which has a mean of 1.67 with this scale. Land steepness (1 = flat, 2 = average, 3 = steepest) is on average 1.29.

The considered households own on average 8.7 farm animals and apply an average of 49 kg of fertilizers per hectare, although 51 percent of households do not use fertilizer. Only 31 percent of households report days worked off the farm. Moreover, over the four months preceding the survey, 91 percent of households reported less than 31 days worked off the farm. It is therefore not irrelevant to approximate the situation of these households by considering that the household family workforce is essentially employed on the farm. These households have an average of six members. Among them, on average about three adults per household are engaged in farming activities and domestic work.

The observed household members have little education. Only 40 percent of these household heads can read and write. Moreover, only an average 23 percent of all other members can read or write. Even for literate members, formal education is rare. A mere 10 percent of the considered heads have completed primary schooling. This is consistent with an average of 0.74 schooling years for heads. We now describe how the labor input is related to other household characteristics in an elementary model.

The Model

Under perfect markets and with no uncertainty, household decisions can be seen as originating from the maximization of a utility function representing their preferences under a budget constraint and some technology constraints. In these conditions, and for non-corner solutions, the optimization program can be decomposed in two stages. In the first stage, the household makes its production decisions by maximizing its profit, accounting for market prices of outputs and inputs, including labor, under the technology constraints that it faces. This generates a certain amount of realized profit that can be added to other income sources to yield the full income of the considered household. Then, in a second stage, the household can incorporate this full income in its budget constraint and simply maximizes its utility under the obtained budget constraint. In that situation, the “separability property” describes the facts that: (1) production decisions affect consumption–leisure decisions only through the profit effect, and (2) production decisions are not affected by consumption–leisure decisions or their determinants such as household preferences.

In contrast, a “non-separability” situation is obtained when, for example, there is no market for labor. In that case, the labor quantity offered by the household, that is, its total available time minus its total leisure, is strictly equal to the labor input into household production. No family member works off the farm, and no external agricultural worker is employed on the farm. In that case, the labor demand depends on most household characteristics, including on the determinants of its preferences and on its assets.

I examine labor demand, which is a production decision, in order to test if the considered households are, on average, in a separability situation or not.[3] Consider the following model of agricultural household, directly inspired by Singh, Squire and Strauss (1986), with one good and one input to simplify the discussion.

$$\mathrm{Max}_{c,\ l,\ L_{hired},\ L_{ext},\ L_{farm}}\ U(c,\ l)$$

Subject to:

$$p\ c = p\ F(L_{farm} + L_{hired}) - w\ L_{hired} + w\ L_{ext},$$

$$\text{and } l + L_{farm} + L_{ext} = T,$$

where U is the household utility function describing the preferences, while F is the farm production function, c is the consumption demand, l the leisure, L_{farm} is the labor input from household members working on the farm, L_{hired} is the labor input corresponding to hired agricultural workers from the labor market, L_{ext} is the labor supply to the labor market by household members, T is the household total available time, p is the price of the consumption and production good, w is the wage rate, which is assumed to be identical for hired workers and labor supply.

Of course, more complex and realistic hypotheses could be adopted. In particular, we neglect positivity constraints and other possible constraints, and we assume perfect markets. However, this program is useful because it helps clarify what the separability property is. Specifically, within this model, the optimization can be decomposed

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[3] Due to the limited sample size we cannot hope to analyze the heterogeneity across households and assumptions of market failure or imperfect markets, as for example in Vakis et al. (2004).

into two stages. The first one consists in a producer problem based on profit (P) maximization. It describes household decisions viewed from the producer side.

$$\text{Max}_L\ P = p\ F(L) - w\ L, \text{ where L is the total labor input.}$$

Solving this program yields an optimal profit level denoted by P*. In the second stage, the household maximizes its utility under the resulting budget constraint.

$$\text{Max}_{c,\ l}\ U(c,\ l) \text{ subject to: } p\ c = P^{*} + w\ (T - l).$$

This following graph illustrates the corresponding situation (Figure 1).

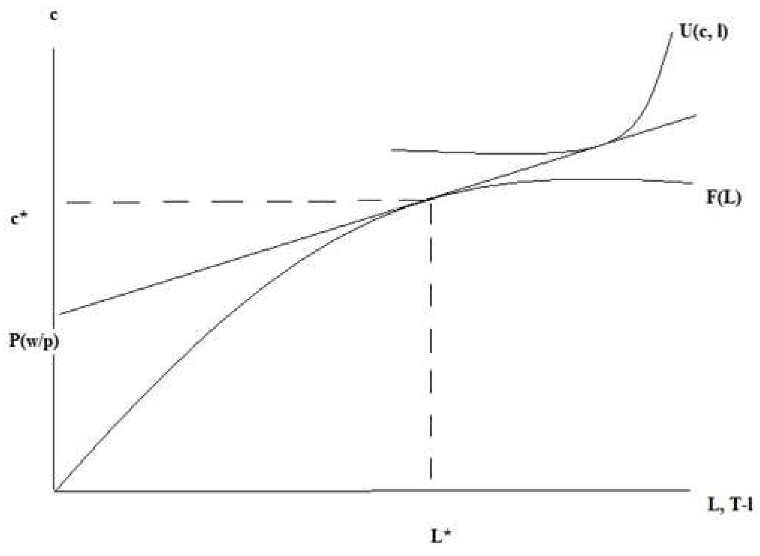

Figure 1.

In particular, the demand function for the first stage does not depend on household preferences characteristics. This is not the case for example if there is no labor market, which would correspond to the following optimization program.

$$Max_{c,\ l}\ U(c,\ l) \quad \text{subject to} \quad c = F(T - l).$$

However, other sources of separability may exist, for example the presence of binding constraints or production uncertainty.

I now specify an agricultural labor demand function in the form of a basic equation that I shall estimate. Specifically, for a household i, we assume:

$$Ln(L_i) = b_0 + b_1\ LAND_i + b_2\ ln(LAND_i) + b_3\ ln(LQ_i) + b_4\ ln(LS_i) + X_i'b_5 + \text{site dummies effects} + u_i,$$

where the b_j's (j=1,..,5) are some coefficient vectors to estimate, L_i is the labor demand of household i, $LAND_i$ is the land area cultivated by the household, LQ_i is the land quality index, LS_i is the land steepness index, X_i regroups socio-demographic household characteristics and u_i is an error term. Since plowing and harvesting are the two main agricultural tasks, the labor demand variable is measured as being the number of person-days used for these tasks. We excluded the days spent in weeding as this task often does not correspond to intensive work, so much so that it is sometimes hard to distinguish from idleness. Excluding minor tasks has also the advantage of generating a rather homogenous measure of aggregate labor supply.

Vector X_i incorporates characteristics of household preferences that should not be present in a labor demand function under separability since in that case production decisions are independent of household preferences or household assets and depend only on the efficient organization of production and markets. In our applied specification, these preference characteristics are: ten variables describing the number of members into respective age–gender groups, a dummy variable for heads who can read and write, the number of schooling years of the head, the mean schooling level of household members, a dummy for heads who have completed at least primary education, the average age of the head, the average age of family farm workers (including or not including domestic workers), a dummy variable for houses with solid walls (stone, brick, concrete or cement), a dummy variable for houses with a roof made of galvanized iron or wood, a dummy variable for female heads and, finally, the household size.

We have introduced site dummies in the specification of the labor demand equation in order to capture both the unobserved heterogeneity of local factors associated with the sites and possible measurement errors related to "enumerator effects," since the data collection in each site was carried out by different enumerators.

Land is the main agricultural input and considered as being fixed. We account for its quality and steepness, as these characteristics may affect the household permanent needs for labor input.

In Ethiopia, labor is the second most important agricultural input, after land. Not only does agricultural labor incorporate diverse tasks, but it is also made up of the varied contributions of (1) different family members, and (2) possible temporarily hired workers. As mentioned before, plowing (LABP) and harvesting (LABH) are the main tasks performed, with the mean number of person-days for each task equal to 51 and 68 respectively.

Separability Tests

Various tests for separability based on agricultural labor demand appear in the literature, starting with Lopez (1984). These tests are often based on the property that under perfect markets and without uncertainty, unearned income and household characteristics such as household composition and assets should not affect the labor demand function for on-farm tasks.

The interpretation of the results of such tests is not obvious a priori as separability and non-separability situations are based only on approximate models. In particular, it may be that the features associated with separability vary, not only with the considered household or period, but also with the complexity of the decision that is referred to. Nonetheless, the fact that household characteristics that have a priori nothing to do with production are affecting production decisions is also interesting in itself, whether related to a precise decision model or not.

Let us first discuss some of the separability tests in the literature, which are based on similar labor demand equations. Lopez (1984) is the seminal article on separability. Lopez rejected separability using a test of non-nested alternative hypotheses in order to compare a separable model with a non-separable model. However, a close look at these equations reveals that the non-significance of household demographic characteristics in the labor demand equation plays a crucial role in the test.

Other approaches are possible. For example, Pitt and Rosenzweig (1986) argue that if labor can be hired as a substitute for family labor then farm profits should be unaffected by farmer illness. In the same vein, Behrman, Foster and Rosenzweig (1997) find in Pakistan that planting-stage calorie consumption affects harvest time profit. This suggests that in this context labor markets are not working efficiently at the harvest stage, and that there is no separability. Land demand can also be used for the test. Shapiro (1990) reports that household composition affects the cultivated farm area for a sample of agricultural households from the Democratic Republic of Congo.

However, the most common method remains that of testing whether labor demand is affected by determinants of household preferences, for example household composition. This is the case of Benjamin (1992), using Indonesian farm level data, who does not strongly reject the separability of production and consumption decisions on the basis of similar labor demand equations to our setting. Fafchamps and Quisumbing (1997) use rural household data from Pakistan and also reject separability. Other authors also reject the separability property in various contexts (Jacoby 1993; Kevane 1994; Udry 1996; Barrett 1996).

To my knowledge, the separability hypothesis does not seem to have been specifically tested for Ethiopia, notably through the examination of the labor demand of agricultural households. However, there is an article worth mentioning related to our concerns. Mekonnen (1999) carries out a case study of rural household biomass fuel collection and consumption in Ethiopia, using a non-separable agricultural household model. Of course, since biomass (wood and dung) is simultaneously produced and fully consumed in this context, there is obviously no question of testing separability in that case.

The Test Results

Table 2 reports the estimates of the labour demand equation, in which diverse household and house characteristics have been included. As mentioned before, this specification is similar to the one used by Benjamin (1992). House characteristics are included as they are potentially informative on non-earning incomes (e.g. when the house is inherited), assets and household dwelling tastes, and other various features that do not affect production choices under separability.

The regression is well determined with an adjusted-R^2 of 0.50. Several household composition variables, the dummy variable for a house roof made of galvanized iron or wood and the age of the household head have significant coefficients. These results clearly indicate that the separability hypothesis is rejected without doubt. Let us examine these results in detail.

Land has been introduced both in level and in logarithm in the estimated demand equation, so as to better capture some possible nonlinearity. Even if only the coefficient of the logarithm of the land area is significant, it still corresponds to substantial elasticity (0.52) of the labor input with respect to the fixed input that is land. Land slope and land quality have non-significant coefficients. They do not seem to affect the level of labor demand in these data. These three characteristics of land are valid correlates in any equation of labor demand, whether or not the separability hypothesis is satisfied. This is also the case for the site dummies that may recover unobserved agro-climatic features of the environment likely to affect agricultural tasks. This is confirmed by the fact that the coefficients of these site dummies are generally significant, and often even highly significant, except for Site 7.

In contrast, the estimates of the coefficients of the other included regressors should not be significant if the separability hypothesis is satisfied. Among the age categories for the numbers of female members, only the number of female babies (under 5 years old) has a (highly) significant positive coefficient. It may be that babies sometimes imply special urgent needs that must be financed through additional production effort. For male members, the coefficients of the number of children between 10 and 18 years old, and the coefficient of the number of (non-elderly) adults, are both significant and positive at 5 percent level. This suggests that a higher household male labor force implies higher input, a typical feature of non-separable models where there is no perfect substitutability of family labor by hired labor. Indeed, male teenagers and male adults make up a major part of the household labor force, especially for hard tasks like plowing. In the absence of an active labor market, the potential labor demand is restricted by the household labor force, which may explain all these demographic effects. Beyond the rejection of separability, the elicited relationship of labor demand with gender–age classes is more complex than expected.

The education of the head and that of the other household members, as well as their average age and the dummy variable for female heads, have non-significant coefficients. However, the coefficient of the age of household head is positively significant at slightly more than 5 percent. It may be that the families with more experienced heads have often more ambitious production plans, which requires more agricultural labor.

Households with a house roof made of galvanized iron or wood, that is, with a relatively solid roof in this context, have significantly higher labor demand levels. They may be wealthier households who can afford to take more risks, and therefore a larger production effort. This is not the case for houses with robust walls whose coefficient is non-significant. On the whole, the significance of many coefficients of variables that would be excluded under separability allows us to reject separability without doubt.

Conclusion

In this paper, I tested and rejected separability between agricultural production decisions and consumption decisions for poor farm households in Ethiopia. This is a confirmation of similar findings for several poor countries in the world. I also elicited socio-demographic and asset variables that are positively linked with agricultural labor demand.

These results may be due to incomplete or missing labor markets, consistent with some of the literature. They reflect the limited development of fully organized labor markets in rural Ethiopia.

This situation implies that purely market-driven agricultural policies like price subsidies or taxes, may have only limited, and perhaps sometimes even perverse, impacts. They should be complemented by policies directly affecting household decisions, such as food aid, technology transfer, training, free supply of fertilizers and so on.

A few limitations nonetheless remain in this analysis. In particular, availing of larger nationally-based samples with more recent data would allow a robust confirmation of the separability in the contemporary Ethiopian context. It would also make possible a more precise investigation of the precise role of socio-demographic human capital characteristics in production decisions.

Table 1.
Descriptive Statistics

Variable	Mean	Standard Deviation	Range
Production index	1.7	0.22	0.96-2.33
Land (ha)	1.488	1.094	0.21-8.13
Labor for plowing (person-days)	51.33	56.56	1.00-436.00
Labor for harvest (person-days)	67.92	87.58	1.00-744.00
Land quality	1.670	0.664	1-3
Land steepness	1.286	0.416	1-3
Number of female members aged 0-4	0.470	0.66	0-3
Number of female members aged 5-9	0.488	0.69	0-3
Number of female members aged 10-17	0.637	0.82	0-4
Number of female members aged 18-49	1.144	0.74	0-5
Number of female members aged 50+	0.270	0.48	0-2
Number of male members aged 0-4	0.435	0.63	0-3
Number of male members aged 5-9	0.493	0.72	0-3
Number of male members aged 10-17	0.661	0.83	0-5
Number of male members aged 18-49	1.130	0.72	0-5
Number of male members aged 50+	0.342	0.5	0-2
Female head	0.114	-	0-1
Head’s age	44.23	15.14	18-101
Average age	32.79	9.30	17.5-73
Solid walls	0.10	0.31	0-1
Solid roof	0.30	0.46	0-1
Head’s schooling (Years)	0.742	2.20	0-16
Average member’s schooling (Years)	0.07	0.79	0-6
Head can read and write	0.40	-	0-1
Family size	6.16	2.70	1-17

Note. 430 observations.

Table 2.
Least-Squares Estimates of Labour Demand

Variable	Coefficient	T-ratios
Intercept	**4.0970**	16.12
Land	0.0199	0.30
ln(Land)	0.5210	4.42
Land quality	-0.0616	1.23
Land steepness	0.0392	0.47
Number of female members aged 0-4	0.1111	2.22
Number of female members aged 5-9	0.0524	1.14
Number of female members aged 10-17	0.0346	0.91
Number of female members aged 18-49	-0.0432	0.97
Number of female members aged 50+	-0.0569	0.82
Number of male members aged 0-4	0.0311	0.64
Number of male members aged 5-9	-0.0438	1.00
Number of male members aged 10-17	0.1057	2.89
Number of male members aged 18-49	0.1509	3.47
Number of male members aged 50+	0.1424	1.53
Head can read and write	0.0582	0.80
Average members' schooling (Years)	-0.0088	0.33
Solid walls	-0.0248	0.17
Solid roof	0.2218	2.90
Female head	-0.0028	0.03
Head's age	0.0064	1.90
Average schooling	-0.0017	0.38
Head's schooling	0.0281	1.33
DU2	-1.0483	3.84
DU3	-0.9041	6.11
DU5	-0.2422	1.57
DU6	-0.6569	4.32
DU7	0.1004	0.72
DU8	-0.4472	3.14
DU9	-0.8095	5.611
DU10	-0.6747	4.53
DU11	-0.9470	5.65
Adjusted-R^2	0.50	

Note. 430 observations.

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