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The Impact of Location on Crop Choice and Rural Livelihood: Evidences from Villages in Northern Ethiopia

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The Impact of Location on Crop Choice and Rural Livelihood: Evidences from Villages in Northern Ethiopia

Abstract

This paper attempts to demonstrate how location of an agricultural economic activity in relation to urban centers determines households' decision to allot their agricultural land to the production of either staple crop or a high value but risky cash crop. Analyzing household data from villages in North Eastern Ethiopia, we find that proximity to urban centers, access to road, and education along with other factors determine the crop choice in favor of the production of high value crops. Crop choices further significantly predict levels of per capita income across villages where the farthest with no access to road are the poorest.

Kurzfassung

In dieser Arbeit wird gezeigt, dass die Entfernung eines Anbaugebiets zu Ballungsgebieten Einfluss nimmt auf die Entscheidung eines Haushalts darüber, ob eher minder- oder hochwertige aber risikoreiche Pflanzen angebaut werden. Bei der Analyse von Daten aus Nordost-Äthiopien, konnte festgestellt werden, dass die Nähe zu Ballungsgebieten und der Zugang zu befestigten Straßen zusammen mit weiteren Faktoren Einfluss auf die Entscheidung über die anzubauenden Nutzpflanzen nimmt. Geringe Entfernung und Zugang zu Straßen beeinflussen dabei die Entscheidung zugunsten des Anbaus von hochwertigen Nutzpflanzen. Die Wahl des Pflanzenportfolios hat ebenso einen Einfluss auf das Pro-Kopf-Einkommen in den untersuchten Dörfern, wobei die entfernt gelegenen Dörfer ohne Zugang zu befestigten Straßen die ärmsten sind.

1 Introduction

Early thinking on the relation between location and crop choice dates back to the 19th century owing to von Thünen who first pointed out the importance of location in shaping the duality between the rural and urban economy. In his 'Isolated State,' Thünen portrays an economy that consists of an urban center surrounded by homogenous agricultural land which differs only in terms of distance from the urban center. Agricultural produces from the land are transported to town for trading. Crop choices depend on the cost effectiveness of each crop in terms of transportation. In the inner ring around the town, crops which are costly to transport (such as vegetables) are produced. At the outer annulus of the rings, crops involving lower transport costs (such as grain) are grown (Samuelson, 1983; Fujita and Thisse, 2002).

The decision of households located in the outer annulus to produce grains may not be entirely driven by price incentives but could also be an outcome of their desire to be self-sufficient in staple crops in order to smooth consumption. Inherent to different distances of villages from the urban centers is, thus, an unequal distribution of income, since vegetables are cash crops that yield high returns on the market while staple food grown at the outskirts can be sold only at low prices.

Despite Thünen's early approach, there has been put little attention to the role of location in recent crop choice models (Fujita and Thisse, 2002) which rather focus on uncertainties arising from weather conditions and price shocks. In an attempt to fill this gap, this paper analyzes the impact of location on crop choices and the associated disparity in income using data from villages in North Eastern Ethiopia.

It has been widely argued that various forms of uncertainties contribute to the subsistent nature of many rural areas in developing countries (Dillon and Scandizzo, 1978; Fafchamps, 1992; Dercon, 1996; Ayalew, 2003). In response to this, rural households have developed different strategies to cope with the risk associated with agricultural production. Diversification has been conceived as a feasible insurance strategy, which often implies lower returns, however. Price fluctuations can be compensated if households cultivate a wide portfolio of crops, among which staple crops—tending to be more stable in terms of prices—constitute an important safety measure. In particular, poor and risk-averse households tend to ensure self-sufficiency in staple crops leading to the limitation of diversification to only different kinds of staple crops.

Even given stable and high prices for cash crops, households' decision to engage in the production of cash crops depends on transportation costs, which in turn depend on the distance of the particular plot or village from the market. For instance, markets for logs and lumber of eucalyptus are well established in urban centers of Ethiopia. However, households living far from urban centers do not grow eucalyptus trees even on their marginal land because eucalyptus growers living closer to urban centers outbid in the market. One reason is higher transportation cost. Distance to markets has thus an important influence on the development prospects of remote villages. Decisions by households to allocate the bulk of land to the production of less valued staple crops results in low surplus and low incomes, implying that the incidence of poverty is likely to increase with distance away from urban centers.

This paper attempts to look into how the location of an agricultural activity in relation to markets in urban centers affects the production of high value cash crops. The remaining part of the paper is organized as follows. Section 2 highlights descriptive facts from surveyed villages. Section 3 presents a simple theoretical framework while Section 4 deals with the econometric analysis. Finally, section 5 concludes.

2 Location of Agricultural Land and Crop Choice in Selected Villages of Ethiopia

Ethiopia has about 77 million people growing at about 2.8% annually. About 85% of the population makes a living from land intensive subsistent agriculture accounting for 45% of GDP. The country exhibits one of the lowest rates of urbanization where only 15% dwells in urban centers. As a result, arable land per household decreases making the land issue critical in transforming the Ethiopian economy. Average land size in the country remains at about 1 hectare per household. This is equivalent to a mere 0.2 hectare per head with an average rural household size of 5, which is mostly used for staple crop production (CSA, 2005).

Due to a poorly developed transport network and low demand from the urban center, Ethiopian farmers focus on the production of staple crops except for coffee for which an already established international market exists. According to the national data from CSA, in 2005, 84.3% of rural households in Ethiopia, excluding nomadic areas, live on crop and livestock production. About 84% of the total production of major crops is accounted by cereals. If we exclude teff[1] which is both staple and cash crop, the share of the purely staple crops in the major crop production is as high as 79%. Pulses which are predominantly cash crops have a share of less than 5% (CSA, 2005).

2.1 Location

The study covers six villages in four locations. The villages were systematically selected based on their location from urban centers. The survey also accounts for agro-ecological differences. The distance between the reference district town and the nearest villages to the town is about 4 kilometers. The farthest village is 20 kilometers away from the nearest district town. Proximity to major towns is also considered. The major towns that are taken as references are Dessie and Woldiya. Dessie is the capital of South Wollo Zone (one of the eleven Zone administrations of the Amhara State) and has an estimated population of 169,000. Woldiya is the capital of North Wollo Zone with an estimated population of 43,000. The two towns are 120 kilometers apart along the main Addis Ababa – Mekele road. District towns include Kutaber and Mersa.

One of the villages covered by the study called Alasha is located in Kutaber district some 12 kilometers from Dessie. The nearest district town to Alasha is Kutaber with an estimated

[1] *Teff* is an indigenous grass growing in Ethiopia which is used to make Ethiopian staple bread called '*Injera*'.

population of 5,000. Two major attributes of the village compared to other survey areas in terms of location are (i) it is the nearest village to major urban centers, and (ii) it is located in the highland plateau characterized by a relatively cool climate.

The other study site, Mersa Zuria area, includes three villages intercepting the district town Mersa on either side of the Dessie-Woldiya road. Mersa has an estimated population of 6,500. The villages have easy access to the market primarily due to their proximity to the major Addis Ababa-Mekele road via Mersa and Woldiya. Besides, the villages are nearer to the district town, Mersa, and the Zone town Woldiya. Among the three villages, Buhoro has significant access to irrigation partly due to availability of tributary rivers.

The third study site is Girana. It is located about 7 kilometers east of the Addis Ababa-Mekele road. There is a gravel road linking the village to the major highway. The major attribute of the village is that it has some tributaries which allow for irrigating a significant part of land. Moreover, there is weekly open market in the village attracting people from the surrounding villages. The village has a potential of being upgraded to township.

Among the villages covered by the study, Habru-Ligo has the farthest distance from both urban centers and major roads, and even lacks feeder road. Individuals have to travel a minimum of three hours on foot on difficult terrains to work on their land. About 25 to 30% of the land possessed by the villagers is irrigable.

2.2 Land Size and Crop Choice

The average land size per household ranges from 0.61 hectare in Alasha area to about 1 hectare in Mersa Zuria area. Although Alasha and Kulie have similar distance from district towns, per capita land size in Alasha is lower than in Kullie and even less than that of Menentela which is closest to the next district town. The pattern is similar in term of per capita land size where Alasha has the lowest with 0.13 hectare and Mersa Zuria has the highest with 0.27 hectare. Girana and Habru-Ligo have a roughly equal size of per capita land which is about 0.14 hectare.

Table 1: Location and Land Size by Village

	Distance from District Town (in km)	*Distance from Major Towns (in km)*		*Land Size per Household (in hectare)*	*Proportion of Land Allotted for Cash Crop and Eucalyptus (%)*
		Dessie	Woldiya		
Alasha	7	12	-	0.613	7.9
Mersa Zuria				1.020	18.2
Menentela	4	94	20	0.822	12.2
Kulie	7	97	25	1.000	9.4
Buhoro	8	98	20	1.160	28.3
Girana	15	75	50	0.666	19.9
Habru-Ligo	20	85	60	0.643	0.9

In terms of land allocation, Buhoro exhibits the highest share of land allotted for the production of cash crops (about 28%) while Habru-Ligo has the lowest share which is less than 1%. Major cash crops produced are sugarcane, fruits (orange, papaya, guava), coffee, and vegetables. The staple crops include sorghum of various varieties, and teff in villages other than Alasha. Teff is used both as a cash crop and staple food due to its high value in urban markets as it is the major staple for the urban population. During periods of poor harvest, households usually sell their teff and buy other cheaper staple crops such as sorghum for household consumption. However, since teff has low productivity, households in the study areas allot only a small portion of their land for the production of this crop unlike other regions which are endowed with large land size and specialize in the production of the crop on a large scale. Households in Alasha area produce wheat, barley, oats, and pulses.

2.3 Patterns of Income

Among the villages under study, Mersa Zuria area is relatively affluent with a per capita income of 1830 Birr. This is well above the average per capita national income of about 1300 Birr recorded in 2005 (NBE, Annual Report 2006). Buhoro with a relatively better access to irrigation is specialized in cash crop production. Unlike other villages, 47.5% of its income comes from cash crops. The peasants' involvement in the production of high value cash crops in the area is reflected by the fact that about 48% of their income comes from 28% of their land. Kullie and Menentela, where irrigable land is lacking, the highest share of their income is derived from commercial livestock farming. About 24% of household income in Menentela area and 26% of the income in Kullie come from livestock farming.

Table 2: Sources of Income of Households by Village

	Per capita income (in Birr)	*Source of Household Income and their Contribution to Total Income (%)*							
		Staple crops	Cash crops	Eucaly ptus	Wage	Remittance from Abroad	Remittance from Towns	Rural Enterprise	Sale of Animal
Alasha	934	3.7	2.9	18.3	1.6	2.1	1.6	3.1	12.8
Mersa Zuria	1830	1.2	23.7	9.6	5.3	7.6	2.6	0.0	16.8
Menentela	1545	5.3	0.8	10.4	6.7	15.1	5.0	0.0	24.0
Kulie	1079	7.5	0.6	3.7	8.4	8.3	0.0	0.0	25.5
Buhoro	2298	2.5	47.5	11.2	3.1	2.3	2.0	0.0	8.7
Girana	1087	5.6	20.3	0.1	6.3	14.8	0.6	2.4	3.7
Habru-Ligo	520	6.3	3.8	0.1	1.8	2.2	0.0	0.7	3.2

Habru-Ligo has the lowest per capita income (about 520 Birr) among the villages covered by the survey. A typical rural farmer in Habru-Ligo earns just 23% of what a typical farmer in Buhoro earns. Though the village has irrigable land, cash crop production is not very common. Peasants in the area do not invest in commercial livestock even though the village is well endowed with suitable conditions for animal husbandry. Households raise cattle, goats and sheep mainly as a buffer stock.

Besides crop production, villagers operating nearer to urban centers allot some plots of land for fast growing trees in particular eucalyptus. This partly depends on the type of slope and soil fertility of the plot of land possessed by peasants. In Alasha, hilly and marginal land which is held by peasants privately is largely covered by eucalyptus forests which have demand from urban centers for purposes of construction and energy supply. About 18% of household income in Alasha comes from the sale of logs of eucalyptus. In Menentela and Buhoro, between 10 and 11% of household income is derived from selling eucalyptus.

3 Theoretical Framework on Location, Crop choice and Rural Income

3.1 Background

We model a Thünen type of environment where rural households make a living from income that is generated from their farming activities. Households dwell and operate at different distance from urban centers. Each household consists of working household members who maximize a joint utility function. Labor time is optimally allocated between agricultural activities and off-farm income generating activities, most importantly employment in the urban centers. However, to make the analysis tractable, the household is assumed to consist of a single individual only.

Agricultural activities involve mainly crop production and animal husbandry. Crop production, which is the mainstay of rural households, involves various items of products, of which the production technologies may differ. We restrict our attention to two major activities, namely, production of stable crops and production of cash crops. In fact, about 74% of the income of households in the villages covered by the survey comes from crop cultivation.

The household produces crops by combining land and other inputs such as labor, animal draft power, fertilizer and pesticides. Part of the staple crop and a significant share of the cash crop have to be sold to purchase manufactured goods for consumption. A household not producing sufficient staple crops thus falling short of home consumption has to purchase additional food from the market using the proceeds from the sale of cash crops.

The decision to produce a particular item depends on the relative distance of the activity from the town. Moreover, unlike the Thünen’s rings, the land surrounding the town needs not to be uniform so that villages at the same distance from town specialize in different crops. In what follows, we attempt to analyze how location affects the decision of a household to allot a plot of land for either staple or cash crops.

3.2 Production Technologies and Costs

Land is a limited resource. As a result, households rationally decide to invest in high value crops that maximize income per unit of land. Cash crops are preferred not necessarily by virtue of high yields per unit of land but for their high market value, most importantly in urban centers. Some cash crops such as coffee are not consumed for their nutritional values while some others such as vegetables are highly perishable. Staple crops on the other hand give more security to the household against low prices for agricultural products as the household can survive on it.

The production of the two crops requires factors such as land and labor. We further assume that labor is not a binding constraint for agricultural production. The household is assumed to have a single unit of labor and a single plot of land that can be allotted to the production of cash crops and staple crops. Let l^c and l^s represent the shares of land for cash and staple crops, respectively, so that $l^c + l^s = 1$. Using l^c portion of land, the household produces q^c units of cash crops to be sold at price p^c in urban centers. The remaining land ($l^s = 1 - l^c$) is used to produce q^s units of staple crop. Part of this crop will be consumed at home and any surplus is sold at the market at a price of p^s.

The production function of the two types of crops that relate the output per labor q^i to a fraction of a unit of land l^i is, therefore, given by:[2]

$$q^c = A^c f\left(l^c\right)$$

$$q^s = A^s g\left(l^s\right) \qquad (3.1)$$

where q^i denotes output per unit of labor and A^c and A^s are the levels of technology required to produce cash and staple crops, respectively. The production functions are assumed to fulfill the standard conditions:

$$f'\left(l^c\right) > 0 , \quad f''\left(l^c\right) < 0 \; ; g'\left(l^s\right) > 0 , \quad g''\left(l^s\right) < 0.$$

where $f'(.)$, $g'(.)$ and $f''(.)$, $g''(.)$ refer to the first and second order derivates with respect to land, respectively. The technology required to produce staple crops, A^s, is considered a numéraire to which the technology A^c can be compared. Thus, A^s is set to unity so that $q^s = g\left(l^s\right)$.

It is assumed that the decision to produce cash crops also depends on the technical know-how about the production of the particular cash crop. An individual might be a quick innovator

in terms of acquiring new technology if he has some formal education. The technological parameter in the production function of the cash crop is given by:[3]

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[2] Practically, some cash crops such as coffee, orange, and pawpaw have maturity period of two to five years. There are also some crops such as vegetables and oilseeds with a maximum maturity period of one year. Ayalew (2003) noted this issue and has taken the opportunity cost of land in terms of yield of annual crops as a result of longer maturity period of coffee trees into account in his model. However, it is customary in the area under study that the land under permanent cash crops can at the same time be used for the production of annual crops until the cash crops grew to a full-fledged tree. Thus, it is not harmful to continue the analysis without considering the opportunity cost of land due to long gestation period of permanent crops.

$$A^c = A_0^c e^{\psi E} \qquad (3.2)$$

where A^c_0 is some indigenous knowledge of the technology, E is level of education (say in years of schooling), and ψ is a parameter.

Given prices of cash crop and staple crops, the total monetary value of these crops is given by:

$$y = A_0^c e^{\psi E} p^c f\left(l^c\right) + p^s g\left(l^s\right) \qquad (3.3)$$

The household incurs production costs for each crop. Costs of production of each crop are proportional to land allotted to the production of the crops. Let w^c and w^s represent factor prices per unit of land. The associated cost of production of cash and staple crops are given by $w^c l^c$ and $w^s l^s$.

The household also incurs transportation costs for both crops. We further assume that direct cost of transportation is the same for each crop. However, the cost of transportation varies depending on the amount of crop the household wants to sell. Household sell small shares of the staple crop because most of it is produced for home consumption. We assume that all cash crops are sold and let n denote the share of staple crop that is marketable. Then, the total transportation cost with k unit price of transportation is given by $kq^c r$ and $knq^s r$, where r is the distance between the village and the urban center.

The household also faces cost due to the perishable nature of each crop. We define an index that measures the degree of the perishable nature of each crop in connection to transporting the surplus to the market. Let r be the distance of the plot from the market place and $r^i_{\max}$ denote the maximum distance of the i^{th} crop beyond which the crop cannot be sold at the market due to its perishable nature. Then, the index for the i^{th} crop is given by:

$$r^{*i} = \frac{r}{r^i_{\max}} \qquad (3.4)$$

where:

$$r^{*i} = \begin{cases} 0 & if \;\; r = 0 \\ 1 & if \;\; r \geq r^i_{\max} \end{cases} \qquad \text{so that} \qquad r_i^* \in [0,1].$$

[3] The adoption of the technology once it is available is assumed to evolve exponentially according to $A^c = A_0^c e^{gt}$ where g is the rate of innovation and t is time required to acquire the technique. The rate of growth of technology is assumed to be a function of education over time, $g = \psi E.$

If the crop produced at distance r is perishable, then it loses a value of r^{*i} monetary units per unit of crop. If almost all cash crops produced and n fraction of the staple crop are intended to be sold at their respective prices, and if all staple crops are not perishable, then the associated total cost incurred can be summarized by:

$$C = \left(q^c + nq^s\right)kr + r^{*c}p^c q^c + w^c l^c + w^s l^s \quad (3.5)$$

Given the revenue function in Equation (3.3) and the cost function in Equation (3.5), the profit π of the household is, therefore, given by:

$$\pi_t = A_0^c e^{\psi E} f\left(l^c\right)\left(p^c - kr - r^{*c}p^c\right) + g\left(l^s\right)\left(p^s - nkr\right) - w^c l^c - w^s l^s \quad (3.6)$$

3.3 The Problem of the Household

The household maximizes profit according to:

$$\max_{l^c} \pi = A_0^c e^{\psi E} f\left(l^c\right)\left(p^c - kr - r^{*c}p^c\right) + g\left(l^s\right)\left(p^s - nkr\right) - w^c l^c - w^s l^s \quad (3.7)$$

Taking the first order derivatives with respect to proportion of land under cash crop, the first order condition is:

$$\frac{d\pi}{dl^c} = A_0^c e^{\psi E} f'\left(l^c\right)\left(p^c - kr - r^{*c}p^c\right) - g'\left(l^s\right)\left(p^s - nkr\right) - w^c + w^s = 0$$

This can be rearranged to give:

$$\begin{aligned} &p^c A_0^c e^{\psi E} f'\left(l^c\right) = \\ &\left[A_0^c e^{\psi E} f'\left(l^c\right)\left(kr + r^{*c}p^c\right) + w^c\right] + \left[g'\left(l^s\right)\left(p^s - nkr\right) - w^s\right] \end{aligned} \quad (3.8)$$

The right hand side of Equation (3.8) is the value marginal product of land in the production of cash crops. The first term of the right hand side in square brackets is the marginal cost of producing and selling cash crops. The term in the second square bracket denotes the opportunity cost of production of cash crops at the net margin. In general, this condition says that an optimum allocation of the available plot of land between cash and staple crops ensures that the marginal product of land in the production of cash crops equals the foregone value of the marginal product of staple crops net of marginal costs of production in the alternative use plus direct marginal costs**.**

Given our assumptions, it can be shown that the second order derivative of the profit function with respect to plot of land allotted for the production of cash crops is negative.

$$\frac{d^2\pi}{d\left(l^c\right)^2} = A_0^c e^{\psi E} f''\left(l^c\right)\left(p^c - kr - r^{*c} p^c\right) + g''\left(l^s\right)\left(p^s - nkr\right) < 0$$

By the assumption of diminishing returns to scale, $f''\left(l^c\right)$ and $g''\left(l^s\right)$ are negative. The household produces cash crop if his optimization condition insures that unit profits are greater than unit costs so that $p^c > \left(kr + r^{*c} p^c\right)$ and sells his staple crop if $p^s > nkr$. This implies that the second derivative is negative. Thus, the sufficient condition for maximization of profit is met. Note that the second order derivative becomes positive if r^{*c} is unity, that is if $r \geq r^c_{max}$. Nonetheless, at $r^{*c} = 1$, the household has no incentive to produce any cash crop as it would intuitively mean that all cash crops that have to be transported will be spoiled before they reach the market.

3.4 Comparative Static Analysis

In this section we examine the impact of varying the distance of producers to the urban centers and the level of education on land allocation decision. The first order condition can be re-written in the form of an implicit function *F(.)*:

$$\begin{aligned} &F\left(l^c; r, r^*, E, p^c, p^s, w^c, w^s, k, n\right) \\ &\quad = A_0^c e^{\psi E} f'\left(l^c\right)\left(p^c - kr - r^{*c} p^c\right) - g'\left(l^s\right)\left(p^s - nkr\right) - w^c + w^s = 0 \end{aligned} \tag{3.9}$$

By totally differentiating the implicit function, we have:

$$\begin{aligned} dF = &\left\{A_0^c e^{\psi E} f''\left(l^c\right)\left(p^c - kr - r^{*c} p^c\right) + g''\left(l^s\right)\left(p^s - nkr\right)\right\} dl^c \\ &+ \left\{k\left[A_0^c e^{\psi E} f'\left(l^c\right) - ng'\left(l^s\right)\right]\right\} dr \\ &+ \left\{A_0^c \psi e^{\psi E} f''\left(l^c\right)\left[p^c - kr - r^{*c} p^c\right]\right\} dE + \ldots = 0 \end{aligned}$$

Holding other exogenous variables constant, the change in l^c in response to a change in distance from the market is given by:

$$\frac{dl^c}{dr} = \frac{k\left[A_0^c e^{\psi E} f'\left(l^c\right) - ng'\left(l^s\right)\right]}{J}$$

where:

$$J = \left\{ A_0^c e^{\psi E} f''\left(l^c\right)\left(p^c - kr - r^{*c} p^c\right) + g''\left(l^s\right)\left(p^s - nkr\right) \right\}.$$

Basically, J is the second order derivative of the profit function with respect to l^c which is negative. In the numerator, $f'\left(l^c\right)$ and $g'\left(l^s\right)$, are positive by assumption. We assume that the marginal product under cash crop production $\left(A_0^c e^{\psi E} f'\left(l^c\right)\right)$ is greater than the n fraction of the marginal productivity of land for the production of staple crop, $\left(ng'\left(l^s\right)\right)$. This implies that the term in the numerator is greater than zero. Hence, we have:

$$\frac{dl^c}{dr} = \frac{k\left[A_0^c e^{\psi E} f'\left(l^c\right) - ng'\left(l^s\right)\right]}{J} < 0$$

That is, a unit variation in location across plots in relation to markets in the direction away from such markets leads to a decline in the share of land under cash crop production. Similarly, the direction of the impact of the index for the perishable nature of a cash crop can be shown to be negative. The higher the index (i.e. the more perishable the crop is), the less proportional land to be allotted for the production of the particular cash crop.

$$\frac{dl^c}{dr^*} = \frac{p^c A_0^c e^{\psi E} f'\left(l^c\right)}{J} < 0.$$

The direction of the impact of other exogenous variables can be determined as well. For instance, the effect of education on crop choices can be shown to favor the allocation of more land for the production of cash crop. After totally differentiating (3.9) and rearranging we get:

$$\frac{dl^c}{dE} = \frac{-A_0^c \psi e^{\psi E}\left\{f'\left(l^c\right)\left[p^c - kr - r^* p^c\right]\right\}}{J} > 0.$$

which is positive. As it has been shown already, J is less than zero, while in the numerator, the term in the square bracket is positive. That is, for the household to engage in the production of cash crops, the unit price p^c must be greater than the unit costs associated with transport. This holds even without considering other costs of production. The negative sign multiplying the whole numerator turns it to negative giving rise to the overall expression to be greater than zero. The result can be interpreted such that an increase in the level of education, say by a year of schooling, increases the proportion of land under cash crop cultivation.

4 Econometric Analysis

The theoretical framework suggests that a household's decision to allot a plot of land to cash crop production in an attempt to maximize household income is by and large a function of, among others, distance from the market (usually urban centers), and level of education. There are, however, other factors which are deemed to be important in affecting crop choice. These include access to irrigation scheme, climatic conditions, and wealth of the household. Some cash crops such as sugarcane are water intensive and its production presupposes availability of irrigation scheme. Areas with irregular rainfall may not specialize in cash crop production. Moreover, wealthier households are highly likely to afford relatively higher initial investments in cash crops.

For given prices p^c and p^s, and costs, the model is given by:

$$l^c = f\left(r_i, AR_i, E_i, DI, DC, W, DR\right) \tag{4.1}$$

where r_i = distance of the plot from market centers, AR_i = access to road, E_i = level of education of the agent, DI = dummy for access to irrigation, DC = dummy for climate, W_i= wealth of the household, and DR_i = dependency ratio. It is expected that r, and DR would affect l^c negatively while other variables except DC affect it positively. The impact of climate on allocation of land for cash crops depends on the particular cash crop, whereas in the Ethiopian context, areas with cold climate tend to specialize less on cash crops.

In this section, we test the hypothesis that proximity to urban centers influences crop choice by applying a fractional logit model. In a second step, we estimate an income function using land under cash crops and staple crops as explanatory variables.

4.1 Estimation Technique

In the crop choice model, the dependent variable is land under cash crop in proportion to total land size. The explanatory variables include distance from urban centers, access to roads linking to urban centers, total land endowment, level of education of the head of the household, a dummy for climate, and a dummy for whether a household possesses irrigable land. Size of own plot, and size of land used under share cropping arrangements are also considered.

Obviously, OLS procedures are not appropriate when the dependent variable is a ratio bounded between 0 and 1. Running OLS on a fractional dependent variable would entail similar problems as it does in the linear probability model for strict binary cases (Wooldridge, 2002). One of the drawbacks of this approach is that predicted values of OLS estimates would not necessarily lie in the [0,1] interval. The other important advantage of using fractional logit model over OLS is that the first accounts for possible non-linear relationship in the model.

A common approach to model dependent variables which are bounded between 0 and 1 is a logistic transformation where the log-odds ratio is modelled as a linear function of a set of independent variables. Unfortunately such procedure does not account for data that includes the limits 0 and 1. Moreover, it is not possible to recover the predictions for the dependent variable without some simplifying assumptions. In our case, though a value of 1 is rare, there are a number of households who do not allot their plots for cash crop at all. One way out could be to proceed with such transformation by giving an extremely small number for values equal to zero and a near unity number for values of 1. This is, however, arbitrary which may lead to undesirable results (Wooldridge, 2002).

Papke and Wooldridge (1996) based on the results of Gourieroux, Monfort, and Trongen (1984) and McCullagh and Nelder (1989) suggested as an alternative the Generalized Linear Model (GLM) that makes use of quasi-maximum likelihood estimation procedures.

The notion of the GLM is that a regression model can be decomposed into a random component with expected value and variance of the dependent variable, a systematic component that is predicted by covariates, and a link function that relates the systematic component to the random component. For classical regression models, the random component is assumed to be distributed normal and the link function is an identity in the sense that the random and systematic components are identical (McCullagh and Nelder, 1989).

What makes GLM more relevant is that the normality assumption on the distribution of the random component could come from any function of the exponential family, and the link function could be any monotonic differentiable function (McCullagh and Nelder, 1989).

Given the dependent variable l^c_i and the vector of the various explanatory variables x, where $0 \leq l^c \leq 1$. Then, for all i:

$$E\left(l_i^c\right) = x_i\beta \qquad (4.2)$$

In this case, the random component, $E\left(l_i^c\right)$, is expected to have a value of μ so that $0 \leq \mu \leq 1$, and, unlike the linear regression model, the random component could have a distribution different from normal. It might rather have a binomial distribution which is from the exponential family.

More importantly, the link function cannot be assumed to be identity because the systematic component ($x_i\beta$) does not ensure the condition that the random component, $E\left(l_i^c\right)$, lies between 0 and 1. Hence, the link function that relates $E\left(l_i^c\right)$ and ($x_i\beta$) could be given by:

$$E\left(l_i^c \mid x_i\right) = G\left(x_i\beta\right) \qquad (4.3)$$

where G (.) is a link function satisfying the condition that 0 ≤ G(.) ≤ 1.

Gourieroux, Monfort, and Trongen (1984) showed that quasi-maximum likelihood estimators (QLME)[4] are consistent as long as the likelihood function is in the linear exponential family and given that the link function under (4.3) holds. Papke and Wooldridge (1996) suggested the random component to be Bernoulli for it being easy to maximize. For the link function, we use the logistic distribution as suggested by McCullagh and Nelder (1999).

Thus, for $l_i^c \sim Bernoulli$ with a logistic link function, we have:

$$G\left(x_i\beta\right) \equiv \Lambda\left(x_i\beta\right) = \frac{e^{x_i\beta}}{\left[1+e^{x_i\beta}\right]} \qquad (4.4)$$

The Bernoulli likelihood function is given by:

$$f\left(l_i^c / x_i;\beta\right) = \left[\Lambda\left(x_i\beta\right)\right]^{l_i^c}\left[1-\Lambda\left(x_i\beta\right)\right]^{1-l_i^c}, \text{ where } l_i^c \in \left[0,1\right].$$

This can be transformed to give:

$$L\left(\beta\right) = l_i^c \log\left[\Lambda\left(x_i\beta\right)\right] + \left(1-l_i^c\right)\log\left[1-\Lambda\left(x_i\beta\right)\right], \qquad (4.5)$$

The QMLE procedure yields a consistent estimator with a conditional assumption on the variance. The assumption is that:

$$\operatorname{var}\left(l_i^c \mid x\right) = \sigma^2 G\left(x_i\beta\right)\left[1-G\left(x_i\beta\right)\right] \text{ for some } \sigma^2 > 0 \qquad (4.6)$$

The other model considered in this section is the income function of rural households. The estimable model is given by:

$$y_r = f\left(L_i^c, L_i^s, N, O, DI, E_h, DR\right) \qquad (4.7)$$

where y_r = household per capita income from crop production, $L^c{}_i$ = land under cash crop, $L^s{}_i$ = land under staple crop, N = labor, O = number of oxen, DI = dummy for availability of irrigable land, Eh = education level of the head of the household, and DR = dependency ratio. The function is estimated by OLS.

4.2 The Data and Estimation Results

In the crop choice model, distance from town is approximated by the distance in kilometer between what is thought to be 'centroid' of the village to the nearest district town. Distance from road is the distance in kilometer of the village from the nearest road accessible by vehicles. We defined access to road as the inverse of the distance from the road.

The dummy variable for availability of irrigation scheme takes a value of 1 if the village has access to irrigation facilities (modern or traditional) at a significant scale and 0 otherwise. The dummy for climate assumes a value of 1 if the village has cold (dega) climate (which is associated with high land areas) and 0 if it has moderate (woina-dega) climate.

Per capita cash income and per capita value of livestock[5] are included to capture the impact of wealth on crop choice. To account for liquidity constraints, we include per capita value of permanent cash income which includes pensions, permanent remittances, and salaries from long-term off-farm employments. Value of livestock is the sum of the average market price of cattle, goats, sheep, and camels.

Livestock ownership may have two opposing impacts on crop choice. On one hand, livestock serve as buffer stock against risk in which case it favors the allocation of more land for cash crop production. On the other hand, livestock farming might be a competing activity to cash crop production. The relative importance of the two effects depends on village specific factors such as distance from urban centers. To disentangle the two effects, we used an interaction variable of distance from urban centers and value of livestock.

For the educational attainment of the head of the household, years of schooling by level (primary, junior secondary and senior secondary levels in which the head has attended some classes) were considered. The maximum years of schooling are 11 years. A dummy is used for each level where a value of 1 denotes some education at the respective level and 0 otherwise. The omitted category is 'never attended any of these levels'. Own land is the size of plot in hectares that belongs to the household. Size of land under sharecropping arrangements is also included as well as a dummy for whether a household has some plots of land that is adapted to irrigation irrespective of whether the plot is irrigated during the survey period. Many households

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[4] Quasi-maximum likelihood estimators, also known as pseudo-maximum likelihood estimators, are methods which maximize probability distributions which do not necessarily contain the true distribution.

[5] Similarly, Dercon (1996), and Kurosaki and Fafchamps (2002) used the value of livestock as a proxy for liquid wealth in their crop choice model.

implanted irrigation schemes but do not necessarily irrigate their plots depending on the season and the type of crop.

A potential source of endogeneity bias arises from liquid assets. Non-agricultural cash income is exogenous because pensions, remittances, and compensations for long term off-farm activities may not be expected to be affected by crop choice decisions. However, the simultaneity problem may arise in the case of value of livestock. Dercon (1996) reports simultaneity between crop choice and value of livestock. On the other hand, Kurosaki and Fafchamps (2002) find that liquid assets and livestock are predetermined and conclude that these variables are exogenous.

In our case we applied a Hausman test to check whether value of livestock is exogenous[6]. The instruments used were total land size, number of oxen, and labor. The test does not support the null that value of livestock is endogenous. A total of 252 households are used for the estimation of both crop choice model and household income function. Estimates along with their marginal effects are reported in Appendix B.

4.3 Results for Crop Choice Model

The results for the land allocation model are shown in Appendix B. In most cases, slopes of the GLM estimates and OLS parameter estimates are not very different both in terms of magnitude and their statistical significance. The results show that proximity to town, access to road, education of the head, liquid wealth, and access to irrigation scheme are significant for predicting household crop choices. Rural households under study who operate nearer to urban centers tend to allot more land for the production of cash crops while those households who operate far from urban centers tend to allocate much of their land for the production of staple crops (grains). This might be due to the fact that rural peasants nearer to urban centers have a greater advantage in terms of transportation cost and information about the market. The results lend support for the argument that for crop choices the location of the village relative to the next market matters.

The irrigation dummy is significant and positive. Irrigation may have two impacts. First, most cash crops which have high demand in the urban market require a sustainable supply of water. As it has been indicated in Section 2.3, major cash crops that are produced include

[6] We estimated an auxiliary regression where per capita value of livestock was regressed on total land, labor, and oxen.

$$PCVL = \underset{(3.68)}{848.03} + \underset{(3.50)}{719.36}Land + \underset{(5.46)}{349.80}Oxen - \underset{(-4.07)}{304.89}Labor$$

We estimated the crop choice model by including the residual of the auxiliary regression along with the per capita value of livestock (Wooldridge 2002). We found that the coefficient of the residual term was not statistically significant indicating that the case of simultaneity is not supported.

sugarcane, and fruits whose production is water intensive. Secondly, availability of irrigation scheme gives households the opportunity to produce more than once within a year. This in turn secures them to shift into the production of staple crops with low gestation period during a risk of falling prices of cash crops such as vegetable.

In the case of liquid asset, estimation results without the interaction variable (VLS×r), value of livestock was found to be insignificant while permanent cash income reveals a positive and significant coefficient. Upon the introduction of the interaction variable, both permanent cash income and value of livestock were significant the latter having a negative coefficient. The interaction variable itself has a positive and significant coefficient.

It can be shown from the coefficients of value of livestock and interaction variables that within about 18 kilometers radius from market centers, the rivalry effect of cash crop production and livestock farming dominates[7]. Beyond 18 kilometers radius, the role of livestock as a buffer stock against risk dominates in that households with more livestock tend to allot land for cash crop. One explanation for positive association between cash crop production and value of livestock might be that remote villages have significant land that is not arable but which can be used for livestock farming. Hence, livestock farming does not necessarily compete with crop production in terms of land use.

In general, education of the head is positively associated with a higher probability of allocating more land to cash crops. Education on primary and junior secondary levels has positive impact. However, additional schooling to senior secondary schooling does not have much influence on the household’s decision to allot more land to cash crops. The negative sign of the dummy for climate shows that highlanders of the villages under survey do not allot much land to cash crop compared to lowlanders. The coefficients and slopes for total own land, and land under sharecropping arrangements are not statistically significant. Land leased out in the form of share cropping arrangements is significant only at 10% level of significance.

Lastly, the dependency ratio (proportion of members of a household below the age of 10 and above the age of 65 to the active labor force) is found to be significant only at 10% level in the case of GLM estimation but significant at 5% in the case of OLS estimates. Households with a higher share of dependants might be more risk averse and hence do not tend to allot more land for cash crop as they prefer food security.

4.4 Results for Incomes Function

[7] We calculated the threshold distance (= 18 km) by differentiating the land allocation equation with respect to value of livestock and set to zero. We used the slope coefficients of the GLM estimates for this purpose.

To investigate whether distance predicts income we use annual per capita income in Birr from agricultural activities, in particular cash and staple crop production as the dependent variable. On the right hand side we include the distance variables along with size of land under

cash crop and staple crops as separate variables as well as a number of further controls. Head counts are used for oxen. In the case of labor, a sort of adult equivalent labor is used. Household members aged 16 and above are given a weight of 1 while those in the age of 10 to 15 are given a weight of 0.5. Some variables which were used as determinants of land allocation decision are also used in estimating the income function. The rationale of including the variables which were used as determinants of land allocation decision (dummy for irrigation scheme, and education) is to see their direct effect on income apart from their impact on it through land allocation decision.

Results are summarized in Appendix C. The null for constant variance under the Breusch-Pagan test for heteroscedasticity was rejected at 5% level. However, there was little change in the standard errors between the OLS and robust estimates causing no change in significance of coefficients at 5% level. The estimates revealed that coefficient for land under cash crop was significantly greater than that of the land under staple crop reflecting that the marginal product of land under cash crop is greater compared to its alternative use of staple crop production. More importantly, distance from the nearest urban center is found to significantly predict the level of per capita income of households. It shows that, other things being equal, households operating far from urban centers tend to have lower per capita income compared to those households nearer to towns.

5 Conclusions

In this paper, we investigate the interaction between distance to markets and crop choice in Ethiopia. We find that proximity to urban centers and access to roads increases the share of land allotted to cash crop production. Shorter ways of bringing the produce to the market imply lower transaction costs and consequently higher prices. Another channel through which market proximity may affect crop choices is better access to information about prices or new technologies. Furthermore, households located closer to urban centers with access to road but who do not have irrigable land tend to invest in commercial livestock farming and fast growing trees such as eucalyptus to be sold in urban centers. This translates into uneven levels of per capita income among villages: a typical household in the richest village nearer to urban center has a per capita income more than 4 times that of a typical household who lives in the village far from urban centers.

Estimation results of the income function of rural household show that size of plots under cash crops and staple crops are significantly related to higher incomes. The coefficient of land under cash crop is by far greater than that of land under staple crop. Distance from the nearest urban center is found to be significant and negative in the incomes function implying that level of per capita income varies over such distances where the households with relative proximity to urban centers are better off.

In conclusion, strong linkages to the urban sector matter for the development prospects of rural areas. Policies that target on supply bottlenecks in the agricultural sector might not be successful without vibrant urban centers which constitute sustainable demand for marketable surplus. In a rural economy such as that of Ethiopia which is characterized by fragmented and static urban enclaves, encouraging township could be considered as a priority. Moreover, enabling rural households to have access to road and better information networking, expanding purposeful education, developing irrigation schemes, introducing new varieties of high yield cash crops including for cold climate zones might help rural households better cope up with shocks and enable them to create surplus that would serve as a basis for agrarian transformation.

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Appendix

Appendix A: List of Variables Used in the Estimation

Variable	Mean	Standard Deviation	Min	Max
Land under cash crop (ratio to the total)	0.12	0.15	0	1
Town-Distance	11.86	5.51	4	20
Distance from Road	3.39	3.80	1	10
Access to Road (inverse of distance)	0.69	0.39	0.1	1
Dummy Irrigation	0.42	0.50	0	1
Dummy Climate (=1 if Dega)	0.29	0.46	0	1
Education - Head				
Years of Schooling	2.06	2.99	0	11
Primary (1-6)	0.43	0.50	0	1
Junior Secondary (7-8)	0.06	0.23	0	1
Senior Secondary (9-12)	0.03	0.17	0	1
Total Own Land in hectare	0.72	0.39	0	2.5
Land Leased in for share cropping (LSC1)	0.21	0.38	0	3
Land Leased out for share cropping (LSC2)	0.02	0.10	0	0.75
Dependency Ratio	0.77	0.80	0	4
Permanent Cash Income (per capita)	30.92	157.57	0	1600
Value of Livestock (per capita)	1220.42	1349.76	0	9250
Per Capita Income (logs)	6.68	0.85	0.37	8.77
Land under cash crop	0.11	0.14	0.00	0.50
Land under staple crop	0.72	0.41	0.09	2.25
Labor	2.33	1.02	1	7
Oxen	1.61	1.25	0	9
Cattle (other than oxen)	2.47	2.47	0	12
Dummy Rural Enterprise	0.19	0.40	0	1

Appendix B: GLM Estimation of Land Allocation Decisions

Dependent Variable*: *Share of Land Allotted to Cash Crop							
	GLM Estimates				OLS Estimates		
	Coefficient		Slope				
Distance-Town	-0.180	[-5.92]***	-0.013	(-6.22)	0.011	(-4.12)	[-4.50]
Access to Road	1.689	[5.64]***	0.125	(5.42)	0.091	(3.20)	[3.21]
Dummy Irrigation	0.787	[2.51]**	0.062	(2.56)	0.067	(3.02)	[2.66]
Dummy Climate	-1.585	[-3.78]***	-0.094	(-3.97)	-0.140	(-4.47)	[-3.41]
Cash Income	0.0009	[3.21]***	7×10^{-5}	(2.89)	0.0002	(3.07)	[2.33]
Livestock (Value)	-0.0005	[-3.08]**	-4×10^{-5}	(-3.08)	-4×10^{-5}	(-2.82)	[-3.56]
VLS×r	5×10^{-5}	[3.21]***	3.4×10^{-6}	(3.26)	3.5×10^{-6}	(2.33)	[3.11]
Education-Head							
Primary (1-6)	0.391	[2.43]***	0.030	(2.31)	0.032	(1.86)	[1.95]
Junior Sec. (7-8)	0.904	[2.65]**	0.094	(1.94)	0.103	(2.94)	[2.43]
Senior Sec.(9-12)	0.398	[0.97]	0.035	(0.83)	0.048	(0.98)	[1.15]
Total Own Land	0.185	[0.89]	0 .014	(0.91)	0.013	(0.59)	[0.58]
LSC1	-0.206	[-1.07]	-0.015	(-1.05)	-0.038	(-1.62)	[-2.01]
LSC2	0.817	[1.80]*	0.061	(1.79)	0.144	(1.69)	[1.59]
Dependency Ratio	-0.243	[-1.89]*	-0.018	(-1.85)	-0.022	(-2.14)	[-2.09]
Intercept	-1.375	[-2.48]**	-		0.201	(3.55)	[3.44]
N	252						
R^2						0.39	
$\bar{R}^2$						0.35	
Joint Stability					F(14,237):	10.59	21.48
Heteroscedasticity					χ^2 (1) =	26.50	

**** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.*
Figures in brackets are t-ratios and those in square brackets are robust t-ratios.

Appendix C: OLS Results of Rural Per Capita Income: Land being instrumented

Dependent Variable: Per capita Household Income (in logs)			
Covariates	Coefficients	t-ratios	
Land under cash crop(Estimated)	1.13	(2.13)	[3.11]
Land under staple crop (Estimated)	0.46	(3.42)	[3.22]
Labor	-0.10	(-2.35)	[-2.47]
Oxen	0.16	(4.12)	[4.21]
Dummy for Irrigation	0.36	(3.20)	[3.67]
Distance from Town	-0.03	(-3.15)	[-3.31]
Access to Road	0.32	(2.20)	[2.56]
Education - Head			
Primary (1-6)	0.02	(0.27)	[0.28]
Junior (7-8)	0.17	(0.86)	[0.79]
Secondary (9-12)	-0.06	(-0.23)	[-0.43]
Dummy for Rural Enterprise	0.31	(0.89)	[3.30]
Dummy food for Work	0.09	(3.04)	[1.01]
Intercept	6.11	(24.00)	[23.72]
N		252	
R^2		0.49	
$\bar{R}^2$		0.47	
F(12, 239)		19.28	29.43
RESET: F(3, 236)		1.28	
Heteroscedasticity: $\chi^2(1)$		4.28	

Figures in brackets are t-ratios and those in square brackets are robust t-ratios.

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