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Full Length Research Paper

Market access, intensification and productivity of common bean in Ethiopia: A microeconomic analysis

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This work analyses on-farm adjustments in land allocation and intensification in a commercial crop following the increases in market demand in a developing economy. Drawing from the survey conducted among common bean producers in Ethiopia in 2008, a two stage econometric method was used to investigate the contribution of market access and other micro-level factors in facilitating crop intensification and productivity. Ethiopia is the leading commercial producer and exporter of common bean in Africa but also one of the countries in Africa with high levels of soil nutrient depletion. Understanding factors that influence input use and productivity is critical for food security and agricultural sustainability in the country. Based on farm survey data, it was shown that most farmers had expanded their area under common bean but the use of fertilizer and improved varieties was still low. Increase in the intensity of fertilizer and seed use produces an increase in yield and so is market access. Market access has intensification as well as specialization effects on common bean yield. Access to credit, extension and household wealth are other factors that facilitate common bean intensification while risk increasing factors constrain it.

Key words: Common bean, intensification, productivity, Ethiopia.

INTRODUCTION

Developing countries face the task of increasing agricultural production to meet food demand while ensuring sustainability of the land resource base on which agriculture depends. Ethiopia is one of the countries in Africa where landholding has already reached threshold levels and soil nutrients are highly depleted (FAO, 1986). Increases in market demand for commercial crops in the last one decade, following the market reforms implemented in early 1990s and the government's deliberate effort to develop the private sector [recognizing that large capital investments are needed to exploit Ethiopia's resources, various incentives are being provided to encourage foreign investment (including joint ventures and marketing arrangements] so that the agricultural sector makes a significant contribution to Ethiopia's development), has added more pressure on land. An increase in market demand in the face of increasing population pressure can lead to adoption of land enhancing technologies such as fertilizers or high yielding varieties (Boserup, 1965; Ali, 1995).

Increase in market demand may also encourage specialization by shifting from low value crops to high value crops without significant change in technology or growth in yields (Kamara, 2004). This work examined the nature of on-farm adjustments in the common bean production systems triggered by changes in commodity markets in the early 1990s in Ethiopia while focusing on the role of market access in facilitating intensification and

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productivity in common bean, a topic that has not been previously studied. The study discussed changes in land use and allocation to common bean and how this compares between farm categories. Then, the effect of market access and that of other factors on the adoption of land enhancing technologies and productivity of common bean was analyzed.

Then, a conceptual framework followed by a brief description of the study area and data sources was presented, as well as sample design. The presentation of the econometric estimation followed while the specification of reduced models and hypotheses were presented next. Results were presented and discussed and the work concluded with the summary of the key findings and policy implications.

Conceptual framework

Agricultural intensification has been defined as the use of an "increased average inputs of labour or capital on smallholding for the purpose of increasing the value of output per ha" (Tiffen et al., 1994: 29). This occurs in response to either, an increased demand for output or a fall in the availability of key factors such as land, labour or water (Boserup, 1965; Ali, 1995). Demand for output may increase due to an increase in population, expansion of markets and increased income. The demand increases associated with expansion of markets is the focus of this work.

According to Boserup (1965), in times of pressure from population growth and increased demand, people will find ways to increase food production by increasing labour inputs, fertilizers or machinery. Initially, farmers may expand the area under crops whose market opportunities are expanding and later adopt more intensive use of land as land base per capita continue to decline. The intensive land use can take the form of continuous cropping or inter-cropping systems with each resulting in rapid soil fertility depletion. Land enhancing inputs such as fertilizers and high yielding crop varieties can be used to enhance land productivity as land becomes a limiting factor. Production theory predicts that, a farmer will allocate inputs to the production of a commodity until the returns from additional input is equal to the unit cost of that input. The cost of land enhancing inputs such as fertilizer and improved seed, in turn, depends on the market conditions.

The effect of market conditions and commercialization on common bean intensification and productivity in Ethiopia is mediated through a complex relationship and cannot be determined *a priori*. An expected increase in market incentives will motivate households to adopt land enhancing inputs such as fertilizer, high yielding variety seed and or apply more labour into production of common bean. The most important exogenous determinants of intensification are population pressure, availability and cost of inputs, as well as investment in road infrastructure. Farmers with better physical access to markets for the output or land enhancing inputs, such as fertilizers and improved variety seed may obtain higher returns to land and labour, thus further reinforcing the intensification process. When the access to land enhancing inputs is limited, the commodity demand theory suggests that, small farmers will respond to increased market incentives by either shifting from one crop to another or increasing cropping intensity (Schultz, 1964; Mellor, 1969). The endogenous consequences of commercialization are household decisions on resource allocation that is mainly land reflected, in land use patterns, labour and adoption of land enhancing technologies.

MATERIALS AND METHODS

Study area

The study was conducted in the Oromia regional State, the major commercial common bean producing region in Ethiopia. Oromia receives a bimodal type of rainfall that is highly erratic. Mean rainfall varies between 800 and 1000 mm; with a 20 to 40% probability of having a failed season. Literacy levels were estimated below 40% and off farm employment was rare. To manage production risks, farmers have limited options other than diversifying agriculture enterprises. Common bean is a commercial crop that plays strategic role in alleviating food deficit during the period of food shortage when other crops have not yet matured (Legesse et al., 2006). The canning type, primarily grown for export market, dominates the Oromia region (Northeast rift valley). Data used in this article indicated that 80% of the harvested common bean in the Oromia region was marketed, confirming that, common bean is a commercial crop in the study areas and market incentives are important in the production decisions.

Common bean has been produced in Ethiopia for export for over 40 years but its growth was interrupted by unfavourable policies implemented between 1975 and early 1980s. During this period, the government put restrictions on all private trade, giving the state-controlled marketing board full monopoly over the marketing of all grains in the country (Gabre-Madhin, 2001). These policies resulted in low incentives to farmers and consequent under investment into crop management. In particular, quality standards were severely affected, resulting in a substantial decline in export volumes, from 80 to 23% of the total production (Ayele, 1990 in Alemu and Bekele, 2005).

In the early 1990s, the government abolished the state grain control and quota system, to restore the private trade (Gabre-Madhin, 2001). The modern warehouses used by the Agricultural Marketing Corporation during the monopoly period were made available for rental by the private sector, as a way of facilitating quick recovery. These reforms triggered significant changes in the export market of common beans (there is evidence that export demand for common bean expanded following the economic reforms which stimulated further increases in production) (Legesse et al., 2006; Alemu and Bekele, 2005). Both international and local private sector participation has since increased, creating significant improvements in the farm gate prices that stimulated an upward trend in area and yield growth since 2002 (Figure 1). An additional factor that is facilitating the process of commercialization and production growth in common bean sub sector in Ethiopia is the investment in bean research and seed systems development, supported by the government and the International Center for Tropical Agriculture (CIAT) (in Spanish: Centro International de

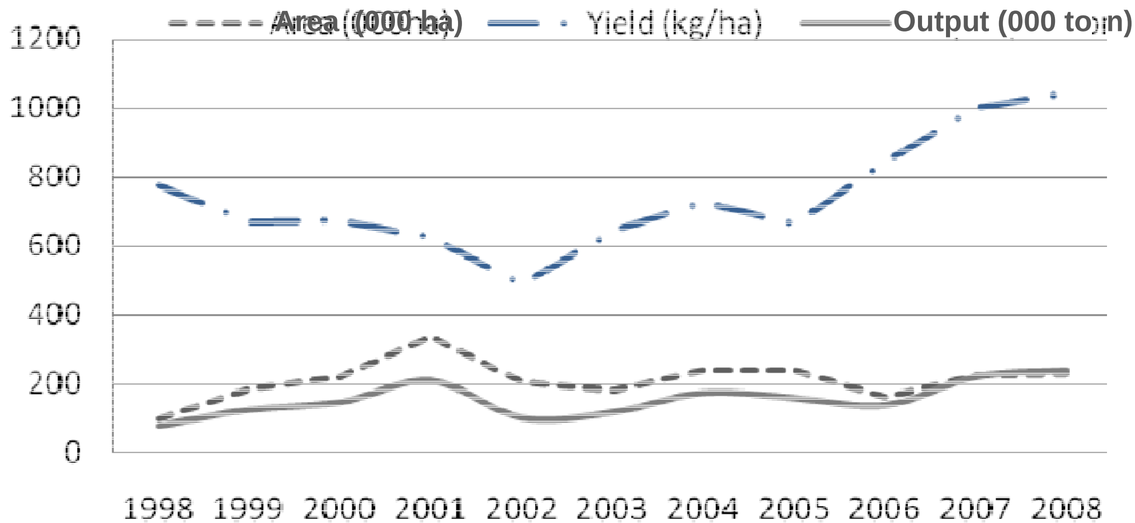

Figure 1. Common bean production trends in Ethiopia (1998 to 2008). Source: Computed from FAO data (2008).

Agricultura Tropical) over the last two decades. This investment has improved the availability of high yielding varieties adapted to the environmental stresses (The Ethiopian Institute of Agricultural Research (EIAR) released about 23 high yielding varieties of common bean between 1996 and 2004 (Rubyogo et al., 2010) . In more recent years, there has also been increased support for the local level seed supply in recognition of the failure of the formal seed sector to respond to the needs of small farmers and marginal environments. This was done through a collaborative arrangement, spearheaded by CIAT, between national research systems, non-governmental organizations and various farmers to enhance wider dissemination of new crop varieties and improved crop management practices (Legesse et al., 2006).

Despite these achievements, there is still a huge yield gap (about 2000 kg/ha) that can be reduced and thus improve the income of common bean producers and other stakeholders involved in the value chain (Setegn, per comm.). It is believed that, this yield gap is caused by low use of inputs, particularly land enhancing technologies (Legesse et al., 2006; Negash, 2007). This study seeks to explore the micro-level factors, that facilitate or constrain agricultural intensification and yield, which is critical for food security and poverty alleviation in the country. Ethiopia is among the poorest countries in the world with dependency on food aid averaging about 700,000 metric tons annually over the past ten years (Byerlee et al., 2007).

Survey design and data

The data set used in the analysis was a subsample of the baseline data collected through a household survey in the two major common bean producing regions of Oromia and SNNPR between June and August 2008. Both regions contributed 80% of beans produced in Ethiopia. The baseline survey was part of the project: "enhancing the productivity of legumes to improve the livelihoods of the poor households in drought prone area" implemented between 2007 and 2010 [implemented jointly by International centre for Tropical agriculture (CIAT)], International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, International Institute of Tropical Agriculture (IITA) and in collaboration with NARS in participating countries of East and Southern Africa and Asia]. The purpose of the baseline survey was to provide information against which the project impact would be monitored. The sample was designed to provide factual and counter factual scenarios in each region. Each scenario in each region involved two woredas (an equivalent of a district in other sub-Saharan countries), chosen purposively according to the amount of rainfall, probability of rainfall failure and literacy levels. These were Adama, Adami Tuli and Siraro from Oromia and Dale from SNNPR. Although Siraro is from Oromia regional state, it is in the border line with SNNPR and also grows significant amounts of the small red cooking type that dominates SNNPR. It was therefore selected as a counterfactual site for interventions in Dale, due to logistical reasons. In each woreda, the villages were randomly selected for the survey. The study then used a randomly selected subsample of 180 households from 10 villages of Oromia region. The households produces common bean primarily for sale.

In addition to eliciting general farm and household characteristics, the survey included detailed questions on area allocated to common bean production, inputs used in common bean production and the total quantity harvested in 2008. Interviews on production related variables were conducted while in the plot to complement the farmers recall with direct observations (the contribution of the direct observations in data quality assurance was further enhanced by the fact that most of the crops including common bean were still in the field at the time of the survey). Each farmer was also asked if there have been any adjustments in areas under common bean during the five years prior to the survey.

Table 1 presents a summary of the general characteristics of the households in the study areas. Households were generally of low education and own smaller farms, though majority depend on farming for their livelihoods. Average landholding was 2.5 ha that ranged from 0.25 to 18 ha but, about 50% of the households had less than 2 ha. Only 45% of the total used inorganic fertilizers (Table 1). Like elsewhere in rural parts of Ethiopia, most households in the study areas were far from all weather roads (paved roads) and urban centers. Based on the survey data, the average distance from the nearest urban center was 7.7 km, with households in a range of 0.05 km to 30 km. Public transport was scarce and most people used household owned horses as mode of transport, for both people and produce, to the market. Off farm employment opportunities were very limited (less than 10% of the household heads were employed off farm as part time) and each household head spent on average, 8.6 months on the farm.

Table 1. Descriptive statistics of the selected sample characteristics.

Variable	Mean	Standard deviation	Minimum	Maximum
Age of household head (years)	40.25	14.96	17	90
Education of household head (years)	2.97	3.17	0	13
Household size	7.82	4.61	1	33
Number of months a household spends on farm	8.67	2.87	0	12
Land holding (ha)	2.54	2.00	0.25	18
Distance from the farm to urban centres (km)	7.72	5.69	0.05	30
Fertilizer use rate (%)	45.09	49.90	-	-

Econometric models and estimation

A two step estimation procedure was used to analyse the determinants of the common bean yields and input use. In the first step, the factors that influenced fertilizer use intensity and adoption of improved varieties were analyzed. In the second step, the effect on common bean yield of fertilizer use intensity, adoption of improved varieties and other production factors were tested. The summary of the econometric methods applied to estimate the determinants of input use, including the results of model specification tests, were presented first and was followed by the production function estimation.

Use of improved varieties

A crop variety is a divisible technology whose adoption is better measured by the area under the variety. In this case, the data showed very low adoption rates (about 29%) but nearly 100% use among adopters. Hence, variation in likelihood of use was a more relevant measure of adoption. A binary Probit regression model was therefore applied to estimate the factors, that affect the probability that a randomly selected bean producer used improved varieties. The binary Probit regression model assumes an underlying adoption latent variable y* defined by:

$$y*_i = \beta Z + \mu_i \quad (1)$$

Where, Z is a vector of exogenous variables hypothesized to influence adoption decisions, β is a vector of coefficients to be estimated and μ_i is the random error term assumed to have zero mean and constant variance. The decision to adopt is only observed, when it is positive and remains unobserved for non-adoption. The estimated model was specified as:

$$y = 1 \text{ if } \quad y^* > 1 \text{ and}$$
$$y = 0 \text{ if } \quad \text{otherwise} \quad (2)$$

Fertilizer use intensity

The data revealed that common bean producers in Ethiopia do differ in terms of the intensity of the fertilizer use. Non-adoption (a corner solution at zero) occurs even in areas of diffusion of the technology. Therefore, there is a cluster of farmers with zero adoption at the limit of the variable, or the “corner” of the optimization problem. A maximum likelihood Tobit estimator commonly used in estimation when the dependent variable is observed within a limited range (Green, 2000) was used. In a Tobit model, the latent variable (y*) is linked to the observed adoption variable (FERT) through the following equations:

$$FERT = y^* \text{ if } \quad y^* > 0$$
$$FERT = 0 \text{ if } \quad y^* \le 0 \quad (3)$$

The latent variable, y*, is defined as: $y^*_i = X_i \beta + \lambda_i$. Vector X contains all variables hypothesized to influence fertilizer use intensity, β is a vector of unknown parameters to be estimated, and λ_i is the independent normally distributed error term assumed to have zero mean and constant variance σ. The intensity of fertilizer is observed when $X_i\beta + \lambda_i > 0$ and censored at zero when $\beta X_i + \lambda_i \le 0$. The effect of the jth explanatory variable X_j on the expected fertilizer use intensity in common bean production was computed following the exposition of Mcdonald and Moffit (1980) discussed in Wooldridge (2002).

Production function estimation

A flexible quadratic functional specification was applied in the estimation of determinants of yield. This specification was particularly suited for the study of yield for common bean in Ethiopia where some farmers do not use fertilizer and hence had zero values in the data (another advantage of a quadratic production function over the Cob- Douglas type of production function is that the production function is generally compatible with the three stage of the production function of neoclassical economic theory) (Debertin, 1992). The following quadratic model was estimated:

$$\log Y = \alpha + \beta FERT + \gamma IMV + \sum \delta X_i \alpha + \varphi X_i FERT + \sum X_i^2 + \varepsilon \quad (5)$$

Where, Y is yield, FERT is per hectare amount of fertilizer and IMV is the use of improved varieties. The vector X represents other inputs and determinants hypothesized to influence adoption and ‘ ’ is the random error term assumed to have mean zero and variance one. One problem is that fertilizer use intensity and improved varieties will be endogenous, if the decision to use these inputs is motivated by the need to increase yield. The endogenous variables are correlated with the error terms, in the main equation (that is, yield in this case), rendering the estimated coefficients inconsistent.

Table 2. Definition and descriptive statistics of dependent variables.

Variable	Variable definition	Mean	Standard deviation
Improved variety (IMV)	A household grew an improved variety in 2008	0.289	0.455
Fertilizer intensity (FERT)	Amount in kg applied per hectare	45.426	93.061
Fertilizer intensity among adopters	Amount in kg applied per hectare within the adopting sample	120.903	118.350
Yield	Amount in kg per hectare harvested	1254.531	1159.819
Log yield	Log of the amount (kg/ha) of yield harvested	6.749	0.984

A strategy to test for endogeneity is using a Durbin–Wu–Hausman test (Wooldridge, 2002). The test involves estimating auxiliary reduced-form regressions for the right-hand side variables suspected to be endogenous, followed by estimation of an augmented original model, including the reduced-form residuals as additional explanatory variables. The statistical significance of the coefficients associated with the residuals was then evaluated.

First, the test was implemented for fertilizer use intensity. Credit were neither significant in variety model nor that of yield and were therefore used as instrumental variables for fertilizer use intensity. The endogeneity of the adoption measure for improved varieties was also tested in a similar way, using the dummy of whether the farmer renewed seed at planting in 2008, as the instrument. The tests confirm the variables to be endogenous in the yield function and an instrumental variable approach was used in a two step least squares regression method (An alternative approach often used to account for endogeneity of inputs on the production function estimation is by use of a three stage least squares regression as that one used by Kamara (2004). This approach is an instrumental variable technique that jointly estimates the entire system of equations (Green, 2000). It was not used because the rank order condition discussed in Wooldridge (2002: p 211-212).

Definition and measurement of variables

Dependent variables

Three dependent variables: yield, fertilizer and improved varieties were considered for the evaluation of the determinants of input use and productivity for common bean in Ethiopia. Table 2 presents the variable definition and their descriptive statistics.

Use of improved varieties

In the last two decades, more than 10 varieties were released in two major common bean regions of Ethiopia. To differentiate these varieties from those introduced many decades ago, a variety was defined as improved, if it was released after 1989. Use of improved common bean varieties was defined as a binary dummy (IMV=1) if a farmer planted an improved variety released after 1989 and as zero if otherwise. Impact of any crop variety depends on the extent of adoption measured in terms of area and a qualitative indicator of “one/zero” is not a strong indicator of how widely the improved varieties are used. Low incidences of use in the data, limited the use of variety area in the analysis. About 29% of the sampled farmers planted the improved varieties in 2008 cropping season. Out of the adopters, 60% allocated all their common bean area to the improved varieties with the remaining 40% allocating over 60% of their common bean area to the varieties. Hence, the dummy indicator was a good approximation of the extent of variety adoption.

Fertilizer use intensity

Inorganic fertilizers commonly used in common bean in Ethiopia are DAP and urea. Attempts to elicit data by fertilizer type were made but farmers were unable to differentiate types and hence a measure of fertilizer use aggregated over types was used. Therefore, fertilizer use intensity was measured as the amount of aggregated inorganic fertilizers applied per hectare during the 2008 cropping season. Data in Table 2 shows that the aggregated inorganic fertilizer use intensity was very low with high variability across farms. On average, each farmer applied 45 kg of the aggregated inorganic fertilizers per hectare which was far below the recommended rate of 100 kg/ha of TSP and 25 kg/ha of urea (David, 1998). Among the adopters, the average fertilizer intensity was about 120 kg/ha but highly variable across farms (Table 2).

Yield

The measurement of common bean productivity was based on the concept of input-output relations (that is the relationship between output and conventional inputs: land, labour, seed and fertilizer). Land was taken to be a fixed factor and all inputs standardized to a hectare. In this study, common bean yield refers specifically to productivity per unit area, expressed in kg per hectare. The data shows an average yield of 1254.5 kg/ha with a standard deviation of 1159.8, implying high variability of yield across farm. To reduce the impact of outliers and improve the robustness of the estimates, the yield measure was transformed into logarithms. The logarithmic transformation was also attractive and easy to interpret as it gives direct effects of one unit change in explanatory variables in percentage change in the dependent variables (Allison, 1999).

Definition of explanatory variables and their hypothesized effects

The choice of the explanatory variables used in the estimation of input use models and yield functions was based on production theory, literature and prior information on the study context. A summary of all the explanatory variables, their definition and descriptive statistics are presented in Table 3.

Improved variety use

A broad literature on technology adoption provided the basis for the choice of explanatory variables used in the analysis, comprising individual, household and farm-physical characteristics. Literature

Table 3. Explanatory variable, their definition, hypothesized effects and descriptive statistics (HH=household).

Variable	Description /Units	Mean	Std. Dev.
Input use			
FERT	Predicted value of Fertilizer applied (Kg/Ha)	121.84	108.24
Labour inputs	Total amount of labour in man hrsha^{-1} used in common bean 2008	151.72	183.45
Family labour	No. of HH members aged above 15 years	3.21	2.02
Hired labour	No. of people hired in common bean production	3.34	7.22
Seed use	Amount of seed Kg/Ha	50.37	48.43
Beanhadum1	Dummy (1 if a farm in the data had less than 0.5 ha of common bean)	0.21	0.41
Beanhadum3	Dummy (1 if a farm had more than 2 ha of bean)	0.15	0.35
Scale	Total area under common bean in 2008 (ha)	0.72	1.02
Extension	Dummy (1 if HH contact extension in 2007-2008)	0.57	2.37
Credit	Dummy (1 if the farmer obtained credit)	0.29	0.46
Agricultural practices			
IMV	Predicted value of improved variety use if farmers planted any variety released after 1989	0.25	0.44
Seed renewal	Dummy (1 if farmer renewed seed)	0.30	0.46
Assets			
Implements	Value of farm implements (Eth.Birr)	4530.02	15349.41
Livestock	Value of livestock (Eth.Birr)	9611.13	15176.62
Donkey	Value of donkey (Eth.Birr)	1146.38	4487.41
Oxen	Value of oxen (Eth.Birr)	4484.68	5622.84
Off-farm income	Dummy-1 if a HH earns off farm income	2.65	11.52
Farm characteristics			
Distance	Distance from farm to the nearest urban centre (km)	7.46	5.50
Easy market	Dummy (1 if HH located within a radius of 5 km from the urban centre)	0.27	0.44
Difficult market	Dummy (1 if HH located beyond 10 km from the urban centre)	0.22	0.42
HH characteristics			
Gender of HH head	Dummy (1 if HH head is male)	1.04	0.23
HH education	No. HH members with more than 7 years of schooling	0.48	1.08
land holding	Total land holding (Ha)	2.16	1.92

specific to Ethiopia identified access to extension, credit and market conditions as the important factors that influence the adoption of common bean production technology (Negash, 2007). Contact with extension in Ethiopia is vital for its effect on access to new technologies because of poor infrastructure, low density of communication technology and low literacy levels. In the sample, 33% of the production decision makers had no formal education and only 40% had more than 4 years of formal education.

Access to credit is also expected to increase the adoption of new common bean varieties through different complementary mechanisms. First, because seed is expensive, it is often sold to farmers on credit, or liquidity constrained farmers can only afford to purchase seed when they obtain credit in cash. Access to credit also has risk reducing effects that could re- enforce the decisions to adopt new crop varieties. Priori information shows that, most of the common bean producers in sub-Saharan Africa, a self pollinated crop, keep their own seed and that this tends to slow down the diffusion of new crop varieties (David and Sperling, 1999). Based on this information, it is hypothesized that farmers who frequently renew their seed from off farm sources are likely to obtain and plant new varieties.

Adoption of technologies in agriculture has generally been observed to start with well-off farmers and gradually trickle to poorer ones (Feder et al., 1985) but mixed results have also been reported for divisible technologies. Feder (1981) found the adoption of the green revolution varieties; a divisible technology, was biased towards larger farms due to their risk preferences and information access. In their impact study of improved common bean varieties, across other various sub-Saharan African countries, Kalyebara et al. (2008) observed that the adoption of common bean varieties was neutral to scale and wealth. Household assets (represented by the value of farm implements, oxen and the size of the land holding) were included to test their relevance in the Ethiopian context. Better and more farm implements can be an indicator of wealth and may increase the likelihood of adopting new technology through risk reducing effects. Farm implements also ease farm work and put the farmer in a wider and richer social network because of lending to neighbours, who may reciprocate by providing information and/or new variety seed. Distance from urban center to the farm, reduces the likelihood that a farmer will learn about the new varieties and be able to access the technology.

Earlier study by Knight et al. (2003) found education of the household members to be important in alleviating risk among farmers in Ethiopia. It was hypothesized to positively influence the use of new improved common bean varieties because of its risk reducing effects. Gender is another variable that is expected to influence the access to new technologies in Ethiopia because of gender biases towards men in community associational life in the country.

Fertilizer use

The definition and description of the independent variables in the fertilizer use intensity model are also presented in Table 3. Fertilizer is an expensive input and its performance depends on soil moisture status that is often beyond the farmer's control in Ethiopia. Because of this, factors that reduce risk and liquidity constraints were expected to be important factors in its use (even when it is supplied in the form of credit through cooperatives, a farmer is expected to pay 15% of the principal and interest in cash as down payments (Mulatu and Regasa), 1987). Credit and education reduced liquidity constraints and risk (Weir and Knight, 2004; Knight et al., 2003) and were hypothesized to be positively related with fertilizer use. Older people tend to discount the future heavily and are expected to use lower fertilizer intensity. The number of dependants may increase the risk of starvation or increase household consumption demand. Hence its effect on fertilizer use cannot be determined *a priori*. The effect of livestock on fertilizer use cannot be determined *a priori*.

Livestock may increase the use of inorganic fertilizer through its risk reducing effect or it may have a negative effect if it provides an alternative source of fertilizer (in the study areas, agriculture is characterized by livestock mainly cattle and crops) . After harvesting, crop fields are used as communal grazing areas (Mulatu and Regasa, 1987). This means that even farmers with limited livestock can access organic manure but this might not be adequate and owners might still be at an advantage because of collection from the kraal.

Although, most of the farm activities are done by family labour, hiring of labour and traditional labour raising practices are often used to complement family labour during periods of critical labour peaks ((Mulatu and Regasa, 1987). It is hypothesized that, access to complementary labour reduces competition between crops and enables the use of labour intensive inputs like fertilizers. Possession of oxen also facilitates early ploughing of the land at the start of rains, thereby enhancing the productivity of fertilizers. Teressa and Heidhues (1996) and Negash (2007), reported a positive correlation between the number of oxen and the use of fertilizers in Lume areas, also located in Oromia. To account for both the number and quality of oxen, the market value of the oxen was used (Mulatu and Regasa (1987) reported that the lack of feed in the dry season makes (oxen too weak to plough properly) . Each farmer was asked the number of oxen and the value of each, if sold at the time of the data collection.

Market access was represented by the distance (km) from the farm to the nearest urban centers and site specific dummies. Although, fertilizer use is not new in Ethiopian agriculture, its market is still under developed due to poor road and communication infrastructure combined with government interventions in the market (of the total roads, only 13% are paved while only 2% of the 100 persons have mobile subscriptions because some sites have no telephone connections (World bank, 2008). The use of fertilizer was expected to be less costly near urban centers due to reduced transport costs and better access to storage facilities. Proximity to urban centers may also increase incentives from output markets and facilitates information access, thereby, increasing the demand for fertilizer.

The three study sites (Adama, Adama Tuli and Siraro) also differed in important ways. The Siraro woreda was far from urban centers and the dominant soils in this study site were sandy, with implications of high fertilizer productivity. On the other hand, study sites in Adama and Adami Tuli appeared to have similar agro-ecological conditions; some farmers were not very far from paved roads but Adama was closer to the regional town (that is, Nazareth town). Hence, market access might be higher in Adama than in Adami Tuli and Siraro. Extension was reported from earlier studies to be an important variable which explain variations in fertilizer use (Negash, 2007) and was thus included. Measures of population density and off farm income were excluded from the final estimation because they were highly insignificant.

Yield

Inputs used in the yield equation were standardized to a hectare and the predicted values for fertilizer use intensity and improved varieties were used in the estimation of the yield function to account for their endogeneity (Table 3) . The production theory predicted that yield increases in all inputs: seed, labour and fertilizer. This is based on the assumption that, any rational decision maker cannot operate in the third stage of the production function. Labour input was computed as the total man hours aggregated across activities and gender (one woman hour was assumed to be equivalent to 0.8 man labour hours). The amount of seed planted was defined by asking every farmer the amount of seed in kg planted in 2008. To standardize per hectare, the total amount of seed planted was divided by the bean area (ha). Fertilizer and improved varieties were measured as described earlier. The value of livestock was included to control the effect of organic fertilizers. The new varieties developed and disseminated in Ethiopia were extensively tested with end-users for agro-ecologic adaptation in many other sub-Saharan countries and was found to increase yield by 30 to 50% (Kalyebara and Andima, 2006). Under this context, it is expected that, yield increases with the use of improved varieties.

Market access operates in several ways that may not be dissociable in a given location at one point in time. For example, it may facilitate access to inputs and hence encourages input intensification. In addition to input intensification, market access has been found to encourage specialization, thereby enhancing efficiency in crop management and productivity (Kamara, 2004). Based on this literature, indicators of market access were included to test for any other effect after controlling its intensification effect. Data exploration tests revealed that, distance from urban centers to the farm was nonlinear in the yield equation. Because inclusion of a quadratic term induced multicolinearity, distance from urban centers was estimated as a dummy. The sample was post stratified arbitrarily into nearly three equal groups: easy market access if the household was located within a radius of less than 5 km (5 km was considered a distance from urban centers within which a number of different transportation modes (horse, oxen or walking, vehicle or bicycle, etc) were possible, allowing flexibility in the choice of transport, competition among transporters, competitive pricing and hence fair prices. This would facilitate mobility among household members from the nearest town (urban center) and difficult market access if a household was located beyond 10 km from the urban center. The omitted categories were households in the middle market access group, located within a radius of 5 to 10 km.

The variable scale, that represented the scale of operations, was also transformed into two dummies to account for nonlinearity and improve the robustness of the estimates. The first dummy was called beanhadum1, assigned a value equal to 1 , if a farm in the

Table 4. Input use in common bean production by farmer category in the study area of Ethiopia, 2008 (in parentheses are the standard errors).

Variable	Small farm (less than 2 ha) (N = 91)	Large farm (> = 2 ha) N=82	Sample (N =173)	t-value
Land fallow (%)	3.3(1.9)	6.2 (2.7)	4.6 (1.6)	0.891
Land allocated o common bean (ha)	0.53(0.04)	1.30 (0.16)	0.91 (0.09)	4.794***
Proportion of crop area occupied by beans	0.35(0.03)	0.36 (0.03)	0.35(0.02)	0.395
Area expansion during 2001-2007 (%)	41.76 (5.20)	56.10 5.51)	48.55 (3.81)	1.893^
Fertilizer use rate (%)	48.35 (5.27)	41.46 5.47)	45.09 (3.79)	0.906
Fertilizer use intensity (kg/ha)	48.35 (5.27)	41.46 5.47)	45.09 (3.79)	0.906
Adoption of improved varieties	18.68 (4.11)	40.24 5.45)	28.90 (3.46)	3.197***

Significance levels are denoted by one asterisk (^) at the 10% level, three asterisks (***) at the 1% level.

data had less than 0.5 ha of common bean while farms in the data with more than 2 ha of bean were categorized into another dummy variable called beanhadum3=1 (The stratification of the sample into categories of scale of operation was arbitrary guided by the mean of bean ha and the need to have enough observation in each category). The omitted dummy variable was for farms with bean area ranging from 0.5 to 2 ha.

RESULTS AND DISCUSSION

Land allocation to common bean in the study areas

The data summarized in Table 4 indicates that, land use intensity in the study areas was high. Less than 7% of the farmers practiced fallowing on their land, irrespective of farm size and market access group. The results indicate that, common bean is as important to small farmers, as it is for larger farmers. The average land allocated to common bean in a cropping season among the smaller farms (landholding less than one hectare) was 0.34 ha, which is about 33% of the total land under crops in season. On the other hand, larger farmers (with more than one hectare of landholding) allocated an average of 1.2 ha, about 36% of the crop area, to common bean.

Generally, a significant proportion of farms expanded their area under common bean in the last five years in response to the increased market opportunities. As expected, the response was more substantial among larger farms than small ones. The results in Table 4 also show that, the use of improved varieties was higher on large farms than on small farms. On the other hand, use rate and intensity (kg/ha) of inorganic fertilizer on common bean was independent of farm size and was low on large farms as it was on small ones. This suggests that, other factors other than population pressure were responsible for its adoption.

Factors influencing use of productivity enhancing inputs

Fertilizer use intensity

Fertilizer use intensity equation was estimated by a Tobit maximum likelihood estimator and the total effect of each explanatory variable was derived, according to the Macdonald and Moffit decomposition procedure of 1980. Results for the intensity of fertilizer are presented in Table 5. Most of the hypothesized factors had the expected signs except for labour input variables but these were not statistically significant. Those significant were access to credit, site specific variables and extension. Credit had a positive effect, which is consistent with what was reported from previous study (Negash, 2007). Most farmers in Ethiopia are poor and access to credit isimportant for their adoption of land enhancement and expensive inputs. Furthermore, fertilizer distribution in Ethiopia is mainly by government through extension in form of credit (Byerlee et al., 2007). Credit and extension had positive effects on both the probability and intensity of fertilizer use. Farmers who accessed credit applied 52 kg/ha more fertilizers than those who did not, while extension increased fertilizer use by 57 kg/ha.

After controlling of credit and extension, farmers close to urban centers were also more likely to use inorganic fertilizer than their counterparts in remote area, but the overall marginal effect on fertilizer use was small (estimated at 2.7 kg/ha less fertilizer for every 1 km away from urban centers). Inclusion of the quadratic terms did not show any evidence of a nonlinear relationship (the inclusion of quadratic term induced multicolinearity, which could have limited the observation of the relationship). Although, the road network in the study region was fairly well developed as compared to the rest of the country, many farming communities were still inaccessible by road during rainy season, which could inhibit easy access to inputs. Farmers in Adama, close to the regional town and those in Siraro were also more likely to use higher fertilizer intensity than their counterparts in Adami Tuli. Since Siraro is far away from the urban centers, this result implies that, application of fertilizer may also be driven by perception of poor soils, which could be worse in Siraro where soils were more sandy than in other regions also according to Gebeheyu, (Per.com), Siraro has a long tradition of using fertilizers in their agriculture. The coefficient was of the larger magnitude. The

Table 5. Tobit estimates for the factors affecting fertilizer use intensity in Oromia, Ethiopia.

Explanatory variables	Normalized coefficient.	Std. Err.	t-value	expected probability	Conditional expected intensity of use	Total effect
Constant	-183.587	73.853	-2.49			
Distance from homestead to the plot	0.335	0.690	0.49	0.010	0.327	0.337
Dummy for Adam	74.022	47.676	1.55	36.931	-13.716	23.215
Dummy for Siraro	179.604	43.917	4.09**	72.574	1.442	74.017
Extension	96.018	42.840	2.24*	15.962	41.504	57.466
Age	0.462	1.248	0.37	-0.136	0.620	0.484
Education	3.812	4.509	0.85	1.756	0.084	1.840
Credit	96.669	29.632	3.26**	24.777	26.841	51.618
Value livestock	-0.002	0.001	-1.7^	-0.001	0.000	-0.001
Value oxen	0.005	0.004	1.06	0.002	-0.001	0.001
Distance	-5.887	3.364	-1.75^	-2.230	-0.517	-2.747
Dependants	9.403	4.978	1.89^	2.715	2.917	5.632
No. of family members	-3.300	7.367	-0.45	-2.456	3.469	1.013
No. of hired people	2.636	2.044	1.29	-0.068	1.715	1.647
No. of communal workers	-1.762	3.213	-0.55	-1.405	0.394	-1.011
No. of observation	102	Probability chi2	0.0005			
LR chi2(14)	38.15	Log likelihood	-285.96			

NB: Asterisks: **, * and ^ denote significance level 1, 5 and 10%, respectively.

econometric analysis revealed an increase of 74 kg/ha as one moved from Adami Tuli to Siraro and of 23 kg/ha from Adami Tuli to Adama sites. Fertilizer use intensity also had expected signs with household assets (that is, value of oxen and livestock). The effect of livestock was negative, implying substitution effects between organic and inorganic fertilizers. Finally, households with higher number of dependants were more likely to use more fertilizers, perhaps reflecting the effect of increase in the consumption demand on common bean intensification with fertilizer.

Improved varieties

A Probit model was used to estimate the factors that influence the probability that, a randomly selected farmer would plant improved varieties released after 1989. The results are presented in Table 6. The estimated model correctly classified 86% of the predictions in the data, implying a good fit. A wide range of factors included in the analysis had the expected signs, though few were significant. Those significant were household assets, renew of seed and farm size and the number of dependants.

Household wealth represented by the value of oxen and other farm implements was positively related to the use of new varieties while physical assets in form of livestock showed negative correlation with adoption of new varieties. The magnitude of the coefficients was too small to derive any meaningful causal relationship. However, after controlling these household assets and other variables, the probability of planting improved varieties was found to be higher on larger farms than on small farms, confirming that adoption of bean varieties began on large farms, which is consistent with the works of other authors Feder and Omara (1981), Feder and Umali, 1993). Larger farms may have been in the position to access information and seed than small farmers. Education and extension had the expected positive signs but were not statistically significant. The use of improved varieties was also not related with market access. Unlike the case of fertilizer, higher number of dependants in a household was negatively correlated with the use of improved varieties, perhaps capturing the risk enhancing effect, when it comes to improved varieties. Finally, the results also indicated that farmers that regularly renewed their seed and acquired seed from sources outside the farm, were also likely to have accessed new varieties and adopted them.

Determinants of yield

Results of the production function estimation are shown in Table 7. The econometric results showed the production response to different inputs and determinants for common bean in Ethiopia. Conventional inputs (that is labour, seeding rate and fertilizer) had positive signs as expected, which is consistent with the theory. Labour had a positive but small effect that was not statistically significant. The seeding rate had a positive and significant marginal effect on common bean yield. An

Table 6. Factors influencing the probability of improved common bean variety use in Oromia of Ethiopia, 2008.

Variable	dF/dx	Standard deviation	Z	P>z
Dummy Adam	0.136	0.126	1.17	0.244
Dummy Siraro	-0.124	0.088	-1.22	0.222
Extension	0.089	0.115	0.88	0.379
Gender	-0.134	0.182	-0.87	0.382
Education	0.008	0.010	0.7	0.482
Credit (Units)	0.063	0.078	0.89	0.372
Seed renewal (units)	0.246	0.130	2.36**	0.018
Land holding (units)	0.074	0.024	3.13***	0.002
Value of livestock (units)	-0.00003	1.0E-05	-2.56***	0.01
Value of Oxen (Units)	0.00005	1.5E-05	2.33**	0.02
Value of other farm implements (units)	0.00002	1.1E-05	2.12**	0.034
Distance (km)	0.001	0.009	0.06	0.949
Number of dependants	-0.033	0.015	-2.38**	0.017
Constant	-1.191	0.706	-1.69^	0.092
Obs. P	0.295			
Pred. P	0.124			
LR chi2(13)	67.88			
Prob > chi2	0.00			
Log likelihood	-46.177			
Pseudo R^2	0.424			

Significance levels are denoted by one asterisk (^) at the 10 % level, two asterisks (**) at the 5 % level, three asterisks (***) at the 1% level.

interaction term of fertilizer and seed was also included and it showed a positive effect on yield. This means that when there was zero fertilizer use and seeding rate was increased, yield also increased. The quadratic term of seeding rate was negative and significant but excluded due to multicolinearity. The significance of the interaction terms also showed that increase in fertilizer intensity was more productive when seeding rate was also higher. On average, each farmer applied 62 kg of seed per hectare which was low compared to what has been reported as recommended seeding rate under broad casting method (Negash, 2007). High variability in the seeding rate was also noted across farms, implying that there was still room for improving yields, if these problems are overcome. As a matter of fact, 1 kg increase in the amount of seed planted per hectare produced 0.5% increase in yield, which translated to 4.5% yield increase for a 10 kg increase in the amount of seed planted per hectare, after accounting for the increase at a decreasing rate of 0.05%. This study did not examine the causes of low seeding rate but it could be due to seed constraints or low knowledge on the proper seeding rate.

The effect of organic fertilizers, represented by the value of livestock was also positive. The estimated coefficient of improved varieties was positive but not significant, perhaps due to the generally low adoption rates of the data. The effect of scale on yield was captured through two dummy variables, representing very small scale (less than 0.5 ha and large scale, more than 2 ha). The very small scale farms and large scale farm, showed statistical significant effect on yield. Yield was highest on the very small farms (less than 0.5 ha) and lowest on the large scale farms.

The effect of market access on yield was estimated using two dummy variables defined in Table 3. Both the coefficients on the dummy, for easy access and difficult access, had a negative sign but only the coefficient for difficult access was statistically significant at 1% level. This is an interesting finding and it suggests that market access exhibited other effects beyond intensification effects. This means that farmers far away from urban centers (beyond 15 km radius) specialize less in common bean. Common bean is one of the preferred commercial crops in the study area and any improvements in market access are likely to encourage the specialization effects that will enhance productivity. This shows that government investment in infrastructural development will create additional benefits from common bean.

CONCLUSIONS AND POLICY IMPLICATIONS

The study used the household survey data to identify factors that facilitate growth on common bean productivity and input use in Ethiopia at a micro level. The contribution of land enhancing technologies (that is, fertilizers and improved varieties) on the productivity was evaluated, using an instrumental variable approach in a

Table 7. Ordinary least square estimates of determinants of common bean yield in Oromia of Ethiopia, 2008.

Variable	Coefficient	Standard error	T	P>t
Constant	6.1466	0.265	23.19**	0
Dummy for scale less 0.5 ha	0.4489	0.2012	2.23*	0.028
Dummy for scale greater than2 ha	-0.6821	0.2479	-2.75**	0.007
Dummy for sites >15km away from urban centers	-1.724	0.5279	-3.27**	0.002
Dummy for sites <5km away from urban center	-0.2161	0.1685	-1.28	0.203
Labour	0.0667	0.0572	1.16	0.248
Value of livestock	0.00001	3.64E-06	3.21**	0.002
Extension	0.2861	0.2231	1.28	0.203
Education	0.03334	0.0214	1.56	0.123
Amount of seed planted /ha	0.00484	0.0020	2.46*	0.016
improved varieties	0.1459	0.2994	0.49	0.627
Interaction term for seed and fertilizer	0.00003	8.59E-06	3.01**	0.003
Fertilizer	-0.0021	0.0026	-0.84	0.405
Number of observations	97			
F(12, 84)	6.19			
Prob > F	0			
R-squared	0.4694			
Adj R-squared	0.3936			
Root MSE	0.65958			

Significance levels are denoted by one asterisk (*) at the 5 % level, two asterisks (**) at the 1% level.

two-stage least squares regression. The study findings showed that following the liberalization and improvements in market incentives, majority of farmers responded by increasing the area under common bean but the use of land enhancing technologies, such as fertilizer and improved varieties remained low. This raised the concern of long term effect on soil nutrient depletion, particularly among small farmers who do not own sufficient numbers of livestock (averaged at a value of ETB. 5556 per farmer) to provide organic manures.

The study confirms poor market access and labour constraints as a key factor constraining fertilizer use, indirectly inhibiting productivity growth in common bean in Ethiopia. Also, demand was still low due to high levels of poverty in a high risk production environment. Currently, farmer's ability to overcome liquidity constraints and absorb the consequences of risk occurrence is an important factor that facilitates intensification and productivity growth, in common bean. This means that government intervention with insurance programmes that help people smoothen their consumption could reduce risks and enhance the use of improved inputs such as improved seed. The positive effect of credit in fertilizer use and productivity supports this conclusion but the current access is still limited.

In addition to the intensification effects, market specialization effects also emerged from the analysis; common bean yield was lower in sites very far away from urban centers. This suggests that locations far away from urban centers and with low access to markets generally, may be involved in many activities to meet their subsistence needs and may not have benefited from the specialization effects. Institutional factors also played a very important role. Both access to credit and access to extension had large and significant effects on fertilizer use and productivity. However, access to both extension and credit was still limited in scope. Given the government budget constraints, expansion was not feasible. Hence, there is need to explore innovative ways, that can complement the government efforts, in increasing information and credit access by farmers.

Complementary effects between fertilizer and seeding rate also emerged from the analysis, implying that promoting common bean land enhancing technologies as a package would encourage input use and productivity. Finally, the study suggests that, there is a big need to increase yield, using the existing technologies and knowledge dissemination. Investment in innovations that reduce seed and knowledge constraints will boost the technical efficiency and common bean productivity.

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