WHAT DO FARMERS FINANCIALLY LOSE IF THEY FAIL TO USE IMPROVED SEEDS? SOME ECONOMETRIC RESULTS FOR WHEAT AND IMPLICATIONS FOR AGRICULTURAL EXTENSION POLICY IN ETHIOPIA[1]

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Abstract

Before making any recommendation for the use of improved seeds, policy makers have to ensure that the improved seeds are superior to the local ones. To generate information on the financial viability of improved seeds, this paper computes the gross margin that farmers lose when they fail to use these inputs. Using the switching regression method, it then examines the contextual factors that affect the income foregone if farmers fail to use improved seeds.

The study is based on the fifth round of the Ethiopian rural household survey data taking wheat as a case. The estimated foregone gross margin ranges from 277 to 886 Birr per hectare and the total gross margin foregone at the national level ranges from 295 million to 946 million Birr per year. On the whole, the results suggest that, even though failure to use improved seeds involves foregoing financial benefits, it varies across farmers and farming systems. Not all farmers forego equal financial benefits.

The regression results show that the gross margin foregone increases with labour use, fertilizer use, farmers' experience with the extension package, wheat marketing, rainfall suitability, and wheat price index. On the contrary, it decreases with plot quality, education, input price index, oxen ownership, and chemical use. The results imply that improved seeds will have better income generating capacity when accompanied by other complementary services. Agricultural extension policy should establish targeting principles based on the comparative advantage of the respective seeds. On the whole, blanket recommendation of improved seeds for all farmers and farming systems across the board has to be re-visited.

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1. Introduction

Seeds are the basic inputs in crop production. To improve agricultural production and productivity in developing countries, adoption of improved seeds is believed to have a key role to play. However, because of the incompatibility of farmers' socioeconomic and agro-ecological environment to the production and marketing of improved seeds, productivity can not be enhanced by simple replacement of the local seeds by the improved ones3. In some contexts, the improved seeds may not be superior to the local ones.

Farmers' local seeds are the breeding basis for developing improved seeds and responding to future potential shocks that may affect agricultural production. In addition, indigenous seeds possess valuable traits such as disease resistance, adaptability to harsh and local conditions, potential without modern inputs such as fertilizer, yield stability and so on. For smallholder farmers, managing a portfolio of local seeds enables them to survive in marginal areas (Edilegnaw, 2004).

Given the seed types available to them (Smale *et al.*, 1998), farmers will choose to grow the seed (s) that is (are) most attractive to them in terms of income or other attributes of value (such as tolerance to environmental stress, early maturity, *etc.*) important to them. This is because farmers' seed selection, maintenance, and storage is a function of their household objectives (Barkley and Porter, 1996; Dercon, 1996). The Ethiopian peasants are operating in highly varied micro-environments differing in characteristics such as topography, soil type, water, temperature, and fertility (Tesfaye and Efrem, 1998). Seed choice is, therefore, far complex than just maximizing household income. Given the diverse ecological conditions of the country, there can not be 'one-size-fits-all' strategy that will trigger sustainable development (Mulat, 2003).

As compared to the availability of a huge adoption literature, studies that deal with the impact of agricultural extension and improved seeds (Gavian and Gemechu, 1996; Beyene *et al.*, 2000; and Mulat and Bekele, 2003) are very scarce. This emphasis is pre-occupied with the presumption that the new seeds are all the time superior to the old ones. But, are we sure that the improved seeds are superior (to the local ones) for all farmers and farming systems? Do the improved seeds fetch better prices? What is it that non-users of improved seeds or users of farmers' seed (s) are losing? What factors promote the positive impact of improved seeds on farmers' incomes? These are questions hardly addressed in the Ethiopian context.

[3] The incompatibility could arise because farmers' working environment (markets, land quality, environmental stress and so on) may not be suitable to the production and marketing of the improved seeds or the improved seeds do not fit to farmers' preferences, potentials, concerns and constraints (Edilegnaw *et al.*, 2005). If the technology does not fit to farmers' conditions, it will have to be shelved after

What needs to be done is not to cover all farmers' fields with either the improved or local seeds. The solution is neither planting improved seeds every where nor covering all farmers' plots with farmers' seeds. Taking the former option would be unacceptable due, among others, to crop biodiversity loss (Edilegnaw, 2004). Taking the latter option is wasting resources committed for getting the improved seeds and lower productivity as the local varieties are already failing to produce enough to feed the growing population. In a nutshell, the target for agricultural extension policy makers should, therefore, be locating the comparative advantage of the respective seeds.

When it comes to agricultural technologies, often blanket recommendations are made disregarding the heterogeneity of farmers and farming systems (Asmerom and Abler, 1994; Mulat and Bekele, 2003). That either has resulted for failure of farmers to take up the technologies and / or marginal impact even if they use the technologies. According to a study in South East Asia (Fujiska, 1994), the six reasons for farmers' failure to adopt agricultural technologies are that farmers do not face the problem targeted by the innovation, farmers' practice is equal to or better than the innovation, the innovation does not work, extension fails, the innovation costs too much, and other social and contextual factors. If at all some farmers take up the technologies partly or wholly bypassing these hurdles, the impact on their livelihoods will remain to be trivial.

For more productive use of technologies, their dissemination has to target farmers and farming systems where they can work better (Edilegnaw, 2003). The limited capacity of the government also necessitates targeted interventions. The premises of this paper is that generating information on the loss that non-users of improved seeds face will serve as an input to this end.

To shade some light on the financial viability of improved seeds, the paper estimates the financial loss (in terms of gross margin per hectare) that farmers face when they fail to take up improved seeds of wheat and further examines the contextual factors affecting the magnitude of this loss.

In terms of policy, such an investigation is timely and of utmost importance to agricultural development for various purposes. It serves policy to target technologies to farmers and farming systems where they have better comparative advantage. It justifies the investment made on seed development and dissemination, enables policy optimize the use of improved seeds, helps identify the best mechanisms of reducing the foregone financial net-benefit, and maximises the impact of farm technologies on farmers' incomes. More over, it informs agricultural researchers on the marginal utility (in terms of financial net-benefits) of the seeds they are developing

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a lot of resources are wasted OR it will not work even if it is used.

and informs extension policy makers on the complementary inputs and market institutions required to enhance the profitability of technologies.
The remaining part of this paper is structured as follows. Section 2 further elaborates the research agenda. Section 3 presents the theory underlying the methods of data analysis and the econometric methods adopted. Section 4 takes up the data generation process and description. Econometric results are presented and discussed in section 5. Finally, conclusions and policy implications are drawn.

2. Defining the research agenda in the Ethiopian context

2.1 Setting the scene

Nowadays, farmers are using improved seeds and fertilizer delivered (on credit basis) by the Ministry of Agriculture and Rural Development. However, they are not benefiting as they should due to various structural and institutional factors. There is a fundamental disconnect between the issues that African research and extension services tend to address and the resources and problems faced by farmers (Snapp *et. al.*, 2003).

Despite the potential benefits (in terms of income) of using improved seeds, many farmers are using their own seeds year after year for risk, tolerance to environmental stress, disease resistance, taste and related reasons (Nkonya *et al.,* 1997; Yapa and Mayfield, 1978). They continue to rely on local seeds and traditional farming practices (Mulat and Bekele, 2003) the reasons of which are well documented in the agricultural technology adoption literature.

One of the major motivations for the use of improved seeds is to increase incomes and achieve better yield response to modern inputs. However, there may not be desperate need to use improved seeds to improve productivity (Brush, 1991) since improved seeds may not have clear income advantage over farmers' seeds (Perales *et al.*, 1998). A traditional variety that is better adapted to local agro-climatic conditions may be more successful than its modern counterpart on a plot of low fertility or on a plot with no means of irrigation (Meng, *et al* 1998). Before moving into the promotion of agricultural technologies of any sort, one has to ensure their viability and superiority contextually. To contribute to this task, this paper analyzes the foregone gross margin for farmers who didn't use improved wheat varieties.

2.2 Theoretical factors affecting the financial benefit foregone

Choice and use of any seed, be it local or improved, involves trade-offs and opportunity costs (in terms of net-return, insurance value, responsiveness to modern inputs such as fertilizer, disease and pest resistance, marketability and the likes). While choosing certain combinations of seeds, farmers forego other attributes from the non-selected seed (s). In using local seeds, farmers, rural communities, and governments face *opportunity costs* (von Braun and Virchow, 1997). In this paper, the positive difference between the gross margin from improved seeds and the gross margin that a similar farmer gets from farmers' seeds is taken as the foregone financial net-benefit (opportunity cost) resulting from non-use of improved seeds. This is the variable taken as a response variable in the regression analysis.

This variable is assumed to be a function of factors affecting resource allocation and resource use efficiency. Accordingly, the explanatory variables to be considered in the regression analysis include household-related factors (such as schooling, farming experience and oxen ownership), level of use of inputs by the household (fertilizer, labor, and chemicals), agro-ecological factors (such as rainfall and plot quality), access and institutional factors (such as experience in the extension package and access to public goods), and input and output prices (price indices)[4].

The financial net-benefit foregone varies from farm to farm subject to the suitability of farmers' working environment to the production and marketing of improved and local seeds. The more favorable the environment is to the production and marketing of improved seeds (compared to farmers' seeds), the higher will be the financial net-benefit foregone. For instance, the financial net-benefit foregone increases as agriculture becomes more intensified and commercialized (Smale *et al.*, 1998). Inputs and local conditions affecting both seeds equally do not affect the foregone net-benefit.

Correcting for potential econometric problems like self-selection (See Sub-Section 3.1 for more complete discussion), the financial net-benefit foregone can be defined as:

$$NB_{FOREGONE} = GMPH_{IV} - GMPH_{FV} \qquad \textbf{(2.1)}$$

where $NB_{FOREGONE}$, $GMPH_{IV}$, and $GMPH_{FV}$ refer to the foregone net-benefit, gross margin per hectare of the improved seeds, and gross margin per hectare of the farmers' seeds, respectively.

[4] Input and output prices are important determinants of gross margin foregone because the gross margin is an increasing function of output prices and decreasing function of input prices.

3. Methods of data analysis

3.1 The choice of methods of data analysis

Due to non-random distribution of the non-seed factors and unobserved variables, selection bias is the most important econometric problem that needs to be addressed in our empirical analysis. Sample selection bias may arise in practice for two reasons (Heckman, 1979). First, there may be self-selection by the individuals and secondly sample selection decisions by analysts. In our case, the first is due to farmers' own self-selection in such a way that each farmer takes the seed (s) that have comparative advantage to his (her) working environment. Accordingly, farm households who have a better potential to use improved seeds will be joining the use of improved seeds and thus will benefit more from it than would a randomly selected farmer. The second type of self-selection could arise due to the purposive selection of the so called 'high potential areas or farmers' by the Agricultural Extension Department, Ministry of Agriculture and Rural Development.

Selection bias could potentially arise due to selection on the observables or un-observables. Better educated farmers, better quality land, and better farm management practices could be skewed towards the users of improved seeds. This is selection on the observables. The gross margins achieved by farmers using improved seeds or farmers' seeds are, accordingly, affected differently by the explanatory variables. Regarding selection on the un-observables, the essence of the problem is that users of improved seeds and users of farmers' seeds are not the same with respect to variables that are relegated to the error term. Given that gross margins for users of improved and farmers' seeds are observed conditional on different unobservable factors, there will be a self-selectivity problem in the observed data (Huang *et al.*, 1991). Both facets of the selection problem will result in biased OLS estimates.

Disregarding self-selection, a gross margin per hectare equation that takes into account the value of using improved seeds could be set using the equation:

$$GM_i = \beta^{'} x_i + \delta IV_i + \varepsilon_i \qquad \textbf{(3.1)}$$

where GM_i is the gross margin for the i^{th} farmer; x_i's are the independent variables; and IV_i is a dummy variable indicating whether or not the farmer has used improved seeds. This simple OLS regression is implying that the two groups of farmers have the same potential to earn gross margin irrespective of their seed choice. However, the coefficient δ does not measure the value of improved seeds if the typical farmer who chooses to use improved seeds would have relatively high gross margin irrespective of the type of seed used (Greene, 2000). Of course, OLS estimate of δ will over-estimate or under-estimate the impact depending on the nature (positive or negative) of self-selection. Thus, the simple gross margin difference is not the result only of use of improved seeds; there are also other household and environment-related factors that affect the financial benefits of the seeds which are not randomly distributed among users of improved and farmers' seeds.

Having justified the non-plausibility of the OLS regression (given by equation 2.1), the other option one can think of is to estimate separate OLS equations for each group. Splitting the data-set into two, a Chow test was run to test whether coefficients differ across by type of seed use status. The test rejects the hypothesis that the two regressions are the same. The equations differ not only in the constant but also in each coefficient. This approach, therefore, does not solve the problem either.
As a result of this problem, this paper has opted for a regression approach that differentiates each coefficient for the two groups. Sections 3.2 and 3.3 below present the econometric methods of data analysis that address the selection problem.

3.2 Homogenous treatment effects models

To see the extent to which the results are sensitive to the choice of the method, the paper uses a variety of econometric methods to estimate average foregone financial benefits in terms of gross margin.

3.2.1 Matching

Matching is an evaluation method based on the intuitively appealing idea of contrasting the outcomes of users of improved seeds (denoted y_{1i}) with the outcomes of 'comparable' users of farmers' seeds (denoted y_{0i}). Using logit or probit models in the first step, matching uses the predicted value of the first step estimation for finding a counterpart for each farmer using improved seeds from among those farmers using local seeds (Rosenbaum and Rubin, 1983). It homogenizes the two groups so that the differences ($\Delta = y_{1i} - y_{0i}$) in outcomes between the two groups can be attributed to use of improved seeds. In this sense, matching is addressing selection on the observables because it matches each user with a corresponding non-user (using the observable regressors) in such a way that each pair is made the same except by the type of seed used.

3.2.2 Instrumental variable and treatment regression models

Unlike the instrumental variable regression which estimates linear probability model in the first stage (Baltagi, 1999), the treatment regression considers the dummy for the use of improved seeds (z_j) as dichotomous by fitting a probit equation model. The reason to use treatment regression is the belief that the random shocks which affect a farmer's gross margin also affect whether or not that farmer uses improved seeds. Before running these 2-stage regression methods, the endogeneity of one suspected variable, namely, '*impexep*' (experience in growing improved seeds) has been tested. It is found that endogeneity does not exist for this variable.

3.3 Switching regression model

All the above methods generate an average figure for the financial net-benefit foregone. The more interesting question could be: 'Who foregoes higher financial net-benefit and who pays lower?' 'Why?'or 'What factors determine the size of the benefit foregone?' Addressing these questions requires estimating gross margin equations for both groups of farmers in such a way that the coefficients can be compared and self-selection can be addressed.

If the use of improved seeds does have not only an intercept effect but also a slope effect (*i.e.* the coefficients differ according to seed use status as well), then a switching regression model is the appropriate model to use (Goldfeld and Quandt, 1973; Quandt, 1988). More over, a switching regression model can correct the possible selection bais problem (Freeman *et. al*, 1998). Thus, the switching regression model has been used for the compelling reason that the impact does not just show-up as an intercept effect *per se*. This model allows full set of interactions between seed use status and the *x*'s.

One of the potential uses of switching regression models is to evaluate the benefits of social programs (Maddala, 1983). In the context of Ethiopian agriculture, this model has, among others, been used by Beyene and others (2000) to study the impact of agricultural extension on farm productivity.

Let us consider the usual linear regression problem:

$$y_i = x_i \beta_i + e_i \qquad \textbf{(3.2)}$$

Taking this basic equation, we can split it into two regimes and the gross margins generated by the two regimes can be given as (Maddala, 1983):

$$y_{1i} = \sum_{j=1}^{k} \beta_{1j} X_{ji} + u_{1i} \quad \text{(Regime 1)} \tag{3.3}$$

$$y_{0i} = \sum_{j=1}^{k} \beta_{0j} X_{ji} + u_{0i} \quad \text{(Regime 0)} \tag{3.4}$$

$$C^{*} = \gamma_j Z_{ji} + u_i \tag{3.5}$$

where the errors, u_{1i} and u_{0i}, are assumed to be distributed normally and independently, with mean zero and constant variance, σ^2. The γ_j's are unknown coefficients to be estimated and Z_{ji}'s determine in which regime the i^{th} observation is generated. The X_{ji}'s refer to the explanatory variables described in Table 1. C^* is the criterion or choice function that itself is explained and it determines the regime (Quandt, 1988) *i.e.* regime 1 holds when C = 1 and regime 0 holds when C = 0. The size and sign of the gross margin difference in the two regimes ($\hat{y}_{1i}$ - $\hat{y}_{0i}$) is the indicator for the financial net-benefit foregone *i.e.*

$$GM_{foregone} = \underbrace{E(y_{1i}|C_i = 1)}_{\text{Users of improved seeds GM}} - \underbrace{E(y_{0i} \mid C_i = 1)}_{\text{Users of local seeds GM had they been like users of improved seeds}} \tag{3.6}$$

If gross margin foregone is zero, users of traditional seeds have nothing to regret as far as income is concerned. Positive and negative values indicate the gross margin foregone for non-use and use of improved seeds, respectively.

4. Data generation and description

4.1 Data generation process

Wheat is taken as an example considering its national importance. It is one of the most important crops for Ethiopia ranking fourth in total crop area and production (Gavian and Gemechu, 1996). The country is the largest wheat producer in Sub-Saharan Africa second only to South Africa.

The data are extracted from the fifth round of the 1999/2000 Ethiopian rural household survey data collected by the Economics Department, Addis Ababa University (AAU) in collaboration with the USAID. The data come from 1681 farm households of four large regions in the country (Oromiya – 625 households, Amhara – 466 households, SNNP[5]- 440 households, and Tigrai – 150 households).

[5] Southern Nations, Nationalities, and Peoples Regional State.

From among the 671 plots only 634 of them which were not inter-cropped are considered so as not to mix gross margins of other crops with wheat. Part of the data that deal with 402 wheat-growing farmers (352 users of farmers' seeds and 50 users of improved seeds) have been extracted. Even though the analysis is only for wheat, these farmers are growing other crops too. The 50 farmers are exclusively using improved wheat varieties.

Naturally, computing gross margins is a partial cost-benefit analysis exercise since it considers only variable costs in the calculation. However, complete valuation of costs and benefits is neither desirable nor relevant for the purpose at hand as long as inputs statistically different between users and non-users are valued and computed *i.e.* if a given variable input is of equal size for users of improved and local seeds, its impact on the foregone gross margin will cancel out. The cost of land is disregarded since the gross margins are on per hectare basis.

To compute the gross margin per hectare for each household, the costs of fertilizer (DAP and UREA), labor, seeds (improved and local), and herbicides have been subtracted from gross value of wheat. The value of non-marketed wheat (stored and consumed) has been imputed using the prevailing market price at the time of the interview.

Input and output prices are the other most important factors affecting the foregone financial net-benefits. To study the effect of prices on the gross margin foregone, input and output price indices are computed. Output price indices are computed as the ratio of the price of output that the i^{th} household faces to the overall average price. To construct the input price index, for *n* inputs used in producing wheat, the weighted input price index is computed in two steps. First, the individual input price indices (ψ_{ij}) are computed for each household using the same procedure as output price indices. Following that, the ratios of the i^{th} input cost to total cost (η_{ij}) are computed for each household to be used as weights in the input price index computation. For each household, the ratio tells the contribution of the i^{th} input in the total cost structure of the household to produce wheat. Thus, the input price indices (κ_{ij}) will be:

$$\kappa_{ij} = \sum_{i=1}^{n} \psi_{ij} \eta_{ij} \tag{4.1}$$

where *j* indexes inputs and *i* indexes households.

4.2 Data description

The following table reports descriptive statistics for the variables used latter in the regression.

The variables *Age*, *Schooling*, *Exteexpr*, *RFdistri*, *Whetinde*, *Sold*, and *Inpuindx* are household level variables which hold for all plots. The rest are plot level variables which hold for wheat. The response variable in the two regimes, *Gmperha*, is the wheat gross margin per hectare for users of improved wheat seeds (regime 1) and users of local seeds (Regime 0). It is on per hectare basis and most of the explanatory variables are on per hectare basis. That is why land size is not part of the regressors. Plot quality and rainfall distribution are meant to capture agro-ecological differences across farmers.

Table 1: Descriptive statistics of the variables used in the regression

Variable	Description	Mean (SD) – users of improved seeds (50)	Mean (SD) – users of farmers' seeds (352)
Age[6]	Age of the HH head (Years)	44.84 (11.9)	51.21 (15.6)
Schooling	The highest grade the farmer has achieved at the time of the interview	2.14 (1.4)	1.78 (1.2)
Exteexpr	Experience in the extension package (years)	1.5 (1.9)	0.30 (1.1)
RFdistri	Rainfall distribution (1 – bad, 2- medium, 3-good)	2.2 (0.6)	1.85 (0.6)
Plotqulx	Plot quality (3 – good, 2- medium, 1- bad)	2.42 (0.7)	2.51 (0.6)
Chemical	1 if chemical is used and 0 other wise (dummy)	0.48 (0.5)	0.42 (0.5)
Fertph	Fertilizer on the wheat plot hectare (quintals per hectare)	1.41 (0.8)	0.83 (0.7)
Oxenph	Number of oxen per hectare of land holding	4.76 (5.2)	5.11 (5.03)
Whetinde	Wheat price index	1.01 (0.2)	0.99 (0.3)
Sold	1 if wheat is sold and 0 otherwise (dummy)	0.58 (0.5)	0.39 (0.5)
Laborph	Labor used on the wheat plot (Man-days per hectare)	192.88 (249.6)	81.07 (77.2)
Inpuindx	Input price index	0.97 (0.1)	1.02 (0.2)
Gmperha	Gross margin per hectare	1731.1 (1280.4)	1015.7 (1119.3)

[6] Experience in using improved varieties, instead of age, can better capture the difference but there was no information on this variable.

Source: Computed based on the fifth round of the Ethiopian rural household survey data, AAU / USAID

All the farmers included in the econometric analysis have a single plot allocated for wheat on which either local or improved seeds are grown. There were three farmers with multiple wheat plots but only the larger plot and its quality are considered to simplify the analysis. The results reported in Table 4 are, therefore, for 402 farmers / plots. Farmers are classified into users and non-users at the farm / farmer level, not at the district level.

5. Econometric results and discussions

5.1 Estimates of foregone financial net-benefits

The table below shows the average financial net-benefit foregone for wheat which is generated from different homogeneous treatment statistical procedures discussed in Section 3.2.

Table 2: Average gross-margin foregone for not using improved seeds

Method	Gross margin foregone in Birr per hectare
Matching	276.5
Treatment regression	687.02
Instrumental variable regression	885.9
Over-all mean difference[1]	715.4
Mean difference[2]	299
Simple OLS[3]	435.4

Source: See Table 1

Notes: [1]This mean difference is the average difference based on the gross margin figures reported in Table 1.

[2]In this case, we are only considering users of farmers' and improved seeds (different farmers) on plots of the same quality.

[3]We are considering seed use as an exogenous variable.

Obviously, the simpler methods (over-all mean difference, mean difference and simple OLS) do not solve the basic econometric problems like endogeniety and self-selection. The purpose of reporting all of them is to show the extent to which the results are sensitive to the violation of the different econometric problems. All the results of Table 2 assume that improved variety use has only intercept effect.

All in all, the data show that users of improved seeds are applying inputs (such as fertilizer and labor) more intensively than the users of farmers' seeds. Depending on the method of analysis used, the average financial benefit foregone for not using improved seeds of wheat ranges from 277 to 886 Birr per hectare. On average, the results imply that improved seeds are financially viable and failure to use them involves foregoing financial benefits. This is in line with a study in West Shewa which has shown significant improvement in farm level maize productivity and profitability among the extension package participants as compared to non-participants (Beyene *et al.*, 2000). According to Negussie and Mulat (2003), improved seeds had significant impact on farm productivity. However, all previous studies do not confirm positive impacts. For instance, according to Mulat and Bekele (2003), the contribution of extension to yield is not significant.

To explore implications of the results reported above at the national level, the national level estimates of land use for wheat production are used. For instance, according to FDRE (2003), for the 2001/02 cropping season, wheat was planted on about 1.1 million hectares of land. Of this, only 1.99 percent of the land was planted with improved seeds. Using these estimates, the total gross margin the country has foregone as a result of not using improved seeds of wheat can be estimated to range from 295.3 million Birr to 946.2 million Birr per year7. If improved seeds are subsidized, the financial benefit foregone will be lower by the size of the subsidy.

Even though improved seeds are financially better than the farmers' seeds, all users of improved seeds are not equally enjoying the benefits of improved seeds and neither are all non-users foregoing equal financial net-benefit. There are users of farmers' seeds who have earned a gross margin greater than the average of the users of improved seeds. Failure to use improved seeds does not always involve foregoing financial benefits. Neither does loss in gross margin using farmers' seeds mean that higher financial benefits are sacrificed. According to the data, from 50 users of improved seeds, 12 have negative gross margins. Out of the 352 users of farmers' seeds, 131 farmers have attained gross margins greater than the average of the users. Computing the foregone financial net-benefit for farmers of nine Districts reveals some important results on how the benefits foregone and the gross margins vary across localities.

Based on the above simple descriptive results, four groups of localities can be identified. First, there are Districts earning negative gross margin and foregoing higher financial benefit (eg. Koro Degaga). It implies that had they used improved seeds, they would have either lost less or they would have attained a positive gross margin. These are the Districts for which using improved seeds could make a big difference. Second, there are Districts enjoying positive gross margin and foregoing lower to higher financial benefits (eg. Shashemene and Haressaw). These are the localities for which targeting for better adoption of improved seeds is essential depending on the magnitude of the foregone net-benefit. Third, there are Districts

[7] All the potential financial benefit of the improved seeds could not be realized due to capacity limitations and non-suitability of all plots and farming systems to improved seeds.

getting positive gross margin with no foregone net-benefit involved because, on average, the gross margins of the non-users was higher than the users (eg. Yetmen). These farmers were getting the best result from the farmers' seeds and there is no regret for failure of extension to introduce improved seeds. Fourth, there can be Districts earning negative gross margin with no benefits foregone. This is possible because if these farmers were to use the improved seeds, they would still have lost even more as the investment made on the complementary inputs will be lost.

The results are by and large context-specific. Lower average gross margin from the farmers' seeds (in Haressaw, Durame Azedebos, and Shumsha Lalibela Districts) was associated with higher foregone financial benefit. Higher gross margin from the farmers' seeds (in Debre Berhan, Debre Zeit, Shashemene and Eteya) was associated with lower foregone financial benefit. All in all, these results imply that using improved seeds is not a *panacea* for all farmers.

Table 3: The estimated foregone financial benefits and the average gross margins across Districts

District	Number of wheat plots	Average gross margin foregone (Birr)	Average gross margin per hectare for non-users (Birr)
Debre Berhan	158	217.41	914.59
Eteya	117	197.00	934.99
Shashemene	82	120.16	1011.84
Debrezeit	77	152.53	979.47
Haressaw	31	1052.72	79.28
Koro Degaga	22	1248.31	-116.31
Yetmen	19	-1226.26	2358.26
Durame	15	812.93	319.07
Adele Tike	11	1028.83	103.17

Source: See table 1.

5.1 Factors influencing magnitudes of foregone financial net-benefits

The computations made above reveal that the financial net-benefits foregone vary across farmers and farming systems. The regression analysis that follows explains this variation for wheat.

If any of the variables is insignificant in both regimes (like *Oxenph* and *Fertph*), it is not relevant to explain the foregone gross margin. If it is not significant in either of the regimes, it takes a value zero in the regime where it is insignificant. If the coefficients of a given regressor are significant in both regimes, they are compared in the two regimes to decide its impact on the gross margin foregone (Regime 1 minus Regime 0). The gross margin difference between the users of improved and local seeds is our definition of the foregone gross margin. Hence, if the coefficient in Regime 1 less the corresponding coefficient in Regime 0 is positive (negative), that particular coefficient is affecting the gross margin foregone positively (negatively).

According to the results above, labor use per hectare, fertilizer use per hectare, farmers' experience with the extension package, quantity of wheat sold, rainfall suitability, and wheat price index are the most important factors increasing the foregone gross margin. On the contrary, age of the household head, education level of the household head, land quality, input price index, oxen ownership per hectare of land holding, and chemical use on the plot are found to have the opposite effect.

Table 4: Full information maximum likelihood estimates of a switching regression model

Variable	Coefficient	Variable	Coefficient
Regime 1 – Users of improved seeds		**Regime 0 – Users of farmers' seeds**	
Constant	-770.7 (-1.3)	Constant	-699.6 (-0.42)
LABORPH	1.3*** (2.6)	LABORPH	-1.2 (-0.98)
AGE	1.4 (0.3)	AGE	30.6** (2.20)
SOLD	1048.7*** (7.6)	SOLD	297.9 (0.75)
EXTEEXPR	112.0*** (2.8)		
INPUINDX	-847.8** (-2.2)	INPUINDX	588.3 (0.46)
SCHOLING	248.7*** (4.7)	SCOLDUMY	260.0** (2.00)
PLOTQULX	-110.5 (-1.1)	PLOTQULX	398.2** (1.98)
RFDISTRI	194.5** (1.9)	RFDISTRI	-368.1 (-1.56)
OXENPH	.983 (0.08)	OXENPH	41.9 (1.11)
WHETINDE	1727.6*** (8.9)	WHETINDE	1341.9* (1.66)
CHEMICAL	-124.9 (-0.9)	CHEMICAL	368.6 (0.97)
FERTPH	-71.8 (-1.00)	FERTPH	-518.2*** (-2.6)
Sigma(1)	971.9 (26.9)	Sigma(0)	1272.4 (7.8)
Dependent variable GMPERHA Number of observations 402			
The sample separation variable is use of improved variety (DUMMY)			

Source: See Table 1.
Notes: ***-Significant at 1%; **- Significant at 5%; and *- Significant at 10%. Values in parentheses are the ratio of the coefficient to the estimated asymptotic standard error. The coefficient for *Exteexpr* in Regime 0 is missing due to lack of enough observation on users of local seeds with some experience in using agricultural extension service.

Fertilizer and labor use per hectare increase the opportunity cost of not using improved seeds of wheat implying that farmers who can apply these inputs easily have comparative advantage to use improved seeds more productively. Farmers' decision to use fertilizer more intensively with improved seeds (while 94% of the users of improved seeds are applying fertilizer, 76% of the users of farmers' seeds are applying fertilizer) is, therefore, rational. Farmers having better experience with the improved seeds and those who are marketing their produce get better benefit from the improved seeds. When the rainfall and output prices are more favorable, the improved seeds have better comparative advantage.

Education and age of the household head reduce the financial benefit foregone enabling the users of farmers' seeds earn better gross margin. When schooling by the household head increases, the foregone net-return decreases because those who are better educated can produce more from farmers' seeds compared to the average user. Therefore, other factors held constant, better education can reduce the benefit foregone enabling local seed users to benefit more. The effect of plot quality on the net-benefit foregone is also negative implying that better quality plots can reduce the gross margin difference and make the farmers' seeds more advantageous. Oxen ownership also reduces the gross margin difference implying that farmers' capacity to undertake agricultural practices on time enables them to reduce the foregone gross margin.

The negative impact of input prices on gross margin is more pronounced for farmers growing improved seeds reflecting their capital intensity. Better output prices increase the benefit foregone because better prices benefit more the users of improved seeds as the wealthy farmers (who are able to store and sell when prices are better) are the ones predominantly using the improved seeds. The result of a previous study in Arsi Zone has indicated that the greatest improvement in the returns to the higher yielding packages came from increases in grain prices, not from decreases in input prices (Gavian and Gemechu, 1996). Given that wheat is relatively a rich man's crop, the prospect for getting a better price is very high if farmers can postpone selling their products right after harvest.

The benefit foregone is a negative function of favorable natural factors like rainfall. Accordingly, if the rainfall distribution suits the production season, farmers who are planting their seeds are foregoing less financial benefits.

6. Conclusions and implications for agricultural extension

Before taking up the conclusions derived from the results, some cautionary notes and directions for further research are in order. One of the shortcomings is that improved seeds and farmers' seeds are grouped into two as if all seeds in each group are synonymous. Because the data used in this paper do not capture input-output information based on type of seed used, seed-based analysis is not pursued.

Secondly, it has to be noted that achieving higher gross margin is not the only reason for which improved seeds are developed. Wheat breeders have had goals far wider than direct net return increases (Brennan, 1984). Food taste, early maturity, feed value, and tolerance to environmental stress are other traits often targeted. Despite their importance, these attributes are not considered due, simply, to the difficulties involved in their valuation which will take the paper beyond its scope. The third problem that forces us to cautiously interpret the results is that non-users of improved seeds are over-represented in the sample used for this analysis. Last but not least, the data are of cross-section nature representing only the 1999 / 2000 cropping season.

6.1 Conclusions

In recent times, the Ethiopian government is trying to address problems of low agricultural productivity, poverty, and resource degradation through technology-driven agricultural extension programs. However, before scaling up the dissemination of agricultural technologies to wider areas, evaluating their financial, technical and economic viability can't be over-emphasized. To contribute to this daunting task and draw policy lessons for agricultural extension, this paper has empirically examined the financial net-benefit foregone when farmers fail to use improved seeds of wheat. Having this motivation, the paper has generated information on the financial benefit that wheat growing farmers forego if they fail to use improved seeds.

Based on the descriptive results, four groups of farmers have been identified. First, there are Districts earning negative gross margin and foregoing higher financial benefit. Had these farmers used improved seeds, they would have either lost less or they would have attained a positive gross margin. These are the localities for which adoption of improved seeds could make a big difference. Second, there are Districts enjoying positive gross margin and foregoing lower to higher financial benefits. These are the localities for which targeting for better adoption of improved seeds is essential depending on the magnitude of the foregone net-benefit. Third, there are Districts getting positive gross margin with no foregone net-benefit involved because, on average, the gross margins of the non-users were higher than of the users. These farmers were getting the best result from the farmers' seeds and there is no regret for failure of extension to introduce improved seeds. Finally, there can be Districts earning negative gross margin with no benefits foregone.

Depending on the method of analysis used, the average financial benefit foregone for not using improved seeds of wheat ranges from 277 to 886 Birr per hectare. Despite the variations across farmers and farming systems, the results imply that, on the whole, improved seeds are financially viable and failure to use them involves foregoing financial benefits. However, the results have also shown that higher average gross margin from the farmers' seeds does not necessarily mean that there is no foregone net-benefit. Neither does loss in gross margin from the farmers' seeds necessarily mean absence of foregone financial benefit.

The estimates suggest that all users are not equally enjoying the benefits of improved varieties and neither are all non-users foregoing equal gross margins. Using the estimates of foregone gross margin and the 2001/02 cropping season CSA statistics, it has been shown that the total gross margin the country has foregone as a result of not using improved seeds of wheat ranges from 295.3 million to 946.2 million Birr per year. If improved seeds have been subsidized, the financial benefit foregone will be far lower.

The regression results show that labour use per hectare, fertilizer use per hectare, farmers' experience with the extension package, quantity of wheat sold, rainfall suitability, and wheat price index are the most important factors increasing the foregone gross margin. On the contrary, age of the household head, education level of the household head, land quality, input price index, oxen ownership per hectare of land holding, and chemical use on the plot decrease the foregone gross margin.

Farmers who can apply labor, and oxen easily have better benefited from the use of improved seeds. Improved seeds have better comparative advantage if farmers can sell their products. The results show that farmers' seeds have better comparative advantages with better quality plots. Better educated farmers do not necessarily have comparative advantage in using improved seeds. Similarly, when schooling by the household head increases, the net-return foregone decreases.

6.2 Implications for agricultural extension

The current agricultural extension system in Ethiopia is criticised from various angles. Here, the paper would like to list the most relevant ones for this paper and show how the results can help address them. It is technology-driven failing to account for agro-ecological, cultural, and socioeconomic diversity of farmers' working environment. The existing extension disregards the potentials and comparative advantages of each farming system. Its criterion of success is the number of farmers involved in the program, not the impact of extension on farmers' productivity and incomes. It never asks the question 'What do farmers lose if they fail to take part in the extension package?' It focuses on activities rather than on outcomes. Extension is mainly catering the needs of the better-off and more commercialized farmers[8].

8 More details on the features, challenges, and impacts of Ethiopia's agricultural extension can be found in a recent publication by the Ethiopian Economic Association (EEA/EEPRI, 2006).

The results of the paper re-enforce the need for revisiting the extension program and highlight the directions for improvement to address the preceding shortcomings. The results have shown that availability of improved seeds alone is not enough to make these technologies profitable. Agricultural development is not just a question of disseminating improved seeds. It needs market development and ensuring the availability of other complementary inputs that improve the comparative advantage of using improved seeds.

The results imply that improved seeds have comparative advantage when accompanied by other complementary services such as irrigation, credit, input supply, market and storage infrastructure. If they have to be productively and profitably used, government has to, therefore, invest on those services. So far, Ethiopian smallholders have not been able to fully benefit from modern technologies such as improved seeds due, mainly, to lack of other complementary services. For instance, unless farmers get better prices for their produce, they will be using more inputs, incurring more costs, producing more, selling at low price, and losing more. This is especially the case when there is drought and natural disaster during which there will be recurrent food insecurity and hunger.

Mostly, it is argued that as long as the subsistence farmers have no opportunity to get hold of improved seeds, they do not face opportunity costs. But access factors are just policy variables that can be improved to realize the comparative advantage. Moreover, from income distribution point of view, the first argument will impoverish the poor and marginalize them. As a result, Lipton and Longhurst's (1989) story of new seeds and poor people will prevail. Once access-related policy variables are dealt with, recommendation of improved seeds should be made based on their comparative advantage considering the prevalence of variables promoting the comparative advantage. Targeting principles should be established based on the comparative advantage of the respective seeds.

Hence, blanket recommendation of improved seeds for all farmers and farming systems across the board is a waste of resources because in some farmers' working environment the local seeds may even work better. In some farmers' working environment, the farmers' seeds can even perform better. Identification of farming systems and farm households for targeted technology adoption optimizes the benefits of using both sets of seeds. All the results re-enforce the need for targeted intervention to improve the benefits from improved seeds. Adoption of improved seeds is not some thing that policy makers can favor for all farmers and farming systems across the board. It all depends on which technology can work better under which conditions.

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