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Abrar Suleiman

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A Profit Function Analysis

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Department of Economics
University of Sheffield
9 Mappin Street
Sheffield
S1 4DT
United Kingdom
www.shef.ac.uk/economics

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Abrar Suleiman

Department of Economics, University of Sheffield

9 Mappin Street, Sheffield, S1 4DT

email: a.suleiman@sheffield.ac.uk

Summary

Empirical studies on gender and agricultural productivity are typically based on production function estimates of a single crop or aggregate output, ignoring the role of prices and endogeneity of input choice. We apply the profit function approach to farm-level data from Ethiopia to compare supply response between male and female farmers, incorporating the full range of crops and prices and non-price incentives. Gender-differential in labor productivity is accounted for by including separate variables for adult male and female labor as well as child labor. We find that women respond to price incentives as strongly as men farmers do, but responsiveness largely depends on the type of crops and the relative importance of binding constraints. In contrast to price responses, differences in the non-price effects are not qualitatively different between the two groups, with location-specific factors soliciting significantly larger share of output response than household-specific factors. The data shows that female-headed farmers are more likely to be asset-poor subsistence farmers living in climatically less favored areas; consequently, constrained by limited access to better quality land, male labor and animal traction to diversify into high-yielding fertilizer-intensive food crops. Gender-targeted interventions that explicitly address low endowment of capital by women are likely to pay-off, as well as technologies that improve the productivity of land and labor. Well-integrated pro-poor policies that facilitate access to basic physical capital and credit are equally important. Our findings suggest that broad-based price and fertilizer policies are unlikely to be optimal, as they do not target the prevailing crop and agro-climatic mixes. Broad-based infrastructure and market access policies, on the other hand, are more likely to benefit all farmers.

JEL classification: O13, Q11, Q12, Q18.

Keywords: Supply Response, Gender, Agriculture, Ethiopia.

1 Introduction

There is a growing mass of evidence documenting the key role played by women in agricultural production (e.g., Boserup, 1970), identifying gender-specific constraints that might result in lower productivity (e.g., Udry, 1996). Women's role in African agriculture ranges from providing a significant share of labor for food as well as cash crop production (e.g., Aredo, 1992) to managing their own field (e.g., Saito *et al*, 1992). As heads of households, women directly participate in agricultural products and inputs markets and make household level decisions about how to respond to changes in price and non-prices incentives they face.

Empirical studies on gender and agricultural productivity are typically based on production function estimates of a single crop or aggregate output, ignoring the role of prices as well as endogeneity of input choice (see, Quisumbing, 1996). The dual approach would be preferred because it gives more flexibility in modeling multiple output and input situations, while at the same time enabling the researcher to distinguish productivity differences due to differences in access or input choice. It also allows to identify both intra-household differences in the productivity of labor and gender-based extra-household (price and non-price) constraints. We simultaneously address these two related issues by applying the profit function approach to farm-level data from Ethiopia.

The gender implications of economic reforms have been increasingly recognized. There is a growing concern that the emphasis of adjustment policies on export-led growth and producer prices of cash crops, at the expense of food crops, might deteriorate the position of women relative to men (Warner and Campbell, 2000). More concretely, conventional adjustment programs are criticised for not adequately addressing the specificity of women's contribution and the physical and institutional constraints they face (Evers and Waters, 2000). On the other hand, studies on gender and agricultural supply response in Sub-Saharan Africa typically assume that women do not participate on the sale of cash crops (e.g., Darity, 1995). The validity of these assumptions depends, among other things, on the farming system (Evers and Waters, 2000), calling for a detailed analysis of women's circumstances in specific countries. The aim of this paper is to fill this gap for Ethiopia.

In the 1990s, the Ethiopian government has introduced a package of structural reform measures mainly consisting of: a) deregulation and liberalization of grain markets; b) devaluation and price support for export crops, particularly coffee; and c) broad-based fertilizer-led extension program. A key objective of the reforms is to increase supply response and productivity of smallholder sector, thereby achieving the dual goals of food self-sufficiency and poverty reduction. Unlike the common practice in West Africa, control and management of resources in Ethiopia is frequently centralized by the head of the household. All plots are managed and cultivated jointly, making it difficult to isolate intra-household gender differentials in farm management and decision-making.[1] Traditionally, wives are responsible for decisions regarding consumption, while husbands often make production and marketing decisions.

The main objective of this paper is to assess the extent of gender-linked differential in supply response in Ethiopia and identify extra-household factors that may constrain the supply response of women farmers. Using farm-level panel data in 1994-2000, we estimate two systems of output supply and input demand equations (for female-headed and male-headed households), incorporating the full range of crops and prices and non-price factors. The literature suggests that men's labor and women's labor are not perfect substitutes (e.g., Jacoby, 1992). Hence, we account for the gender division of labor by including separate variables for adult female, adult male and child labor. The major finding is that female-headed farmers respond to prices as strongly as male-headed farmers, but this responsiveness varies according to the type of crops and the relative importance of the binding constraints.

[1] However, the extent of women's contribution to farm decisions varies according to the type of crop and farming system. Women usually make independent decisions on the production, management and disposal of some minor cash crops like vegetables. This is particularly the case for *enset* in South Ethiopia, where

2 Data and variables

The data we use is the Ethiopian Rural Household Survey (ERHS), a nation-wide panel data of rural households conducted in five waves during 1994-2000. The survey was undertaken in 18 villages across the country from which nearly 1500 households were selected randomly. The villages were deliberately selected to account for the diversity of agro-climatic and farming systems in the country, and the two major farming systems and technologies (grain-plough and *enset*[2]-hoe systems) are fairly represented. For this study, we use data from the four waves (1994, 1995, 1997 and 2000) and consider 953 farmers (717 male-headed and 236 female-headed) from 13 villages of the grain-plough mixed farming system. Summary statistics on production, input use and prices are given in Tables A1 and A2.

2.1 Definition of Variables

The output data mainly consists of quantities produced (in kilograms) and prices (in *Birr*) of five major cereals - *teff*, wheat, barley, maize and sorghum. An aggregate of perennial cash crops, largely composed of sugar cane and *gesho*, but also some coffee and *chat*, labeled as 'tree crops', is added for male-headed group.[3] An additional output variable is formed as 'other crops' for both groups. This is an aggregate of three minor cash crop categories - legumes, root crops and vegetables.[4] We used current prices collected from the nearest market of each village by an independent price survey in each wave. For crop aggregates, 'other crops' and 'tree crops', an implicit quantity index was calculated by dividing total value of output by the Laspeyer price index.

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women are not only exclusively responsible for its production and harvest, but have a high level of discretion over its disposal.

[2] *Enset* is a perennial and major staple for an estimated 15-20 percent of the population, mostly in South.

[3] *Teff* is a cereal unique to Ethiopia, a non-exportable cash crop that is most popular staple in urban Ethiopia. There are two types of this cereal, inferior quality black and mixed (coarse) and the best quality white *teff*. *Chat* is a perennial cash crop and a mild stimulant which is widely used in the Southern and Eastern parts of the Ethiopia, as well as Eastern Africa and some parts of Arabia. It is rapidly emerging as an export crop. *Gesho* is also a perennial domestic cash crop used to make Ethiopia's traditional and most popular liquor, *tej*. *Birr* is Ethiopian currency.

[4] The number of crops, relative importance and composition of these crops, however, vary not only across regions but also across gender. Legumes (notably beans and linseed) and vegetables (notably onions) dominate the basket in the North, root crops (notably potato) in Central. The data shows that female-headed households in the North grow only a few of the small-scale, garden-type crops like vegetables, but male-headed households larger numbers of the high-value crops like pulses and oilseeds.

The input data consists of two variable inputs, chemical fertilizer (in kilograms) and labor (person-days), and four quasi-fixed inputs, area cultivated (in hectares), family labor (number of family members), animal traction (number of oxen) and farm capital (cost of hoe and plough). Traditional (exchange)[5] and hired labor are modeled as variable inputs, while family labor is treated as fixed in the short run. Gender-differential in labor productivity is accounted for by including separate variables for the number of adult male and female labor as well as child labor engaged in farm activities. Land is adjusted for quality using an index of the quality of cultivated land (1 being worst, 2 mediocre and 3 best).[6] The wage rate per person-day is calculated from the wage bill of hired labor. The price of fertilizer is calculated by dividing total expenditure on the amount applied.[7]

We include four ‘exogenous’ controls - extension services (hours of visit), land access, market access, and rainfall. A proxy for access to land is measured by the share of the harvest paid in the form of rent for land.[8] Infrastructure (and/or market access) is measured by dividing the total population of the nearest town (or big market) to the road distance between the town and the village. The rainfall variable is measured by multiplying the amount of rain (in millimeters) by the dummy for rain included in the questionnaire, in which the farmer is asked if rain was enough or on time. This way of measuring rainfall helps to capture the seasonal and/or temporal variation of rain, as well as the amount, which is typically important.

2.2 Production Pattern and Access to Inputs

On average, male-headed households inter-crop more crops and cultivate more and larger plots of similar quality than female-headed households (Table A2). Average land holding is 1.58 hectares for female-headed compared to 2.48 for male-headed group. However, significantly better quality of land is cultivated by male-headed group for all crops but

[5] Exchange labor is adjusted for quality using average product as a weight. The implicit assumption is that hired labor is more productive than share and family labor, an assumption justified by the data.
[6] We combined the two indices of land quality given in the data (one for fertility and another for steep-ness) into one index using total area cultivated as a weight.
[7] For those farmers (villages) with no hired labor, we imputed the wage rate from the off-farm income of farm-related employment. For those farmers who do not report use of purchased fertilizer, the mean of those who applied (in the same village) is used (to impute the cost of non-purchased fertilizer usage).

barley, for which land quality is better for female-headed (Table A1). Also, male-headed households have at least three times better access to share and rented land than female-headed households (which provide access to inputs, such as oxen and labor).

Significant differences exist in access to human capital in general (as indicated by family size, composition and education) and to labor in particular. Male heads are significantly more educated, but are of similar age as the female heads. Households with male-heads have significantly larger and more educated members who are also more experienced. Perhaps, the biggest difference in access is on the composition of the family. Female-headed households have higher number of female adults, but the difference is not significant, whereas the number of male adults and children are significantly higher for male-headed households.

The data indicate significant differences in access to animal traction, farm equipment, credit and extension, all higher for male-headed. Generally smaller number of households have access to animal traction (16.5% and 21.1% for female-headed and male-headed) and extension (8.9% and 14.5% for female-headed and male-headed), and the proportion of farmers having access to credit is not quite different (41 and 50 percent for female-headed and male-headed group). However, twice as many male-headed households have access to farm capital as female-headed farmers. The data shows no significant difference in market access, but male-headed farmers live in areas that are almost twice as rainy.

Male-headed households produce significantly higher quantities of all crops (at least twice higher except barley). Female-headed households generally cultivate smaller acreage and use significantly smaller quantities of fertilizer and labor but achieve lower yields. Female-headed households use more fertilizer and labor per hectare but the difference is not significant. Differences in yield are significant for all crops but barley and maize, for which the share of land and prices are higher for female-headed households. Despite significant differences in production and the size and quality of

[8] Land access, farm capital and animal traction may capture wealth effects, the latter capturing access to natural fertilizer as well.

acreage, the relative importance of crops is generally the same. For both groups, barley, *teff* and other crops are the leading crops in terms of production and land use, with wheat and maize (instead of barley) leading in terms of fertilizer use and intensity. Also, the share of area is significantly higher for male-headed households for *teff* and wheat, but female-headed households allocate significantly more land to barley (36%) than male-headed (22.5%). The are no significant difference in prices received by the two groups, but there are significant differences in market participation, with male-headed households twice as likely to have marketed some crop. Interestingly, female-headed households receive significantly lower prices for other crops, but higher prices for barley and sorghum.

Overall, despite similar patterns in crop-mix and input use, major differences exit between the two groups regarding factor endowment, input intensity and yield. In a widely cited study, Udry (1996) found that yields are significantly lower on plots controlled by women but attributes this to lower input intensity (particularly male labor) on female-managed plots. Therefore, yield differentials may not necessarily reflect differences in productivity between the two groups. It might as well be due to differences in access to inputs and thus the intensity with which the inputs are applied. In our case, differences in input use and yield are significantly higher for male-headed, but intensity of input use, although higher for female-headed households, is not significant.[9] Moreover, the difference in yield is apparently substantial for wheat and other crops, for which differences in the size and quality of land are the highest but differences in intensity are the smallest. On the other hand, yield difference for barley is the smallest, so are production, input use and intensity.

2.3 Plough-Based Cereal Farming in Ethiopia

The grain-plough farming system can be represented in two geo-climatic zones, Northern and Central highlands. The data indicate major differences in the production pattern between the two zones and between male-headed and female-headed farmers within a

[9] The higher intensity by women may not necessarily mean that small farmers use fertilizer more intensively. In interpreting this result, we should bear in mind the narrow range in area cultivated (see Croppenstedt *et al*, 2003). It may imply that it is the quality (not size) of land that matters more.

zone. First, production in the Central zone is more intensive, diverse and commercial. It is characterized by a higher level of output and yield, higher use of fertilizer and other inputs. It is also the more favored in terms of climate, terrain, and soil fertility. *Teff* is the major crop, accounting for about a third of production, followed by maize. Wheat, barley and sorghum are also widely produced. Other corps is major cash, but a significant amount of tree crops such as *chat*, coffee, and sugarcane is also produced.

Although average land holding in the North is higher, land quality is low, farms are typically small and fragmented and the productivity of land is very low. Barley is the leading cereal accounting for nearly 35 percent of the area cultivated and 46 percent of production. *Teff* is more important than barley in the relatively diverse and better-off villages, but barley remains the most widely grown cereal in the Northern zone. Nearly 50% of farmers in the North produce barley, compared to 32, 31, 29, and 15 percent for sorghum, wheat, *teff* and maize respectively. Other crops is major cash, and is as important as barley in terms of number of producers (about 48%).

Therefore, *teff* and barley are the most widely produced cereals in our sample of the grain-plough system. The general pattern emerging is barley and sorghum dominating production in the North, as do *teff* and maize in the Central. A disproportionately larger number of barley (70%) and sorghum (59%) producers come from the North, where as the majority of *teff* (66%) and maize (76%) producers are from the Central. There is fairly similar number of wheat farmers in each zone. A typical farmer in the Central zone grows about 4 crops; farmers in the North tend to grow fewer crops. Particularly, female-headed households in the North seldom produce *teff* and maize, and nearly all *teff* (80%) and maize (86%) producers come from the Central.

Second, within a zone, variations in cropping patterns are higher in the North.[10] The study villages in the Northern zone can be classified into either barley-wheat (6 villages and 343 farmers) and *teff*-sorghum areas (3 villages and 251 farmers). The barley-wheat areas

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[10] Note that 594 farmers are from 9 villages of the North and belong to Tigray and Amhara zones, and 359 from 4 villages of the Central zone, all in Oromia region.

are less diversified and highly subsistence, with some of the villages characterized by an extreme form of climate, frequent failure of rain, as well as chronic drought and famine. Third, female-headed farmers are more likely to live in the North (65%) than male-headed (60%), most of them in the poorer areas of the North. About 40 percent of female-headed come from the three most deprived villages (compared to only 24% of male-headed), and about 46 from barley-wheat areas (compared to 33% of male-headed).[11] Note that female-headed farmers are more likely to be land-less (46 households, or 13%) than male-headed (36 households, 3%).

Finally, regardless of where they live, female-headed farmers are generally less diversified than male-headed and tend to specialize in low-value and/or low-yielding crops. For instance, nearly 90% of female-headed households grow the (coarse) black and mixed *teff*. The data show that female-headed farmers rarely cultivate perennial cash crops (only 16 households compared to 115 male-headed). So few farmers produce these crops that we excluded tree crops from the female-headed. Also, they seem to specialize in small-scale, garden-type crops like vegetables for cash, while men produce more and higher value crops like pulses and oil seeds.

3 Modeling Supply Response

We model supply response within the framework of the profit function. Using the wage rate as a numeraire, the normalized restricted profit function (Lau, 1976) is expressed as:

$$\pi^* = \pi(\mathbf{p^*}, \mathbf{w^*}; \mathbf{z}) \tag{1}$$

where π^*, $\mathbf{p^*}$, $\mathbf{w^*}$, and $\mathbf{z}$, respectively, represent normalized restricted profit, and vectors of (normalized) m output and n input prices, and k fixed inputs and other exogenous factors. Using Hotelling's Lemma, the profit-maximizing levels of output supply and input demand functions are derived from (1), respectively, as:

$$y_i\,(\mathbf{p^*}, \mathbf{w^*}; \mathbf{z}) = \partial\pi^*(\mathbf{p^*}, \mathbf{w^*}; \mathbf{z})/\partial p^*_i,\ \forall\ i = 1, \ldots, m \tag{2}$$

[11] Female-headed households represent about 45% of the sampled farmers in Tigray, most deprived region.

and

$$-x_r\,(\mathbf{p^*}, \mathbf{w^*}; \mathbf{z}) = \partial\pi^*(\mathbf{p^*}, \mathbf{w^*}; \mathbf{z})/\partial w^*_r,\ \forall\ r = 1, \ldots, n \tag{3}$$

where r and i index outputs and variable inputs respectively (r =2 for both groups, and i =5 and 6 respectively for female-headed and male-headed households). The stochastic form of the profit function is chosen to be quadratic. We used one-year lagged prices for all outputs to represent farm-level price expectations. This has reduced the panel to three years (1995, 1997, and 2000). We have not imposed lags on fertilizer prices, because farmers know these prices only at the time of delivery. Homogeneity is imposed by dividing profit and prices by the wage rate. We have not included the profit and labor demand equations in our estimation.[12] We estimate two systems of output supply and fertilizer demand equations (for male-headed and female-headed farmers). We cannot conduct separate estimations for the Northern and Central zones due to lack of sufficient observations for female-headed group. Instead, we include a dummy to control for the geo-climatic effect. To ensure invariance to choice of the numeraire, the system is estimated using iterative Seemingly Unrelated Regression (SUR).

3.1 Accounting for Sample Selection Bias

A major problem encountered with the data is that farmers grow only a few of the crops, especially so for the female-headed group. In a few villages no one grows a particular crop. It is reasonable to expect relatively richer farmers (with better access to input) to specialize in a few (intensive but high-yielding) crops to take advantage of the potential for higher yield and commercial benefits. In our case, most of the farmers are barley and sorghum producers from the climatically less favored areas of the North where production is risky and access to inputs and markets is low. Also, low use of fertilizer is not because farmers do not find it profitable at current prices, rather because of credit and supply constraints (Croppenstedt *et al*, 2003).

[12] Estimation of the whole system of equations, including the profit functions would give more efficient estimates, but excluding the two equations will not introduce inconsistencies or biases into the parameter estimates of the remaining equations. Further, we can still obtain the parameters of the labor demand equations residually from the homogeneity and symmetry restrictions.

In this context, the dependent variables of the system of equations are censored by unobservable latent variable influencing the decision of whether or not to grow a crop or use fertilizer, rendering standard OLS or SUR estimates biased. Two types of econometric problems need to be tackled: censored dependent variable and sample selection bias. If zero values of dependent variables were the result of rational choice of farmers, a Tobit model would be more appropriate. The assumption underlying a Tobit estimation is that farmers are unconstrained which is untenable in light of the fact that fertilizer use is below the saturation point. Hence, we use the Heckman selection model to account for sample selection bias (Greene, 2000). First, the probability of participation (growing a crop or using fertilizer) is modeled by Maximum Likelihood Probit, from which crop- and input-specific inverse Mill's ratios are estimated.[13] In the second-stage, the Mill's ratios are included as right-hand variables in the corresponding output supply and fertilizer demand functions.

4 Results and Discussion

Estimated parameters from the (Selectivity-adjusted) system of output supply and fertilizer demand equations for female-headed and male-headed farmers, with symmetry imposed, are given in Tables B1 and B2 respectively. All own price coefficients have expected signs, with the exception of barley for male-headed (insignificant). The coefficient on the selectivity variable (Mill's ratio) is statistically significant for male-headed farmers in all equations but barley, and in *teff*, wheat and other crops equations for the female-headed, justifying the need to correct for sample selection. The zone dummy is significant in all equations but wheat (for male-headed) and *teff*, barley and other crops (for female-headed). Judging by the relatively large size of this coefficient, location-specific factors are likely to play a significant role in determining supply response.[14] Further, the size of the coefficient is substantially higher in the *teff* and barley equations, implying major differences in the production of these crops between the two

[13] Four village-level variables are included (representing access to market, extension and animal traction and rain and a variable indicating risk behavior) as well as variables representing household-level access to land, labor, education and age.

[14] The probit results (not reported here) also show that village-level variables are the most important determinants of fertilizer use and cropping decisions, yielding consistently higher marginal effects.

zones. What is more, zonal differences are likely to be smaller for female-headed than male-headed farmers.

4.1 Crop-Level Supply Response

Estimated elasticities of all crops and fertilizer at mean values of prices and non-price variables are presented in Tables C1 and C2 for female-headed and male-headed farmers, respectively. Also, given in these tables are implied elasticities of each crop and fertilizer to a general increase in all and/or a set of prices and non-price factors, calculated as column sums of the corresponding set of variables (Sadoulet and de Janvry, 1995).

4.1.1 Own-Price Effects

For both groups, only two crops have statistically significant response to own price, of which is sorghum has the highest elasticity for male-headed farmers, and the second highest for female-headed group. Own price elasticities of other crops (female-headed) and tree crops (male-headed) are also statistically significant. For female-headed group, other crops has the highest elasticity, 0.49, which is about two times higher than *teff* and barley. Tree crops has the second highest elasticity for male-headed group, followed by maize. Own price elasticities of other crops, barley and *teff* are higher for female-headed households, but male-headed farmers have higher elasticities for wheat, maize and sorghum. The difference is substantial for what and maize, crops with lowest elasticities for female-headed households. The highest difference is for own price elasticity of other crops, which is four times higher for female-headed households. This may be partly due to the difference in the number of crops included in this category.

Female-headed farmers generally tend to respond more to low-value and low-yield subsistence crops in which they tend to specialize, while male-headed households respond more to commercial and fertilizer intensive cereals. Output response to prices of food crops by female-headed farmers may be driven by the tendency of subsistence farmers to self-insure through higher production of food crops when prices increase (Sadoulet and de Janvry, 1995). This is particularly the case for sorghum, a crop with the lowest marketed surplus (Table A1). Note that the production and price risks are lower for black *teff*, barley and sorghum (food grains with highest elasticity for female-headed farmers). Also, female-headed farmers produce inferior quality (black and mixed) *teff*.

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4.1.2 Cross-price Effects

In the female-headed group, only two pairs of crops have significant cross-price elasticities (both involving sorghum and other crops, the two significant own price crops), compared to ten pairs in the male-headed group (half of which is positive). The highest cross-price elasticity for female-headed is 0.99 between sorghum and barley, while it is -0.75 for male-headed between maize and sorghum. The complementarity of sorghum with barley is mainly due to the fact that they are rarely produced together (56 farmers in all, and only 9 female-headed). Its substitution with maize (and *teff* for female-headed) comes from the fact that they are the major alternative staples in sorghum-producing areas. The three fertilizer-intensive cereals are mostly complements to each other, more so in the male-headed group, perhaps because of better opportunities for resource sharing, particularly fertilizer and male labor.[15] *Teff* is a weak substitutes with wheat for female-headed, while it is a complement with both wheat and maize (significant with maize) for male-headed.

For both groups, the general picture emerging is complementary *teff* and maize competing with barley and sorghum. The pure cash crops strongly compete with *teff* and wheat, but are mostly complements to sorghum and barley. In general, relationships among crops are more likely to be substitutes (but less likely to be significant) for female-headed than male-headed farmers, suggesting lower flexibility in production. This is consistent with the finding that the effect of an overall increase in prices is generally higher for male-headed than female-headed farmers (Tables C1 and C2). For female-headed group, barley seems to benefit most from an overall increase in output prices, whereas *teff*, maize and other crops actually decrease if all output prices increase. For male-headed farmers, sorghum is the crop benefiting most from such an increase in prices, followed by tree crops, largely at the expense of barley. In general, the size of the implied elasticities suggest that a concomitant increase in the production of all crops is

[15] Male-headed farmers inter-crop about twice as many crops as female-headed farmers (see Table A2).

made difficult by the severity of the binding constraints; implying little or no response of total farm output to changes in price incentives.

4.1.3 Non-Price Effects

For male-headed households, market access is the most consistently important factor (positive and significant for all crops but *teff*), followed by animal traction and land access (positive and significant for all crops but tree crops and sorghum, crops with highest elasticities for land quality exceeding one). The impact of an increase in area cultivated is strongest for sorghum, whereas other crops has the highest elasticity for animal traction and male labor and the second highest for market access. For female headed-households, land quality is consistently positive and significant, except for *teff*, which seems to benefit most from area expansion. Other crops has the highest elasticity for market access, animal traction and male labor. In general the relative contribution of non-price factors are higher for female-headed than male-headed farmers, but these elasticities are more likely to be significant for the latter. Female-headed households have higher overall non-price elasticity for all crops except sorghum. The difference in size is substantial for wheat (4.02 for female-headed as opposed to 1.83 for male-headed). Most importantly, an overall increase in private fixed inputs, particularly area cultivated and farm capital, will benefit female-headed more than male-headed farmers.

Although a varied pattern of output response to non-price factors emerges, the key binding constraints are rather similar for both groups. First, the crops that elicit the highest response to an overall increase in non-price factors are the cash crops and the fertilizer-intensive cereals. Second, private fixed inputs (excluding land variables) are more likely to be important for fertilizer intensive crops, whereas public and exogenous factors are more limiting for barley and sorghum. Third, the marginal contribution of adult male labor is found to be significantly higher than adult female and child labor, particularly for the fertilizer intensive crops, in which adult male labor seem to be associated with use of animal traction, market access and rain. Forth, land quality seems to be more important than area cultivated both in terms of statistical significance and size of the elasticities, more so for fertilizer intensive crops. Farm expansion benefits sorghum and barley more than wheat and maize, whereas the latter benefit more from increases in land quality, as well as market access and rainfall.

Finally, non-price factors elicit larger volume of output response than prices except for barley (male-headed) and sorghum (female-headed), for which price elasticities are at least as large as non-price elasticities. However, non-price elasticities are least likely to be significant for barley and sorghum. This is especially the case for female-headed farmers, where most of these elasticities are negative. Note that female labor has not only negative elasticities in most of the equation, but it is statistically insignificant, mostly in the barley and sorghum equations. Despite generally positive response of output to child labor, it is also insignificant.[16] The negative effects of labor on sorghum are mainly because additional resources are rarely allocated to this "drought-friendly" crop. This is compatible with the subsistence-oriented production of sorghum and associated low productivity of resources (particularly family labor) as a result of limited off-farm opportunities.

4.2 Response of Fertilizer Demand

In general, fertilizer use by male-headed farmers is significantly affected by fertilizer price, while output prices, particularly those of barley and sorghum, are more important determinants of fertilizer use for female-headed farmers. For female-headed farmers, the own price elasticity of fertilizer is very low and insignificant but for the male-headed farmers the negative elasticity is relatively high at 0.13 and is significant. For male-headed farmers, fertilizer use is negatively and significantly responsive to price of barley. As fertilizer is used far less intensively on barley (Table A1), this suggests substitution into barley when fertilizer prices are high. This is consistent with the finding that all fertilizer-intensive crops but *teff* have negative output elasticity with respect to fertilizer price. The negative response of fertilizer use to price of *teff* is surprising; it may reflect the low and inefficient use of fertilizer on a per hectare basis.

[16] This variable represents access to labor as well as determinants of supply decisions not accounted for by prices and other non-prices factors, but by household's subsistence needs (Savadogo *et al*, 1995).

For female-headed group, response is positive and significant to prices of barley and sorghum, and negative to wheat and maize, for which most fertilizer is applied. The significant response of fertilizer use to price of sorghum seems surprising in light of the extremely low use of fertilizer to sorghum. This might be due to the wealth effects of prices and opportunistic planting of the fertilizer-intensive crops. Note that, for female-headed farmers in the North, *teff* and wheat are opportunity crops that are produced in large quantities only when there is good rain and when fertilizer is available. They are usually produced by shifting land away from the regular crops (barley and sorghum) to which a disproportionately larger share of the land (about 50 percent) is allocated (Table A1). Lower barley and sorghum prices could result in more resources for, and higher production of, *teff* and wheat and hence higher demand for fertilizer. These farmers also appear to have severe liquidity problems and acute shortage of complementary inputs like animal traction and male labor. Hence, the wealth (income) effects of price increases would be more pronounced, as well as the scale of restructuring.

This is reinforced by the fact that farmers with better access to area cultivated, animal traction, farm capital, and male labor, as well as good rainfall, are more likely to use fertilizer for the production of maize, *teff* and wheat.[17] On the other hand, the negative response (of wheat, maize and *teff)* to price of fertilizer may be because female-headed farmers in the Central zone, producing the 'intensive' crops, will need to increase the production of these crops, largely at the expense of barley and sorghum, so as to be able to afford existing levels of fertilizer. The results imply that female-headed farmers are almost as responsive as male-headed farmers for a general increase in all output prices, but will be only slightly affected if the price of fertilizer increases as well. In contrast, for male-headed farmers, any gains from a simultaneous increase in output prices will be quickly offset by an increase in fertilizer price.

[17] Recent studies have shown that farmers growing white *teff*, wheat and maize are more likely to use improved varieties, compared to only a few farmers growing barley and sorghum (Benin, *et al*, 2003). *HYV*-rich crops are not only fertilizer-intensive, but require multiple and timely plowing prior to sowing when the rain starts.

5 Conclusions

In spite of large and growing literature on gender and agricultural production, the role of women in marketing and supply decisions is rarely addressed, partly due to the methodological limitations of the production function approach used by most studies. Using farm-level panel data from Ethiopia, we estimate two systems of output supply and input demand equations (for male-headed and female-headed farmers) to identify key extra-household factors behind gender differential in supply response. All major crops are identified and the full range of prices and non-price constraints are taken into account, as well as the gender division of labor. The major finding is that female-headed farmers respond to price incentives as strongly as male-headed farmers, but this responsiveness varies according to the type of crops and the relative importance of the binding constraints. Price responses by female-headed farmers are substantially higher for inferior cereals and minor cash crops in which they tend to specialize, while own price elasticities of fertilizer intensive crops are higher for male-headed farmers. Male-headed farmers respond significantly to own price of fertilizer, but output prices, particularly barley and sorghum, are more important determinants of fertilizer use for female-headed farmers.

There are important differences in the magnitude and significance of non-price effects, which appear to be generally more binding for female-headed households. In contrast to price effects, differences in the non-price effects are not qualitatively different between the two groups. We find that wealthier farmers, with access to better quality land, male labor and animal traction are more likely to use fertilizer. The data indicate that female-headed farmers are more likely be asset-poor subsistence farmers living in climatically less favored areas, apparently more constrained to diversify into the production of fertilizer-intensive food crops. Moreover, location-specific constraints are found to be more pressing than household-level determinants of supply response, with market access and land quality eliciting some of the highest output responses observed. Five of the seven crops in the male-headed, and three of the six crops for female-headed, respond positively and significantly to market access, with elasticities exceeding one in six cases.

The results stress the need to take into account the specificity of constraints faced by women in designing price support schemes. Gender-targeted interventions would be important not only for equity reasons, but also for increasing food crop production, thereby achieving the dual objectives of food security and poverty reduction. Public investment that explicitly addresses low endowment of capital by women are likely to pay-off, as well as technologies that increase the productivity of female labor. Well-integrated pro-poor policies that facilitate access to basic physical capital and credit are equally important. What our findings suggest is that broad-based price and fertilizer policies are unlikely to be optimal, as they do not target the prevailing crop and agro-climatic mixes. Price support schemes should promote different crops in different regions. Barley and sorghum seem suited to the North, whereas maize and wheat (with *teff*) in the Central highlands. Broad-based infrastructure and market access policies, on the other hand, are more likely to benefit all farmers.

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Table A1 Summary Statistics on Output, Input Use and Prices by Crop and Gender

Variable		*Teff*	Wheat	Barley	Maize	Sorghum	Other Crops	Tree Crops
Output (kg)	Female	89.6	62.3	124.1	47.5	45.9	85.2	6.2
	Male	194.2	138.8	193.7	80.6	102.4	174.4	16.5
	t-statistics	4.15	4.57	3.10	2.68	4.99	3.61	2.67
Output (kg/ha)	Female	137.2	173.5	211.0	168.6	136.1	193.3	6.0
	Male	218.6	316.6	281.3	259.6	227.2	408.2	22.4
	t-statistics	2.60	3.29	1.72	1.87	2.53	3.08	2.45
Revenue Share (%)	Female	12.4	3.7	21.7	10.0	12.6	7.8	1.2
	Male	20.2	8.9	19.8	9.2	17.3	11.1	2.9
	t-statistics	3.91	6.35	-0.73	-0.46	2.14	2.34	2.48
Producers (% farmers)	Female	26.7	19.9	34.7	24.6	20.3	25.4	6.8
	Male	45.3	38.5	40.9	36.0	32.0	47.3	16.0
	t-statistics							
Marketed Surplus (%)	Female	2.6	2.3	1.0	0.95	0.4	3.5	3.5
	Male	5.6	3.9	1.5	1.5	1.1	6.2	8.6
	t-statistics	3.65	1.88	0.95	1.04	2.36	2.14	3.46
Sellers (% farmers)	Female	8.9	5.1	3.6	2.5	1.7	11.0	2.5
	Male	18.3	12.8	5.2	3.3	4.5	23.3	6.8
	t-statistics							
Prices (*Birr*/kg)	Female	1.82	1.48	1.61	1.27	1.26	1.41	3.46
	Male	1.84	1.49	1.60	1.25	1.29	1.47	3.65
	t-statistics	0.88	0.86	-0.52	-0.79	-1.66	2.20	1.20
Area Cultivated (ha)	Female	0.24	0.10	0.37	0.15	0.11	0.20	0.02
	Male	0.47	0.21	0.50	0.20	0.24	0.39	0.04
	t-statistics	5.65	5.82	2.44	1.80	5.14	5.78	2.02
Area Share (%)	Female	14.4	6.3	36.0	12.1	11.1	12.6	1.9
	Male	21.0	10.5	22.5	12.1	14.0	14.8	2.8
	t-statistics	3.46	3.88	-4.68	-0.04	1.58	1.36	1.42
Land Quality (index)	Female	0.86	0.68	1.29	0.77	0.55	0.92	0.21
	Male	1.24	1.06	1.19	1.08	0.82	1.36	0.31
	t-statistics	3.85	4.22	-1.15	3.37	3.27	4.67	1.81
Fertilizer (kg)	Female	78.1	110.3	64.2	63.6	23.7	74.8	59.4
	Male	94.4	126.3	84.5	88.0	34.4	100.5	89.9
	t-statistics							
Fertilizer (kg/ha)	Female	51.0	63.3	34.0	92.1	21.5	41.8	82.6
	Male	48.9	60.3	38.0	68.5	27.0	47.1	71.0
	t-statistics							

Table A2 Various Farm Characteristics by Gender

Variable	Female	Male	t-statistics
Total output (*Birr*)	443.7	857.7	6.35
Yield (*Birr*/ha)	324.6	504.1	4.12
Marketed Surplus (%farmers)	21.6	43.1	
Land holding (ha)	1.58	2.48	6.83
Land-less Households (% farmers)	3.4	5.7	
Area Cultivated (ha)	1.3	2.2	7.89
Own Land (ha)	1.5	2.1	5.43
Rent/share Land (ha)	0.17	0.59	6.87
Rent/share land (% farmers)	11	32.6	
Land Quality (index, 1=best, 2=mediocre, 3=worst)	2.4	2.4	0.94
Number of Plots	3.3	4.6	5.49
No. of Crops inter-cropped	3.9	5.8	7.89
No. of Trees	81.5	145.1	2.47
Fertilizer Use (kg)	42.7	71.9	5.05
Fertilizer Use (% farmers)	46.6	65.6	
Fertilizer Use (kg/ha)	46.9	45.5	-0.12
Price of fertilizer (*Birr*/kg)	1.48	1.49	0.55
Labor use (person-days)	21.2	28.5	2.01
Labor use (person-days/ha)	18.1	14.2	-1.60
Wage rate (*Birr*/kg)	2.92	2.88	-0.40
Animal Traction (No. of oxen)	1.4	2.3	2.3
Access to Traction (% farmers)	16.5	21.1	
No. of draught animals (horses, mules, donkey, camel)	0.75	1.1	2.49
Access to farm capital (cost of hoe and plough in *Birr*)	14.9	30.9	7.29
Access to Capital (% farmers)	58.1	91.8	
Access to Credit (amount borrowed in *Birr*)	97.5	135.7	2.33
Access to credit (% farmers)	40.7	50.1	
Access to extension (hours)	0.07	0.25	3.13
Access to extension (% farmers)	8.9	14.6	
Household Size (number)	3.6	4.8	7.80
No. of Male Farmers	0.92	1.7	9.99
No. of Female Farmers	1.58	1.51	-1.25
No. of Child Farmers	1.24	1.66	4.33
Schooling of head (Years attended)	0.08	0.82	8.52
Literate members (% farmers)	53	68.5	
Age of adults (Years)	38.7	35.6	3.35
Age of head (Years)	46.1	46.2	1.49
Market Access (Pop/distance)	4367.1	4848.7	1.66
Rain (mm)	143.3	269.5	5.15

Table B1 Selectivity-Corrected System of Output Supply and Fertilizer Demand Equations, symmetry imposed: (Female-Headed)

Variables	*Teff*	Wheat	Barley	Maize	Sorghum	Other Crops	Fertilizer
Price *Teff*	18.006	-39.826	9.080	27.501	-8.533	-44.257	-30.705
	(0.18)	(0.80)	(0.14)	(0.73)	(0.18)	(1.94)*	(1.35)
Price Wheat	-39.826	8.316	50.894	26.723	-5.612	-16.974	-11.939
	(0.80)	(0.12)	(0.95)	(0.56)	(0.15)	(0.57)	(0.67)
Price Barley	9.080	50.894	31.420	-30.747	50.987	43.593	35.916
	(0.14)	(0.95)	(1.48)	(0.59)	(2.36)**	(1.14)	(1.43)
Price Maize	27.501	26.723	-30.747	9.487	-27.233	-40.032	2.349
	(0.73)	(0.56)	(0.59)	(0.14)	(0.70)	(2.42)**	(0.12)
Price Sorghum	-8.533	-5.612	50.987	-27.233	19.532	-7.273	43.184
	(0.18)	(0.15)	(2.36)**	(0.70)	(2.33)**	(0.31)	(3.27)***
Price Other	-44.257	-16.974	43.593	-40.032	-7.273	50.615	-17.905
	(1.94)*	(0.57)	(1.14)	(2.42)**	(0.31)	(1.99)**	(1.18)
Price Fertilizer	30.705	11.939	-35.916	2.349	-43.184	17.905	-2.153
	(1.35)	(0.67)	(1.43)	(0.12)	(3.27)***	(1.18)	(0.15)
Area cultivated	269.088	59.194	53.531	12.543	10.937	14.515	11.042
	(8.42)***	(2.48)**	(3.53)***	(0.39)	(1.35)	(1.00)	(1.92)*
Land Quality	-53.765	45.396	24.536	31.724	23.703	79.837	8.247
	(3.79)***	(4.19)***	(2.06)**	(3.07)***	(3.36)***	(4.22)***	(0.80)
Land Access	0.096	0.011	0.028	0.003	0.086	0.023	-0.003
	(4.59)***	(0.54)	(1.07)	(0.14)	(6.22)***	(0.69)	(0.33)
Male Farmers	27.308	13.872	10.094	20.964	2.329	48.057	12.146
	(2.65)***	(1.43)	(0.76)	(2.19)**	(0.33)	(3.00)***	(2.82)***
Female Farmers	22.235	9.306	-11.578	-5.763	-5.205	-3.135	6.777
	(1.74)*	(0.78)	(0.72)	(0.49)	(0.62)	(0.16)	(1.12)
Child Farmers	8.301	-18.457	14.686	2.851	2.139	-2.759	0.562
	(1.08)	(2.59)**	(1.52)	(0.40)	(0.42)	(0.23)	(0.15)
Animal traction	29.751	26.192	33.160	19.737	-3.303	3.979	7.671
	(4.43)***	(4.29)***	(3.91)***	(3.35)***	(0.74)	(0.38)	(2.47)**
Farm Capital	1.347	1.938	0.085	1.550	-0.171	0.872	0.332
	(3.58)***	(5.57)***	(0.18)	(4.54)***	(0.69)	(1.95)**	(1.98)**
Market Access	-0.003	0.030	0.003	0.023	0.000	0.049	0.003
	(0.57)	(5.93)***	(0.48)	(4.21)***	(0.03)	(5.86)***	(1.14)
Rainfall	0.070	0.034	0.034	0.047	0.057	-0.004	0.011
	(2.11)**	(2.61)**	(0.47)	(3.86)***	(1.43)	(0.05)	(0.40)
Extension	9.189	7.338	-24.078	2.226	-1.123	-14.956	3.517
	(0.53)	(0.46)	(1.13)	(0.14)	(0.10)	(0.55)	(0.44)
Mills' ratio	19.925	-37.839	6.607	-10.396	13.429	-118.211	-11.809
	(1.92)*	(4.19)***	(0.45)	(0.90)	(1.32)	(4.64)***	(1.24)
Kersa Dummy	-165.956	-112.493	252.077	-19.922	-48.452	-516.246	-9.899
	(3.28)***	(2.63)***	(3.96)***	(1.28)	(1.27)	(6.17)***	(0.62)
Zone Dummy	654.791	-10.275	-308.859	34.623	31.635	-65.038	-8.218
	(13.87)***	(0.71)	(9.98)**	(0.27)	(1.08)	(2.29)**	(0.39)
Constant	-31.961	48.450	-102.165	-6.337	-16.515	155.307	-20.908
	(1.00)	(1.64)	(2.25)**	(0.23)	(0.83)	(2.77)***	(0.80)
R-squared	0.81	0.64	0.67	0.44	0.56	0.52	0.51
	(1054.7)***	(449.49)***	(496.20)***	(194.39)***	(298.74)***	(263.7)***	(208.61)***

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Zone dummy (1=Central, 0=North). For Kersa, which is from eastern Highlands (Kersa=1, 0 otherwise)

Table B2 Selectivity-Corrected System of Output Supply and Fertilizer Demand Equations, symmetry imposed:: (Male-Headed)

Variables	*Teff*	Wheat	Barley	Maize	Sorghum	Other Crops	Tree Crops	Fertilizer
Price *Teff*	13.118	21.925	-58.649	29.931	45.153	-16.800	-5.775	-6.492
	(0.50)	(1.23)	(3.16)***	(2.02)**	(3.52)***	(1.19)	(2.00)**	(0.95)
Price Wheat	21.925	41.036	-31.367	4.832	-15.771	-11.887	-4.296	2.998
	(1.23)	(1.82)*	(2.04)**	(0.35)	(1.01)	(0.94)	(2.66)***	(0.48)
Price Barley	-58.649	-31.367	-6.708	3.778	57.716	25.839	1.035	-16.552
	(3.16)***	(2.04)**	(0.28)	(0.27)	(4.96)***	(1.93)*	(0.34)	(2.71)***
Price Maize	29.931	4.832	3.778	21.488	-68.963	-6.991	6.132	17.007
	(2.02)**	(0.35)	(0.27)	(1.37)	(5.25)***	(0.67)	(2.77)***	(3.22)***
Price Sorghum	45.153	-15.771	57.716	-68.963	44.643	0.225	5.445	10.085
	(3.52)***	(1.01)	(4.96)***	(5.25)***	(5.17)***	(0.02)	(2.13)**	(1.69)*
Price Other	-16.800	-11.887	25.839	-6.991	0.225	20.317	-0.212	8.206
	(1.19)	(0.94)	(1.93)*	(0.67)	(0.02)	(1.30)	(0.08)	(1.84)*
Price Tree	-5.775	-4.296	1.035	6.132	5.445	-0.212	2.108	1.000
	(2.00)**	(2.66)***	(0.34)	(2.77)***	(2.13)**	(0.08)	(2.41)**	(1.07)
Price Fertilizer	6.492	-2.998	16.552	-17.007	-10.085	-8.206	-1.000	-8.540
	(0.95)	(0.48)	(2.71)***	(3.22)***	(1.69)*	(1.84)*	(1.07)	(2.42)**
Area cultivated	19.142	-0.220	28.759	2.696	19.258	-7.232	0.811	5.886
	(2.48)**	(0.04)	(4.33)***	(0.56)	(3.77)***	(0.74)	(0.44)	(2.59)***
Land Quality	29.877	-5.862	-44.007	32.068	50.094	-26.347	16.888	4.911
	(1.45)	(0.34)	(2.19)**	(2.32)**	(3.12)***	(0.93)	(3.09)***	(0.93)
Land Access	0.149	0.185	0.048	0.068	-0.013	0.292	-0.001	0.052
	(6.66)***	(9.82)***	(2.09)**	(4.47)***	(0.73)	(9.23)***	(0.23)	(8.65)***
Male Farmers	11.579	34.400	-4.064	10.543	1.467	48.986	0.321	5.947
	(1.25)	(4.28)***	(0.42)	(1.67)*	(0.20)	(3.69)***	(0.12)	(2.34)**
Female Farmers	-30.920	-33.791	-8.258	14.517	15.533	14.167	-0.721	-2.887
	(3.14)***	(4.07)***	(0.82)	(2.19)**	(1.99)**	(1.92)*	(0.26)	(1.10)
Child Farmers	-2.206	8.429	3.146	10.377	1.068	20.673	0.247	2.190
	(0.36)	(1.66)*	(0.51)	(2.52)**	(0.22)	(2.43)**	(0.15)	(1.36)
Animal traction	40.340	25.921	21.098	11.563	-11.970	36.217	0.692	8.919
	(7.66)***	(5.83)***	(3.94)***	(3.24)***	(2.89)***	(4.86)***	(0.47)	(6.40)***
Farm Capital	1.113	0.735	0.007	0.388	-0.232	0.353	0.111	0.333
	(4.20)***	(3.29)***	(0.03)	(2.16)**	(1.12)	(0.94)	(1.52)	(4.76)***
Market Access	-0.018	0.024	0.013	0.023	-0.014	0.048	0.002	-0.001
	(5.81)***	(9.55)***	(4.25)***	(10.58)***	(5.69)***	(11.38)***	(2.71)***	(0.64)
Rainfall	0.225	0.118	-0.017	0.008	0.100	0.043	0.049	0.047
	(7.85)***	(3.92)***	(0.54)	(0.35)	(4.55)***	(1.02)	(5.72)***	(5.35)***
Extension	-6.788	10.759	14.568	16.493	7.337	12.262	1.413	0.871
	(1.03)	(1.97)**	(2.17)**	(3.69)***	(1.41)	(1.32)	(0.77)	(0.50)
Mills' ratio	110.687	-33.035	-0.992	-56.839	-46.436	-65.604	-14.082	-18.420
	(5.33)***	(2.64)***	(0.03)	(5.58)***	(2.74)***	(2.78)***	(2.90)***	(2.50)**
Kersa Dummy	-79.847	-180.042	-174.162	21.486	24.814	-316.791	29.375	30.135
	(1.99)**	(5.40)***	(4.91)***	(0.32)	(0.63)	(6.20)***	(2.57)**	(3.38)***
Zone Dummy	902.631	-23.358	-311.049	-73.086	-96.426	-178.482	43.006	74.576
	(24.79)***	(0.73)	(10.23)***	(2.65)***	(3.34)***	(5.44)***	(4.31)***	(7.70)***
Constant	-118.442	-40.225	47.623	-109.820	42.235	19.036	-15.927	-5.050
	(1.94)*	(0.69)	(0.70)	(2.98)***	(1.07)	(0.23)	(1.12)	(0.31)
R-squared	0.75	0.53	0.62	0.37	0.30	0.42	0.16	0.59
	(2134.4)***	(812.4)***	(1204.8)***	(476.8)***	(298.6)***	(520.5)***	(161.5)***	(1006.2)***

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Zone dummy (1=Central, 0=North). For Kersa, which is from eastern Highlands (Kersa=1, 0 otherwise)

Table C1 Elasticities: (Female-Headed)

Variables	*Teff*	Wheat	Barley	Maize	Sorghum	Other Crops	Fertilizer
Price *Teff*	0.20	-0.62	0.07	0.56	-0.18	-0.50*	-0.70
Price Wheat	-0.27	0.11	0.35	0.48	-0.10	-0.17	-0.24
Price Barley	0.09	0.73	0.23	-0.58	0.99**	0.46	0.75
Price Maize	0.23	0.31	-0.18	0.14	-0.43	-0.34**	0.04
Price Sorghum	-0.07	-0.06	0.28**	-0.39	0.29**	-0.06	0.72***
Price Other	-0.40*	-0.22	0.29	-0.69**	-0.13	0.49**	-0.34
Price Fertilizer	0.28	0.16	-0.24	0.04	-0.77***	0.17	-0.04
All crop prices	-0.22	0.25	1.04	-0.48	0.44	-0.12	0.15
All prices	0.06	0.41	0.8	-0.44	-0.33	0.05	0.11
Area cultivated	0.81***	0.09**	0.57***	0.04	0.32	0.23	0.34*
Land Quality	-0.24***	0.63***	0.26**	0.51***	0.59***	0.81***	0.48
Land Access	0.05***	0.01	0.01	0.00	0.08***	0.01	-0.00
Male Farmers	0.28***	0.20	0.07	0.41**	0.05	0.52***	0.26***
Female Farmers	0.39*	0.24	-0.15	-0.19	-0.18	-0.06	0.25
Child Farmers	0.11	-0.37**	0.15	0.07	0.06	-0.04	0.02
Animal traction	0.46***	0.58***	0.37***	0.57***	-0.10	0.06	0.25**
Farm Capital	0.22***	0.46***	0.01	0.49***	-0.06	0.15**	0.12**
Market Access	-0.15	2.09***	0.11	2.09***	0.01	2.50***	0.31
Rainfall	0.11**	0.08**	0.04	0.14***	0.18	-0.01	0.04**
Extension	0.01	0.01	-0.01	0.00	-0.00	-0.01	0.01
All Private fixed	2.27	1.2	1.02	1.39	0.09	0.86	1.24
Family labor	0.78	0.07	0.07	0.29	-0.07	0.42	0.53
Other private	1.49	1.13	0.95	1.1	0.16	0.44	0.71
Land variables	0.62	0.73	0.84	0.55	0.99	1.05	0.82
Purely exogenous	-0.28	2.8	0.41	2.74	0.78	3.3	0.83
Public & exogenous	-0.22	2.82	0.41	2.74	0.86	3.3	0.84
All non-price	2.05	4.02	1.43	4.13	0.95	4.16	2.08

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.

All prices include all output and fertilizer prices. Private fixed inputs include components of family labor, area cultivated, animal traction and farm capital (the latter three are other private category). Land variables are area cultivated, land quality and land access. Public & exogenous include all non-private, that is land quality, market access, rainfall, land access and extension (the first three being in the Purely exogenous category). All non-price includes all non-price variables, both private fixed inputs and public and exogenous.

Table C2 Elasticities: (Male-headed)

Variables	*Teff*	Wheat	Barley	Maize	Sorghum	Other Crops	Tree Crops	Fertilizer
Price *Teff*	0.10	0.21	-0.40***	0.49**	0.58***	-0.13	-0.46**	-0.12
Price Wheat	0.12	0.32*	-0.18**	0.07	-0.17	-0.07	-0.28***	0.05
Price Barley	-0.34***	-0.25**	-0.04	0.05	0.63***	0.17*	0.07	-0.26***
Price Maize	0.14**	0.03	0.02	0.24	-0.62***	-0.04	0.34***	0.22***
Price Sorghum	0.15***	-0.10	0.26***	-0.75***	0.38***	0.00	0.29**	0.12*
Price Other	-0.09	-0.09	0.14*	-0.09	0.00	0.13	-0.01	0.12*
Price Tree	-0.08**	-0.09***	0.01	0.20***	0.14**	-0.00	0.33**	0.04
Price Fertilizer	0.04	-0.02	0.09***	-0.23***	-0.11*	-0.05*	-0.07	-0.13**
All crop prices	0	0.03	-0.19	0.21	0.94	0.06	0.28	0.17
All prices	0.04	0.01	-0.1	-0.02	0.83	0.01	0.21	0.04
Area cultivated	0.21**	-0.00	0.32***	0.07	0.41***	-0.09	0.11	0.17***
Land Quality	0.37	-0.10	-0.55**	0.97**	1.19***	-0.37	2.49***	0.17
Land Access	0.06***	0.10***	0.02**	0.06***	-0.01	0.13***	-0.01	0.05***
Male Farmers	0.10	0.42***	-0.04	0.22*	0.02	0.47***	0.03	0.14**
Female Farmers	-0.24***	-0.37***	-0.06	0.27**	0.23**	0.12*	-0.07	-0.06
Child Farmers	-0.02	0.10*	0.03	0.21**	0.02	0.20**	-0.02	0.05
Animal traction	0.47***	0.42***	0.25***	0.33***	-0.27***	0.47***	0.10	0.28***
Farm Capital	0.18***	0.16***	0.00	0.15**	-0.07	0.06	0.21	0.14***
Market Access	-0.44***	0.85***	0.33***	1.38***	-0.65***	1.35***	0.67***	-0.07
Rainfall	0.31***	0.23***	-0.02	0.03	0.26***	0.07	0.80***	0.18***
Extension	-0.01	0.02**	0.02**	0.05***	0.02	0.02	0.02	0.00
All Private fixed	0.7	0.73	0.5	1.25	0.34	1.23	0.36	0.72
Family labor	-0.16	0.15	-0.07	0.7	0.27	0.79	-0.06	0.13
Other private	0.86	0.58	0.57	0.55	0.07	0.44	0.42	0.59
Land variables	0.64	0	-0.21	1.1	1.59	-0.33	2.59	0.39
Purely exogenous	0.24	0.98	-0.24	2.38	0.8	1.05	3.96	0.28
Public & exogenous	0.29	1.1	-0.2	2.49	0.81	1.2	3.97	0.33
All non-price	0.99	1.83	0.3	3.74	1.15	2.43	4.33	1.05

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
All prices include all output and fertilizer prices. Private fixed inputs include components of family labor, area cultivated, animal traction and farm capital (the latter three are other private category). Land variables are area cultivated, land quality and land access. Public & exogenous include all non-private, that is land quality, market access, rainfall, land access and extension (the first three being in the Purely exogenous category). All non-price includes all non-price variables, both private fixed inputs and public and exogenous.