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# How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana

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**Abstract**

Why do men and women adopt agricultural technologies at different rates? Evidence from Ghana suggests that gender-linked differences in the adoption of modern maize varieties and chemical fertilizer result from gender-linked differences in access to complementary inputs. This finding has important policy implications, because it suggests that ensuring more widespread and equitable adoption of improved technologies may not require changes in the research system, but rather introduction of measures that ensure better access for women to complementary inputs, especially land, labor, and extension services.


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## 1. Introduction

In recent years, development practitioners have become increasingly interested in questions relating to the distributional impacts of technical change in agriculture. Scientific breakthroughs such as the much-publicized green revolutions in wheat and rice have brought about dramatic productivity gains in many important cereal crops, but the persistence of chronic malnutrition among a significant portion of the world's population has led to the realization that millions of people still lack reliable access to sufficient quantities of food. Many of these people are smallholder farmers in developing countries.

This realization has focused increased attention on issues relating to the development and dissemination of improved agricultural technologies. If certain groups of farmers are not adopting improved technologies or are adopting them at a lower rate than other groups, then we need to determine why, because only by understanding the reasons will we be able to develop improved technologies that are appropriate for all. More concretely, since women farmers tend to adopt improved technologies at a lower rate than male farmers, we need to understand the reasons behind what

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appear to be gender-linked differences in technology adoption rates.

### 1.1. Research objectives

Using empirical data from Ghana, we address three questions about gender and technology adoption. First, does including gender as an explanatory variable in standard regression models add to our understanding of the technology adoption process? Second, can farmers' adoption decisions be better understood by explicitly considering household structural variables, particularly the gender of the household head? Third, to what extent are frequently observed differences in the rates at which men and women adopt improved technology attributable to gender-linked differences in access to complementary inputs, such as land, labor, and extension services?

These questions are of obvious practical importance, because they go directly to the issue of whether gender-related differences in adoption patterns occur because (a) men and women have different preferences when it comes to technology, or (b) men and women have the same preferences when it comes to technology but face different constraints that prevent them from adopting at the same rate. Men's and women's technology preferences can differ for many reasons. For example, crop varietal preferences can differ by gender if men and women have different uses for a particular crop. In cases where women grow a crop primarily for home consumption and men grow the same crop primarily for sale, women and men may have different preferences for varietal characteristics such as appearance, taste, ease of processing, ease of cooking, and storage. Also, if women farmers are intrinsically more risk averse than men or less innovative, then this might explain lower levels of adoption.

Identifying the causes of gender-related differences in adoption is crucial, because if gender affects the adoption process directly — in other words, if men and women adopt at different rates even when they face exactly the same constraints — then it may be necessary to modify research strategies to ensure that technologies are developed that meet their dissimilar needs. If, on the other hand, differential rates of adoption arise because men and women face different constraints, especially unequal access to complementary inputs that affect adoption indirectly, then it may be more important to work on improving women's access to these complementary inputs.

## 2. Maize in Ghana

Maize in Ghana makes a particularly appropriate case study for this inquiry into the links between gender and adoption for at least three reasons.

First, maize is Ghana's most important cereal crop. It is grown by the vast majority of rural households in all parts of the country except for the Sudan Savannah zone of the far north. According to official statistics, the area planted to maize in Ghana currently averages about 650,000 ha per year. Most maize is cultivated in association with other crops, so planting densities for maize are generally low. Grain yields of maize per unit land area are correspondingly modest, averaging less that 2 t/ha. Total annual maize production is currently estimated at just over 1 million t.

Second, maize is the most widely consumed staple in Ghana. A national survey carried out in 1990 revealed that over 94% of all households had consumed maize during an arbitrarily selected 2-week period (Alderman and Higgins, 1992). Another study based on 1987 data found that maize and maize-based food accounted for 10.8% of total food expenditures by poor households and 10.3% of food expenditures by all households (Boateng et al., 1990).

Third, both men and women cultivate maize in Ghana. Furthermore — and in this respect Ghana differs from many other countries — women frequently manage their own maize fields, contribute an important proportion of overall labor requirements, and exercise complete discretion over the disposal of the harvest. Because maize production activities are managed autonomously by men and women, technology choice decisions tend to be made independently by men and women, which makes it easier to distinguish gender-related dimensions of the adoption process.

### 2.1. Ghana's maize-based farming systems

Generally speaking, the climate in Ghana grows hotter and drier as one moves northward and inland away from the Atlantic coast. Maize cropping systems and production technologies vary between the four agro-ecological zones in which significant amounts of maize are cultivated.

The Coastal Savannah zone includes a narrow belt of Savannah that runs along the Atlantic coast, widening towards the east of the country. Farmers in this zone grow maize and cassava as their principal staples, often intercropped. Annual rainfall, which is bimodally distributed, totals only 800 mm per year, so most maize is planted following the onset of the major rains beginning in March or April. Soils are generally light in texture and low in fertility, and productivity is low.

Immediately inland from the Coastal Savannah lies the forest zone. Most of Ghana's forest is semi-deciduous, with a small area of high rain forest remaining only in the southwestern part of the country near the border with Côte d'Ivoire. Maize in the forest zone is grown in scattered plots, usually intercropped with cassava, plantain, or cocoyam as part of a bush fallow system. Some maize is consumed in the forest zone, but it is not a leading food staple, and much of the crop is sold. Annual rainfall averages about 1500 mm, and maize is planted both in the major rainy season (beginning in March) and in the minor rainy season (beginning in September).

Moving further north, the forest zone gradually gives way to the transition zone. The exact boundary is subject to dispute, which is not surprising considering that the boundary area is characterized by a constantly changing patchwork of Savannah and forest plots. What is certain, however, is that the transition zone is an important region for commercial grain production. Much of the transition zone has deep, friable soils, and the relatively sparse tree cover allows for more continuous cultivation and greater use of mechanized equipment. Rainfall is bimodally distributed and averages about 1300 mm per year. Maize in the transition zone is planted in both the major and minor seasons, usually as a monocrop or in association with yam or cassava.

The Guinea Savannah zone occupies most of the northern part of the country. Annual rainfall totals about 1100 mm and falls in a single rainy season beginning in April or May. Sorghum and millet are the dominant cereals in the Guinea Savannah, but maize grown in association with small grains, groundnut and/or cowpeas is also important. Some fields are prepared by tractor, but most are prepared by hand. Maize is grown in permanently cultivated fields located close to homesteads, as well as in more distant plots under shifting cultivation.

### 2.2. Improved maize production technologies

Our analysis focuses on factors affecting the adoption of two improved maize production technologies: modern varieties (MVs) [2] and chemical fertilizer. These technologies were developed and promulgated through the Ghana Grains Development Project (GGDP), an 18-year research and extension project that was established to develop and disseminate improved technologies for maize and grain legumes.

### 2.3. Modern varieties (MVs)

Prior to inception of the GGDP, plant breeders working at Ghana's national maize breeding institute, the Crops Research Institute (CRI), had developed and released several MVs of maize. These early MVs generated little interest among farmers, however, and they were not widely adopted. Under the GGDP, the CRI maize breeding program was reorganized, with the objective of strengthening links with international research centers. At the same time, an extensive on-farm testing program was introduced to increase the role of farmers in the varietal evaluation process. These changes led eventually to the release of a series of maize MVs characterized by high yielding ability, increased resistance to diseases and insect pests, enhanced drought tolerance, and improved grain quality. The seed of these MVs was produced and distributed to farmers through a number of schemes involving CRI, the extension service, NGOs, and private seed companies.

### 2.4. Chemical fertilizer

At the time the GGDP was launched, few farmers in Ghana were applying chemical fertilizer to their maize fields. The low level of fertilizer use on maize was quickly identified as a priority problem for rese-

[2] As used here, the term *modern varieties* (MVs) refers to improved open-pollinating varieties (OPVs) and hybrids developed by a formal plant breeding program. *Local varieties* refers to farmers' traditional varieties.

arch, because experimental evidence showed clearly that soil fertility was severely constraining yields in many areas. Although the relative unpopularity of fertilizer among Ghanaian maize farmers could be attributed to a number of causes, one significant problem was that there were no consolidated, widely accessible recommendations for applying fertilizer to maize. In an attempt to remedy this problem, GGDP researchers organized an on-farm testing program aimed at developing fertilizer recommendations for maize. The challenge was to formulate recommendations that would be sufficiently flexible to accommodate the wide range of soil fertility conditions found in farmers' fields, yet at the same time simple enough to be incorporated into existing extension programs. Following several years of trials, GGDP researchers came up with a set of fertilizer recommendations that distinguished among agro-ecological zones and took into account field cropping histories. The recommendations were promoted through a national extension campaign that included thousands of on-farm demonstrations and farmer field days.

It is important to note that the two technologies differ in a number of ways that can be expected to influence the adoption process. MVs are a relatively simple technology, in the sense that farmers who decide to adopt MVs must make relatively few changes to their current practices. MVs are also relatively inexpensive: the cost of MV seed comprises a small proportion of total production costs. Primarily for these reasons, MVs should be accessible to all farmers, regardless of their resource endowment or technical management skills.

In contrast, chemical fertilizer is a relatively complex technology, in the sense that farmers who decide to adopt fertilizer must learn the names of different products, their nutrient composition, correct application rates (based on field characteristics), optimal application schedules, and efficient application methods. In addition, chemical fertilizer is expensive: the cost of purchasing chemical fertilizer, transporting it to the farm, and applying it significantly increases cash outlays. For these reasons, it is reasonable to expect that fertilizer is likely to be adopted more readily by wealthier farmers (who can more easily afford the cost) and/or better educated farmers who possess greater technical knowledge and superior management skills.

In considering the adoption decision, it is important to keep in mind that there is an interaction between MVs and fertilizer, so that the benefits of adopting both technologies exceed the sum of the benefits achieved by adopting only one or the other.

## 3. Data

Data on the adoption of MVs and chemical fertilizer were collected through a national survey of maize growers carried out between November 1997 and March 1998. A three-stage, clustered, randomized procedure was used to select a representative sample of 420 maize farmers located in 60 villages throughout the country. These farmers were questioned at length about their maize production, consumption, and marketing practices; their preferences for different maize varietal characteristics; and their knowledge of and access to improved inputs, such as seed and fertilizer (for additional details about the survey, see Morris et al. (1999)).

An impacts study carried out following the termination of the GGDP revealed that both MVs and fertilizer have been adopted less extensively by women than by men. During the 1997 cropping season, 39.0% of female farmers planted MVs compared to 59.0% of male farmers, and 16.2% of female farmers applied fertilizer to their maize fields compared to 22.5% of male farmers (Morris et al., 1999). Here, we are interested in identifying the factors that gave rise to these observed differences in adoption rates.

Many technology adoption studies distinguish between the *rate of adoption* (defined as the proportion of farmers that adopt a given technology, regardless of the level of use) and the *intensity of adoption* (defined in terms of the level of use of the technology, e.g. the proportion of the farmer's land planted to MVs or the quantity applied of fertilizer). In Ghana, farmers who adopt MVs tend to plant them over their entire landholdings, so the intensity measure usually takes on a value of either 0 or 100%. The rate of adoption measure therefore ends up being very similar to the intensity of adoption measure. In the case of fertilizer, the available data did not enable us to determine the amount of fertilizer applied by each farmer. For these reasons, we chose to focus only on rates of adoption.

## 4. Adoption model

Maize farmers in Ghana must decide whether to adopt MVs, fertilizer, or both. The benefits realized when both technologies are adopted jointly exceed the sum of the benefits realized when each one is adopted separately, so the decision to adopt one technology can be expected to affect the decision to adopt the other. Because the two adoption decisions are linked, we use a two-stage probit approach. In the first stage, the full set of estimators is used to predict the probability of adopting either fertilizer or MVs. In the second stage, predicted values for MV adoption and fertilizer adoption are included as independent variables in the final set of estimations. Consistent standard errors on the independent variables are generated using a bootstrapping procedure.

The basic model is specified as follows:

$$\text{MVadopter} = \beta_1 X_1 + \beta_2 \text{fertadopter}^* + \varepsilon_1$$

$$\text{fertadopter} = \beta_3 X_2 + \beta_4 \text{MVadopter}^* + \varepsilon_2$$

where MVadopter and fertadopter are dummy variables indicating whether the farmer adopted MVs and/or fertilizer, $X_1$ and $X_2$ are vectors of variables expected to affect the technology adoption decision, and MVadopter* and fertadopter* are the predicted values (generated as described in the preceding paragraph) of the adoption variables. All of the independent variables are discussed in detail below.

Dummy variables are included for three *ecological zones* in which maize is cultivated: the Coastal Savannah, the transition zone, and the Guinea Savannah (a fourth zone, the forest zone, serves as the reference). The purpose of the zonal dummy variables is to control for agro-climatic differences that could affect the profitability of the technologies. Since the northern part of the country, including virtually all of the Guinea Savannah zone and portions of the transition zone, is inhabited mainly by Muslim ethnic groups among which women tend to be less responsible for agriculture, the zonal dummy variables may also pick up some cultural variability, which could be linked to gender effects.

Several characteristics of the farmer are included as covariates. The farmer's *gender* is represented by a dummy variable. Instead of using the gender of the household head (the conventional practice in most adoption studies), we use the gender of the farmer. This allows us to examine the behavior of female farmers in both female- and male-headed households. The farmer's *age* is also included, as is the farmer's *education*, expressed as the number of years of formal schooling completed.

Included also are several other explanatory variables thought to affect technology adoption decisions (most of these variables are extensively discussed in the adoption literature; see Feder et al. (1985) and Feder and Umali (1993)). The amount of *land owned* by the farmer is included, because even though MVs and fertilizer are both expected to be scale-neutral, wealthier farmers (i.e. those with more land) are more likely to be able to afford fertilizer. Since agricultural extension agents serve as an important source of technical information and improved inputs, the number of *extension visits* received by the farmer is expected to be positively correlated with the probability of adoption. Market access may also affect the adoption decision, so an index was created to reflect the *level of infrastructure* present in the farmer's village (the index was calculated based on the presence or absence of a tarred road, a good feeder road, reliable transportation, and a physical market). Since adopting a new technology often implies a need for additional labor, *labor availability* is frequently associated with successful adoption. In Model 1, *household size* is used as a simple measure of labor availability. The literature on gender and farming in Africa (see Doss, 1999) suggests that men's labor and women's labor are not interchangeable, however, so in Model 2, we account for labor availability by including as separate explanatory variables the number of *adult men*, *adult women*, and *children* in the farmer's household.

In addition to the many factors that are expected to influence adoption of both MVs and fertilizer, certain technology-specific factors are expected to influence the two adoption decisions separately. In the case of MV adoption, varietal choice is expected to be influenced by the farmer's seed procurement practices. Therefore, in the MV adoption equation, we include a *seed source* variable that indicates whether the seed planted in a given maize field was saved from the farm or externally acquired (e.g. obtained from another farmer, from an extension agent, or from a shop). In the case of fertilizer, the adoption decision is expected to be influenced by soil fertility considerations. Therefore, in the fertilizer adoption equation, we include a *soil fertility* variable based on the number of years that the field had been continuously cropped. If the field had been fallow prior to the year of the survey, we use the number of years that the field had been fallow, so the variable can take on positive or negative values.

## 5. Empirical results

Empirical results obtained from estimating Models 1 and 2 are summarized in Table 1. Three aspects of the results are noteworthy.

First, in both models, the gender variable lacks significant explanatory power. This result is unexpected, considering that men and women farmers are known to have adopted the technologies at different rates.

Second, many of the other explanatory variables have the expected signs and are statistically significant. In the MV adoption equation, ecological zone, level of education, amount of land owned, number of extension visits, level of infrastructure, and number of adult males in the household (Model 2 only) are positively associated with the probability of adoption. In the fertilizer adoption equation, ecological zone, farmer's age, amount of land owned (Model 1 only), number of extension visits, level of infrastructure, and the proxy for soil fertility are positively associated with the probability of adoption.

Third, several of the explanatory variables lack statistical significance. With the exception of the coefficient on the number of adult men in the MV adoption equation, none of the coefficients on the various measures of labor availability are statistically significant. This could indicate that labor availability does not affect MV and fertilizer adoption decisions, or it could simply mean that the variables we are using (based on the number of people living in the farmer's household) are not good indicators of the ability of Ghanaian farmers to mobilize labor to work in their maize fields. Somewhat more puzzling, neither of the estimated coefficients on the (fitted) endogenous variables shows significant explanatory power, suggesting that MV and fertilizer adoption decisions may be taken independently, rather than jointly.

As a further test of the significance of gender on adoption, a likelihood-ratio test statistic was constructed to test the hypothesis that the coefficient on female is equal to 0 ($H_0$: $\beta_{female} = 0$). In both models, the null hypothesis cannot be rejected. This suggests that controlling for other factors, the adoption of MVs and fertilizer is not associated with the gender of the farmer.

## 6. Female-headed households

In Models 1 and 2, the unit of observation is the farmer, so the analysis focuses on the adoption behavior of individual women and men. This is somewhat different from the conventional approach; in most adoption studies, the unit of observation is the household, and gender effects are explored by including a dummy variable indicating the gender of the household head. One drawback of the conventional approach is that it does not reveal anything about the behavior of female farmers who live in male-headed households. In Ghana, as elsewhere in Africa, these numbers may be significant. For example, 70% of the female respondents in our sample were married, suggesting that they may have been living in male-headed households.

Failure to distinguish between the gender of the farmer and the gender of the household head may represent an important omission, because the constraints faced by women farmers who live in female-headed households may be more severe than those faced by women farmers who live in male-headed households (see Doss (1999) for a review of the literature on this issue).[3] A wealth of case study evidence suggests that female-headed households are less likely to adopt new technologies than male-headed households (for recent examples, see Smale et al. (1991) and Kumar (1994)). In some cases, we may indeed be interested in understanding the adoption decisions of female-headed households, but here we ask whether the adoption behavior of female farmers varies depending on the gender of the head of the household in which they live.

Household decision-making processes vary throughout Ghana and presumably also within our nationally representative sample. Typically, however, women

[3] To further complicate matters, definitions of female-headed households found in the literature are not consistent. For a good discussion of the implications of the different definitions, see Rogers (1995).

Table 1
Adoption of improved technologies (modern varieties and fertilizer)

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Coefficient | Standard error | Coefficient | Standard error | Coefficient | Standard error |
| *MV adoption* | | | | | | |
| Female | −0.085 | 0.200 | −0.059 | 0.204 | – | – |
| Female in FHH | – | – | – | – | −0.716** | 0.328 |
| Female in MHH | – | – | – | – | 0.136 | 0.223 |
| Coastal Savannah | 0.601** | 0.266 | 0.606** | 0.274 | 0.640** | 0.255 |
| Transition Zone | 0.924** | 0.331 | 0.998*** | 0.329 | 0.982*** | 0.314 |
| Guinea Savannah | 0.924** | 0.367 | 0.937** | 0.370 | 0.930*** | 0.345 |
| Age | 0.006 | 0.007 | 0.006 | 0.007 | 0.007 | 0.007 |
| Education | 0.059*** | 0.017 | 0.060*** | 0.018 | 0.057*** | 0.017 |
| Land owned | 0.064** | 0.027 | 0.064** | 0.027 | 0.064** | 0.027 |
| Extension | 0.082*** | 0.032 | 0.084*** | 0.031 | 0.081*** | 0.031 |
| Infrastructure | 0.181* | 0.098 | 0.203** | 0.098 | 0.186** | 0.093 |
| Men | – | – | 0.112** | 0.051 | – | – |
| Women | – | – | −0.065 | 0.054 | – | – |
| Children | – | – | −0.018 | 0.027 | – | – |
| Household size | 0.005 | 0.014 | | | 0.005 | 0.014 |
| New seed | 0.976*** | 0.194 | 0.999*** | 0.201 | 0.999*** | 0.196 |
| Predicted fertilizer user | −0.068 | 0.238 | −0.069 | 0.235 | −0.067 | 0.197 |
| Constant | −2.187*** | 0.660 | −2.257*** | 0.652 | −2.241*** | 0.603 |
| Log likelihood | −210.49 | −210.49 | −206.99 | −206.99 | −207.29 | −207.29 |
| LR statistic: $\beta_{female} = 0$ | 0.2768 | 0.2768 | 0.121 | 0.121 | | |
| $\beta_{F/FHH} = \beta_{F/MHH} = 0$ | | | | | 6.68** | 6.68 |
| $\beta_{F/FHH} = \beta_{F/MHH}$ | | | | | 6.40** | 6.40 |
| $\beta_{F/MHH} = 0$ | | | | | 6.30** | 6.30 |
| *Fertilizer adoption* | | | | | | |
| Female | 0.093 | 0.225 | 0.053 | 0.228 | – | – |
| Female in FHH | – | – | – | – | −0.138 | 0.387 |
| Female in MHH | – | – | – | – | 0.175 | 0.247 |
| Coastal Savannah | 0.419* | 0.248 | 0.442* | 0.248 | 0.430* | 0.252 |
| Transition Zone | 0.685*** | 0.246 | 0.652** | 0.255 | 0.705*** | 0.253 |
| Guinea Savannah | 0.450 | 0.305 | 0.457 | 0.315 | 0.449 | 0.317 |
| Age | −0.016** | 0.008 | 0.016** | 0.008 | −0.015* | 0.008 |
| Education | 0.003 | 0.018 | 0.003 | 0.019 | 0.003 | 0.020 |
| Land owned | 0.032* | 0.019 | 0.031 | 0.020 | 0.033 | 0.020 |
| Extension | 0.044** | 0.021 | 0.043** | 0.021 | 0.044* | 0.023 |
| Infrastructure | 0.180** | 0.079 | 0.169** | 0.080 | 0.181** | 0.081 |
| Men | – | – | −0.061 | 0.050 | – | – |
| Women | – | – | 0.070 | 0.051 | – | – |
| Children | – | – | 0.032 | 0.028 | – | – |
| Household size | 0.017 | 0.013 | | | 0.017 | 0.014 |
| Years cropped | 0.042** | 0.017 | 0.042** | 0.017 | 0.043 | 0.146 |
| Predicted MV user | 0.009 | 0.054 | 0.010 | 0.052 | 0.010 | 0.068 |
| Constant | −1.349*** | 0.425 | −1.303*** | 0.433 | −1.362*** | 0.456 |
| Log likelihood | −170.91 | −170.91 | −169.48 | −169.48 | −170.54 | −170.54 |
| LR statistic: $\beta_{female} = 0$ | 0.189 | 0.189 | 0.049 | 0.049 | | |
| $\beta_{F/FHH} = \beta_{F/MHH} = 0$ | | | | | 0.935 | 0.935 |
| $\beta_{F/FHH} = \beta_{F/MHH}$ | | | | | 0.745 | 0.745 |
| $\beta_{F/MHH} = 0$ | | | | | 0.342 | 0.342 |

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

farmers take independent decisions regarding the management of agricultural enterprises and the disposal of revenue earned. Although cash, labor, physical inputs (including seed and fertilizer) and information may be exchanged within the household, each farmer tends to act independently, and we would not necessarily expect to see efficient flows of resources and information (for an example of production losses due to inefficient factor allocation within the household, see Udry (1996)).

The data set for Ghana unfortunately does not include information about the gender of the household head. However, from the available data, it is possible to infer whether the household in which the farmer lives is likely to be male-headed or female-headed. Specifically, it can be assumed that all male farmers and all married female farmers live in male-headed households and that all unmarried female farmers live in female-headed households.[4] Using these assumptions, 25% of the (female) sample farmers living in female-headed households have adopted MVs, compared to 56% of the (female and male) sample farmers living in male-headed households. Similarly, 13% of the (female) sample farmers living in female-headed households and 22% of the (female and male) sample farmers living in male-headed households have adopted fertilizer.

In Model 3, we disaggregate the farmers into three categories: (1) male farmers, all of whom implicitly live in male-headed households (M/MHH); (2) female farmers living in male-headed households (F/MHH) and (3) female farmers living in female-headed households (F/FHH). Within male-headed households, the MV adoption rate does not differ significantly (in a statistical sense) between male and female farmers (Table 1). However, the MV adoption rate for female farmers living in male-headed households is significantly higher than the rate for female farmers living in female-headed households. Table 2 presents the marginal effects; these are negative and relatively large for female farmers living in female-headed households. These results indicate that women do not necessarily make different adoption decisions than men, but they also suggest that there is something about the structure of female-headed households that makes farmers living in these households less likely to adopt MVs. In the case of fertilizer, the adoption decision is affected neither by the gender of the farmer nor by the gender of the household head (Table 1).

Table 2
Marginal effects of technology adoption determinants (Model 3)

| Adoption determinants | Marginal effects |
|---|---|
| *MV adoption* | |
| Female in FHH | −0.2409 |
| Female in MHH | 0.0459 |
| Coastal Savannah | 0.2154 |
| Transition zone | 0.3302 |
| Guinea Savannah | 0.3127 |
| Age | 0.0024 |
| Education | 0.0191 |
| Land owned | 0.0215 |
| Extension | 0.0273 |
| Infrastructure | 0.0624 |
| Household size | 0.0161 |
| New seed | 0.3358 |
| Predicted fertilizer user | −0.2250 |
| Constant | −0.7535 |
| *Fertilizer adoption* | |
| Female in FHH | −0.0355 |
| Female in MHH | 0.0451 |
| Coastal Savannah | 0.1108 |
| Transition zone | 0.1814 |
| Guinea Savannah | 0.1157 |
| Age | 0.0039 |
| Education | 0.0006 |
| Land owned | 0.0085 |
| Extension | 0.0112 |
| Infrastructure | 0.0467 |
| Household size | 0.0043 |
| Years cropped | 0.0109 |
| Predicted MV user | 0.0025 |
| Constant | −0.3507 |

Likelihood ratio tests can be used to disaggregate the effects of the gender of the farmer from the gender of the household head. First, we test the hypothesis that there is no effect of gender on adoption by constraining the coefficients on female farmers in both male- and female-headed households to be 0 ($\beta_{F/MHH} = \beta_{F/FHH} = 0$). This hypothesis is rejected in the case of MV adoption. Then, we constrain the coefficients on the gender of the household head to

[4] This would count women who report themselves as married but whose husbands are absent as living in male-headed households. In addition, if an unmarried woman was living in a household headed by a man that was not her husband (for example, her father, brother, or uncle), she would be incorrectly categorized as living in a female-headed household.

Table 3
Land owned and cultivated, by gender (number, percent of maize farmers)[a]

| Amount of land (ha) | Land owned | | | | Land cultivated | | | |
|---|---|---|---|---|---|---|---|---|
| | Men | Women | | All | Men | Women | | All |
| | | Male HH | Female HH | | | Male HH | Female HH | |
| 0 | 65 (20.6) | 16 (21.9) | 10 (31.3) | 91 (21.7) | n.a. | n.a. | n.a. | n.a. |
| ≤1 | 20 (6.3) | 11 (15.1) | 6 (18.8) | 37 (8.8) | 14 (4.4) | 10 (13.7) | 13 (40.6) | 37 (8.8) |
| 1.1–3 | 59 (18.7) | 22 (30.1) | 6 (18.8) | 87 (20.7) | 76 (24.1) | 27 (37.0) | 8 (25.0) | 111 (26.4) |
| 3.1–5 | 55 (17.5) | 14 (19.2) | 6 (18.8) | 75 (17.9) | 60 (19.0) | 23 (31.5) | 6 (18.8) | 89 (21.2) |
| 5.1–10 | 74 (23.5) | 7 (9.6) | 3 (9.4) | 84 (20.0) | 106 (33.7) | 10 (13.7) | 4 (12.5) | 120 (28.6) |
| ≥10 | 42 (13.3) | 3 (4.1) | 1 (3.1) | 46 (11.0) | 59 (18.7) | 3 (4.1) | 1 (3.1) | 63 (15.0) |
| Total | 315 (100.0) | 73 (100.0) | 32 (100.0) | 420 (100.0) | 315 (100.0) | 73 (100.0) | 32 (100.0) | 420 (100.0) |

[a] Source: 1998 CRI/CIMMYT survey.

be the same ($\beta_{F/MHH} = \beta_{F/FHH} = 0$), testing the hypothesis that the gender of the household head is not significant while controlling for the gender of the farmer. Again, the hypothesis is rejected in the case of MV adoption. Finally, we perform a second test of the hypothesis that the gender of the household head does not matter by constraining the coefficient on female farmers in male-headed households to be 0 ($\beta_{F/MHH} = 0$). This test differs from the previous one in that it does not control for the gender of the farmer. For the third time, the hypothesis is rejected. Therefore, we conclude that the gender of the household head does affect MV adoption.

When similar likelihood ratio tests are used to test the same hypotheses with regard to fertilizer adoption, none of the null hypotheses can be rejected. This result suggests that controlling for other factors, gender is not an important determinant of fertilizer adoption, regardless of whether gender is defined as the gender of the farmer or gender of the household head.

## 7. Access to key inputs and information

The results presented in Table 1 suggest that gender per se is not significantly associated with MV or fertilizer adoption rates, although the gender of the household head may be important. Based on this finding, we ask whether gender is linked to factors that indirectly influence adoption behavior. In particular, since adoption is associated with land ownership, number of adult men in the farmer's household (MV adoption only), education, and number of contacts with the extension service, are these factors correlated with gender?

Descriptive statistics and simple linear regressions can help to determine if women and men enjoy equal access to land, labor, education, and extension services.

### 7.1. Land

Wealth is often positively associated with the adoption of new technologies, because wealthier farmers are better able to bear risk and therefore are more likely to try new technologies. In rural Ghana, land ownership provides a good measure of wealth. Clearly, there is some sort of association between land ownership and gender: women tend to own smaller plots than men, and a greater proportion of women are landless (Table 3). Similarly, women tend to cultivate smaller plots than do men.[5] Female farmers in female-headed households own and cultivate smaller plots than female farmers in male-headed households. The determinants of land ownership were explored using a tobit approach. Controlling for the farmer's age, residency status (native or settler), and marital status, as well as for ecological zone and level of infrastructure, women farmers on average were found to have significantly less access to land (Table 4).

[5] The amount of land cultivated by individual farmers reflects not only their access to land but also their access to the labor needed to cultivate it.

Table 4
Determinants of land ownership (tobit estimates)

| Determinants | Estimated coefficient | Standard error | Significance level |
|---|---|---|---|
| Female | −1.455 | 0.707 | ** |
| Resident status | 3.574 | 0.670 | *** |
| Age | −0.003 | 0.003 | |
| Infrastructure | 0.215 | 0.268 | |
| Coastal Savannah | −2.598 | 0.860 | *** |
| Guinea Savannah | 5.100 | 0.795 | *** |
| Transition zone | −0.474 | 0.093 | |
| Marital status | −5.60 E−03 | 0.79 | |
| Log likelihood = −1109.25 | | | |

** Significant at the 0.05 level.
*** Significant at the 0.01 level.

## 7.2. Labor

Throughout many parts of sub-Saharan Africa, women have greater difficulty than men in obtaining labor, especially male labor needed for land preparation activities (e.g. clearing, burning, plowing). Within our sample, women farmers live in households that contain slightly fewer men on average, except for in the transition zone (Table 5). Household size varies by zone, but within zones there do not appear to be significant differences between the household sizes of male and female farmers. The data thus suggest that male and female maize farmers live in households that contain approximately the same number of adults. Female-headed households have fewer men, but they still contain some adult men. The data do not allow us to determine who these men are, but they may be adult sons.

What these numbers cannot tell us, however, is whether male and female maize farmers have equal access to the labor of other household members. In many parts of Africa, men have claim over women's labor, but women do not have similar claim over men's labor. Therefore, the data do not allow us to conclude that female farmers have access to male labor; they simply indicate that the households in which female farmers live include men who could potentially provide labor.

## 7.3. Education

Although education is not an input, education is known to be important in determining farmers' ability to understand and manage unfamiliar technology. The regression results indicate that education is a significant determinant of MV adoption in Ghana. Education patterns vary by gender. Female farmers have less years of schooling, on average, than male farmers (Table 6). Female farmers in female-headed households have less years of education than female farmers in male-headed households (Table 7).

Table 5
Household size and composition, by zone and gender of farmer[a]

| Household size | Coastal Savannah | | | Forest | | | Transition | | | Guinea Savannah | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male farmers | Female farmers | | Male farmers | Female farmers | | Male farmers | Female farmers | | Male farmers | Female farmers | |
| | | Male HH | Female HH | | Male HH | Female HH | | Male HH | Female HH | | Male HH | Female HH |
| Men | 3.1 | 2.7 | 2.2 | 2.4 | 2.3 | 1.6 | 2.3 | 3.0 | 2.6 | 4.3 | 3.0 | – |
| Women | 2.9 | 2.7 | 3.1 | 2.3 | 2.2 | 2.1 | 2.8 | 3.9 | 4.1 | 4.0 | 2.0 | – |
| Children | 3.5 | 3.7 | 7.1 | 3.5 | 3.5 | 2.8 | 3.6 | 5.3 | 4.3 | 7.2 | 8.0 | – |
| Total | 9.5 | 9.1 | 12.4 | 8.2 | 8.0 | 6.5 | 8.7 | 11.9 | 11.0 | 15.5 | 13.0 | – |

[a] Source: 1998 CRI/CIMMYT survey.

Table 6
Average years of schooling, by gender and gender of household head[a]

| | Men | Women | | All |
|---|---|---|---|---|
| | | Male HH | Female HH | |
| Years of schooling | 6.25 | 4.60 | 2.84 | 5.70 |

[a] Source: 1998 CRI/CIMMYT survey.

Table 7
Education level, by gender (number, percent of maize farmers)[a]

| Years of schooling | Men | Women | | All |
|---|---|---|---|---|
| | | Male HH | Female HH | |
| 0 | 107 (34.2) | 28 (38.4) | 21 (65.6) | 156 (37.3) |
| 1–3 | 13 (4.2) | 2 (2.7) | 1 (3.1) | 16 (3.8) |
| 4–6 | 24 (7.7) | 17 (23.3) | 3 (9.4) | 44 (10.5) |
| 7–10 | 129 (41.2) | 26 (35.6) | 5 (15.6) | 160 (38.3) |
| ≥10 | 40 (12.8) | 0 (0.0) | 2 (6.3) | 42 (10.0) |
| Total | 313 (100.0) | 73 (100.0) | 32 (100.0) | 418 (100.0) |

[a] Source: 1998 CRI/CIMMYT survey.

### *7.4. Extension contacts*

The uptake of new technologies is often influenced by the farmer's contact with extension services, since extension agents provide improved inputs and technical advice. Within our sample, the frequency of contact with extension agents is strongly associated with the gender of the farmer. On average, women reported fewer contacts with extension agents, and a larger proportion of women reported no extension contacts at all (Table 8). In interpreting the data in Table 8, it is important to keep in mind that differences in the number of reported contacts with extension agents may not be attributable to the gender of the farmer but instead could result from other factors that are correlated with the gender of the farmer. For example, it is plausible that extension agents might prefer to visit farmers with more land, a larger area planted to maize, or those who have already adopted improved technologies, all of which happen to be correlated with gender.

On the whole, these findings suggest that male and female maize farmers in Ghana do not enjoy equal access to land, education, and agricultural extension services. The data are less conclusive regarding the availability of and access to labor, especially male labor within the household.

## 8. Discussion

In view of this evidence, what can we conclude about the three questions posed at the beginning of the paper?

First, in this example involving maize in Ghana, after we control for farmer's age and level of education, access to land and labor, contact with the extension service, and market access, there is no significant association between the gender of the farmer and the probability of adopting MVs or fertilizer. Since men and women have adopted MVs and fertilizer at different rates, this finding shows the critical importance of correctly specifying adoption models. Failure to control for gender-linked factors can lead to misleading conclusions about the importance of gender per se as an explanatory factor.[6]

Second, being a female farmer and living in a female-headed household affect the adoption decision in quite different ways. Therefore, although people living in female-headed households are less likely to adopt new technologies than people living in male-headed households, this does not necessarily mean that female farmers are less likely to adopt new technologies than male farmers. Admittedly, simply identifying the gender of the household head does not completely capture what we are interested in, which is whether women farmers can mobilize the support of male household members in order to gain access to resources. However, this information tends to be difficult to obtain through conventional survey methods, so gender of the household head is a useful proxy.[7]

[6] One caveat should be noted. The sample includes only farmers who were identified as 'maize farmers'. If either men or women were disproportionately excluded from the sample because they were not considered maize farmers, the results could be biased. The proportion of women farmers in the sample corresponds to the percentage of women growing maize identified through the 1991–1992 round of the Ghana Living Standard Survey (reported in Doss (1997)), however, so we believe these results were not affected by sample selection bias.

[7] In some cases, making assumptions about control of resources based on the gender of the household head can lead to incorrect conclusions. For example, women farmers frequently report that their husband is the head of the household, even though he may live elsewhere and may not be involved in agricultural decision-making.

Table 8
Reported number of contacts with extension agents, by zone and gender of farmer (number, percent of maize farmers)[a]

| Number of contacts | Coastal Savannah | | | Forest | | | Transition | | | Guinea Savannah | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male farmers | Female farmers | | Male farmers | Female farmers | | Male farmers | Female farmers | | Male farmers | Female farmers | |
| | | Male HH | Female HH | | Male HH | Female HH | | Male HH | Female HH | | Male HH | Female HH |
| 0 | 31 (51.7) | 8 (53.3) | 7 (77.8) | 67 (50.8) | 19 (45.2) | 87 (53.3) | 27 (65.9) | 9 (64.3) | 5 (62.5) | 53 (64.6) | 2 (100.0) | – |
| 1–3 | 11 (18.3) | 4 (26.7) | 1 (11.1) | 14 (10.6) | 8 (19.0) | 0 (0.0) | 3 (7.3) | 2 (14.3) | 1 (12.5) | 16 (19.5) | 0 (0.0) | – |
| 4–7 | 9 (15.0) | 1 (6.7) | 0 (0.0) | 22 (16.7) | 7 (16.7) | 2 (13.3) | 9 (22.0) | 1 (7.1) | 2 (25.0) | 6 (7.3) | 0 (0.0) | – |
| ≥8 | 9 (15.0) | 2 (13.3) | 1 (11.1) | 29 (22.0) | 8 (19.0) | 5 (33.3) | 2 (4.9) | 2 (14.3) | 0 (0.0) | 7 (8.5) | 0 (0.0) | – |
| Total | 60 (100.0) | 15 (100.0) | 9 (100.0) | 132 (100.0) | 42 (100.0) | 15 (100.0) | 41 (100.0) | 14 (100.0) | 8 (100.0) | 82 (100.0) | 14 (100.0) | – |

[a] Source: 1998 CRI/CIMMYT survey.

Third, the observed measures of access to land and number of extension contacts are clearly correlated with gender. However, it is not possible to determine from the data whether women have access to the same quality of land as men. Nor can it be determined whether the quantity and/or quality of information provided by extension workers differ depending on the gender of the farmer. If women consistently have access to poor quality land or consistently receive poorer quality extension information, this would bias our results, in the sense that the effect of gender would be overstated (i.e. the absolute value of the estimated coefficient on the gender variable in an adoption equation would be larger). Conversely, if women consistently farm better quality land or consistently receive better extension information, the effect of gender would be understated. Also, as previously noted, although the number of men in the household is correlated with MV adoption, simply counting the number of household members does not reveal whether women are able to mobilize the labor that is present in their households to work in their maize fields. Thus, even though differences can be observed in access to land, extension visits, and male household labor, unobserved differences may also be present, and these unobserved differences may be as significant or even more significant in influencing adoption behavior.

On the whole, these results from Ghana suggest that technology adoption decisions depend primarily on access to resources, rather than on gender per se. This conclusion should be interpreted with caution, however, because it does not necessarily mean that MVs and fertilizer are gender-neutral technologies. If adoption of MVs and/or fertilizer depend on access to land, labor, or other resources, and if, in a particular context, men tend to have better access to these resources than women, then in that context, the technologies will not benefit men and women equally. Policy changes thus may be needed to increase women's access to the key resources; alternatively, it may be desirable to modify research efforts by deliberately targeting technologies that are particularly suited for the resources that are available to women. The bottom line is that it is important to examine both the technology itself and the physical and institutional context in which the technology is implemented in order to predict whether it will be adopted successfully by women as well as men.

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