Gender gaps in the adoption of modern agricultural technologies

Caroline Miehe and Anusha De

October 28, 2025

Abstract

This study investigates the barriers to effective uptake and impact of modern agricultural technologies among female smallholder farmers, using three rounds of previously self-collected panel data from 3,500 maize-farming households in Uganda. It pursues three objectives. First, we estimate gender gaps in the adoption of improved maize varieties, in agricultural productivity, and in income. Second, we apply the Blinder-Oaxaca decomposition to disentangle the extent to which these gaps are driven by differences in observable endowments versus structural factors. Third, recognizing that women may realize smaller gains from technology adoption even when adopting the same modern agricultural technology, we assess the impact of adopting an improved maize variety on farm productivity and income for female-headed households. To address potential endogeneity, we employ an instrumental variable strategy that leverages randomized exposure to a prior experiment, which influenced adoption behavior but is plausibly exogenous to farm productivity or income. The study contributes new evidence on gender-differentiated impacts of modern technologies and sheds light on constraints to equitable productivity gains from agricultural innovations.

1 Introduction

Agriculture is the backbone of many sub-Saharan African economies, contributing a large share of both output and employment. Although increasing agricultural productivity is essential for GDP growth, poverty reduction, food security, and structural transformation, progress has remained stubbornly slow, with productivity growth lagging well behind other regions (e.g., Suri & Udry, 2022).

One of the most persistent and costly inefficiencies is the gender gap in agricultural productivity and income (Buehren, 2023). Structural, institutional, and social constraints systematically disadvantage female farmers and female-headed households. Women are more likely to farm smaller and lower-quality plots, face weaker land rights, and have more limited access to credit, labor, inputs, and information. Time constraints due to household and caregiving responsibilities further restrict their productive capacity, while limited market access and weaker bargaining power reduce returns and reinvestment opportunities. Risk aversion, exacerbated by narrower financial safety nets, also hampers the adoption of high-return practices.

Another key constraint on agricultural productivity is the widespread under-adoption of modern agricultural technologies, such as improved seeds and fertilizers. Despite decades of investment by CGIAR and others, uptake remains well below potential, as outlined in a recent review by Suri and Udry (2022). And again, women are consistently less likely to adopt productivity-enhancing technologies due to economic, social, institutional, and cultural barriers. These include limited access to extension services, agricultural networks that facilitate technology diffusion, and credit to purchase inputs.

Crucially, even when women adopt improved technologies despite those additional constraints, their productivity and income gains are often smaller. This reflects persistent disadvantages in complementary resources such as fertilizer, labor, and land quality. Inadequate access to agronomic advice, labor shortages linked to domestic responsibilities, and restricted access to markets further erode potential gains. Understanding and addressing these gender-differentiated constraints is essential for achieving inclusive agricultural transformation and realizing the full benefits of modern innovations.

2 Research questions

RQ1: To what extent do gender gaps exist in the adoption of improved maize varieties, agricultural productivity, and farm income?

RQ2: What is the relative importance of endowment versus structural effects to the gender gap in agricultural technology adoption and productivity?

RQ3: What is the impact of adopting improved maize seed varieties on farm productivity and income among female-headed households?

Literature review

First, we contribute to the literature on gender gaps in the agricultural sector (incl. De, Miehe, and Van Campenhout, 2024). While women constitute a substantial share of the African agricultural labor force – over 50% in Malawi, Tanzania, and Uganda; 37% in Nigeria; 29% in Ethiopia; and 24% in Niger (Palacios-Lopez et al., 2017) – they consistently produce less per unit of land than men. In 2014, estimated gender productivity gaps ranged from 6% in Tanzania to 25% in Malawi (O'Sullivan et al., 2014). More recent estimates indicate a gap of 11% in the Democratic Republic of the Congo (World Bank, 2021) and 30% in Nigeria (World Bank, 2022). We extend this body of work by estimating gender gaps in agricultural productivity and income using plot-level data from the Busoga region of Uganda for 2021–2022.

Second, we advance the literature that disentangles the roles of endowment versus structural effects in driving gender disparities. Women face two broad types of constraints: limited access to productive inputs (endowment effect) and discriminatory social norms and practices that reduce returns to those inputs (structural effect). Existing studies indicate that both play a role. When gender differences in access to inputs are controlled for, the estimated productivity gap often narrows (Gilbert et al., 2002 in Malawi; Kinkingninhoun-Mêdagbé et al., 2010 in Benin), highlighting the importance of endowments. However, other studies find that productivity gaps persist even after equalizing input access, pointing to structural constraints (Ali et al., 2016 in Uganda; Bello et al., 2021 in Nigeria; O'Sullivan et al., 2014 in Malawi, Niger, Uganda, Tanzania, and northern Nigeria). We contribute to this literature by estimating the relative contributions of endowment and structural effects to gender gaps in agricultural productivity and income in Busoga.

Third, we contribute to research on gender disparities in agricultural technology adoption. Female farmers are generally less likely to adopt modern inputs, and when they do, tend to use them less intensively (Sheahan and Barrett, 2017). Studies report lower fertilizer access and adoption among women in Malawi, Niger, northern Nigeria, and Uganda (O'Sullivan et al., 2014). In Nigeria, male farmers use over eight times more fertilizer and 50% more herbicide per hectare than women (World Bank, 2022). While most of this literature focuses on fertilizer, we examine gender gaps in the adoption of improved maize seed varieties, a key technology promoted by CGIAR institutions, where evidence remains limited. Moreover, we assess whether adoption disparities are driven more by endowments or by structural barriers.

Lastly, we contribute to evidence on the impacts of agricultural technology adoption by estimating the effect of improved maize seed adoption on productivity and income among female-headed households. While some studies report lower returns from fertilizer use among women (O'Sullivan et al., 2014), others show that fertilizer subsidies increase productivity for both genders but do little to reduce gender gaps (Giné et al., 2015; Kilic et al., 2015; Karamba and Winters, 2015; Ngoma et al., 2021), and again others suggest women may benefit more from bundled interventions: in Benin, women provided with both inputs and information for Nerica rice cultivation achieved higher yields and incomes (Agboh-Noameshie et al., 2007). These mixed findings suggest that the productivity impact of agricultural technology adoption may vary by gender. We contribute to this literature by providing evidence on the gender-differentiated returns to modern agricultural technology adoption.

3 Data

We examine the constraints to uptake and the potential impact of improved maize seed varieties using panel data from three survey rounds with approximately 3,500 smallholder maize farmers in southeastern Uganda. The data were originally collected for a project focused on agro-dealers and their customers. The agro-dealer sample was constructed by listing all agro-dealers operating across eleven districts in the Busoga region. To link agro-dealers with farmers, each agro-dealer was asked to identify the villages where most of their customers reside. Enumerators then randomly sampled ten maize-growing households from each of these villages, yielding the sample of about 3,500 farmers. Baseline data were collected in April 2021, followed by midline surveys in January-February 2022 and endline surveys in July-August 2022.

Enumerators interviewed the household member most knowledgeable about maize cultivation. A subset of questions specifically targeted the household head, who may or may not have been the respondent. In addition to general information on agricultural practices, farmers were asked to list all their maize plots, from which one was randomly selected for detailed data collection. This approach minimized survey duration and respondent burden while preserving representativeness at the household level, due to the random selection of plots.

```
## Error in eval(ei, envir):  oggetto 'tab_latex' non trovato
```

Notes

- At baseline, we asked for the gender of the household head (though it is likely that the gender of the respondent was recorded instead). At midline, no gender information was collected, but it is unlikely to have changed since baseline. At endline, we recorded both the gender of the household head and the gender of the respondent (as I became concerned about this issue between midline and endline and added a question). While this allows for inter-household analyses, we do not always have the gender of the farmer managing the randomly selected plot for which we have data. Furthermore, most farming takes place on plots jointly managed by men and women. These limitations represent a weakness of the study.
- We have relatively few female-headed households, which limits statistical power. At baseline, we supposedly recorded the gender of the household head, identifying 774 female-headed households (22% of 3,470 farmers). At endline, we recorded 760 female respondents (23% of 3,299). While we also collected household head gender at endline, 2,848 observations are missing, suggesting that enumerators may have consistently recorded the gender of the respondent rather than the household head—likely at baseline as well.
- We have multiple measures of adoption, including self-reported use of improved seed on any plot, use of seed from an agro-shop on any plot, hybrid seed or OPV on a specific plot, and use of seed from an agro-shop on a specific plot. We should carefully consider which measure to use.

4 Methods

1. We will begin with a comprehensive review of the literature on gender gaps in agricultural technology adoption, productivity, and income.

Table 1: Descriptive statistics

	Male-headed households					Female-headed households				
	Mean	Min	Max	SD	Obs.	Mean	Min	Max	SD	Obs.
Distance of homestead to nearest agro-input shop selling maize seed in km	3.85	0	52	4.86	2621	3.54	0	40	4.51	718
Number of agro-input shops in the village or neighborhood	2.19	0	25	2.41	2586	2.05	0	20	2.09	677
Available land for crop production in acres	3.53	0	100	4.52	2679	2.70	0	50	3.46	763
Number of plots used to grow maize	1.48	1	5	0.74	2696	1.40	1	4	0.66	774
Area of randomly selected maize plot in acres	1.23	0	15	0.99	2696	1.01	0	20	1.01	769
Total cost of seed used in UGX	40984.12	0	1000000	65745.26	1359	28472.17	0	250000	40881.33	318
DAP/NPK applied (1 = Yes)	0.25	0	1	0.44	2692	0.23	0	1	0.42	773
Urea applied (1 = Yes)	0.07	0	1	0.26	2693	0.09	0	1	0.29	773
Pesticides, herbicides or fungicides applied (1 = Yes)	0.42	0	1	0.49	2691	0.38	0	1	0.48	772
Number of household members	8.85	1	25	4.03	2696	8.15	1	25	3.73	774
Household-head finished finished primary education (1 = Yes)	0.56	0	1	0.50	2668	0.34	0	1	0.48	769
Respondent is the spouse of the household head (1 = Yes)	0.91	0	1	0.28	712	0.87	0	1	0.33	212
The respondent is household head (1 = Yes)	0.72	0	1	0.45	2696	0.72	0	1	0.45	774
Age of household head in years	48.31	18	95	13.37	2680	49.68	20	97	13.40	773
Household head is married (1 = Yes)	0.98	0	1	0.15	2696	0.56	0	1	0.50	774
The respondent used quality seeds (1 = Yes)	0.51	0	1	0.50	2694	0.42	0	1	0.49	772
Household sold maize (1 = Yes)	0.55	0	1	0.50	2696	0.39	0	1	0.49	774
Number of bags sold	5.30	0	250	10.12	1476	3.87	0	30	4.05	303
Bag price in thousand UGX	54.62	0	750	41.81	1471	48.65	0	140	16.17	303
Yield in kg	341.38	0	70000	1905.45	1470	190.84	1	1500	218.07	303
Income from maize sales in thousand UGX	517.90	20	3240	491.08	2635	393.78	20	3080	428.71	754
Maize productivity in kg/acres	478.10	15	4333	387.65	2635	450.88	13	4000	450.42	749
Maize productivity in kg/acre (IHS)	6.58	3	9	0.78	2635	6.42	3	9	0.90	749

Note: For each variable, columns (1)-(5) report mean, min, max, SD, and non-missing observations for *Male*; columns (6)–(10) report the same for *Female*. All statistics are measured at baseline.

2. We will estimate gender gaps in (i) the adoption of improved maize seed varieties, (ii) agricultural productivity (yield), and (iii) agricultural income (sales and revenue). + Anusha's marginal returns idea

3. To investigate the sources of gender disparities in adoption, productivity, and income, we will apply the Blinder-Oaxaca decomposition (Blinder, 1973; Oaxaca, 1973). This method decomposes observed gender gaps into two components:

   (a) Endowment Effect: Captures differences due to observable farmer and farm-household characteristics, such as access to land, credit, education, and inputs. These are factors that reflect unequal resource access.

   (b) Structural Effect: Captures differences in returns to those resources, potentially reflecting discriminatory social norms or practices – for example, women receiving lower prices for the same outputs. This component accounts for unexplained variation not attributable to observable endowments.

4. Women may derive lower productivity and income gains from adopting the same improved maize varieties as men, hence we will estimate the impact of adoption on productivity and income for female-headed households. To address potential endogeneity and isolate the causal effect, we will implement an instrumental variables strategy. Specifically, we will use exposure to a previously implemented experiment as an instrument: it affects the likelihood of adoption but does not directly affect farm productivity or income. Using two-stage least squares, the first stage will predict adoption based on the instrument, and the second stage will estimate the effect of predicted adoption on productivity and income. + Anusha's marginal returns idea (see Note above)

5 Conclusion

Given the substantial benefits of modern agricultural technologies, this study addresses a high-impact research area. While both men and women face adoption challenges, our focus is on understanding constraints specific to female farmers. The project will generate actionable evidence to enhance technology uptake among female smallholders in sub-Saharan Africa, a critical step toward building resilience in a vulnerable population.

6 Notes

- Look into Women's Empowerment in Agriculture Index (WEAI)

7 Literature

- Agboh-Noameshie, A. R., Kinkingninhoun-Medagbe, F. M., & Diagne, A. (2007). Gendered impact of NERICA adoption on farmers' production and income in Central Benin. In 2nd Conference of the African Association of Agricultural Economists, Accra, Ghana, 18–22.

- Ali, D., Bowen, D., Deininger, K., & Duponchel, M. (2016). Investigating the gender gap in agricultural productivity: Evidence from Uganda. *World Development*, 87, 152–170.

- Bello, L. O., Baiyegunhi, L. J., Danso-Abbeam, G., & Ogundeji, A. A. (2021). Gender decomposition in smallholder agricultural performance in rural Nigeria. *Scientific African*, 13, e00875.

- Blinder, A. S. (1973). Wage discrimination: Reduced form and structural estimates. *Journal of Human Resources*, 8, 436–455.

- Buehren, N. (2023). Gender and agriculture in Sub-Saharan Africa: Review of constraints and effective interventions. Gender Innovation Lab. World Bank, Washington, DC.

- De, A., Miehe, C., & Van Campenhout, B. (2024). Gender bias in customer perceptions: The case of agro-input dealers in Uganda. *Agricultural Systems*, 217, Article 103954.

- Gilbert, R. A., Sakala, W. D., & Benson, T. D. (2002). Gender analysis of a nationwide cropping system trial survey in Malawi. *African Studies Quarterly*, 6(1).

- Gine, X., Patel, S., Cuellar-Martinez, C., McCoy, S., & Ralph, L. (2015). Enhancing food production and food security through improved inputs: An evaluation of Tanzania's National Agricultural Input Voucher Scheme with a focus on gender impacts. 3ie Impact Evaluation Report No. 23. New Delhi: International Initiative for Impact Evaluation.

- Karamba, W., & Winters, P. C. (2015). Gender and agricultural productivity: Implications of the Farm Input Subsidy Program in Malawi. *Agricultural Economics*, 46(3), 357–374.

- Kilic, T., Palacios-Lopez, A., & Goldstein, M. (2015). Caught in a productivity trap: A distributional perspective on gender differences in Malawian agriculture. *World Development*, 70, 416–463.

- Kinkingninhoun-Mêdagbé, F. M., Diagne, A., Simtowe, F., Agboh-Noameshie, A. R., & Adégbola, P. Y. (2010). Gender discrimination and its impact on income, productivity, and technical efficiency: Evidence from Benin. *Agriculture and Human Values*, 27(1), 57–69.

- Miehe, C., Nabwire, L., Sparrow, R., Spielman, D. J., & Van Campenhout, B. (in press). Miracle seeds: Biased expectations, complementary input use, and the dynamics of smallholder technology adoption. *Economic Development and Cultural Change*.

- Miehe, C., Sparrow, R., Spielman, D. J., & Van Campenhout, B. (2025). The (perceived) quality of agricultural technology and its adoption: Experimental evidence from Uganda. Unpublished manuscript.

- Ngoma, H., Machina, H., & Kuteya, A. N. (2021). Can agricultural subsidies reduce gendered productivity gaps? Panel data evidence from Zambia. *Development Policy Review*, 39(2), 303–323.

- Oaxaca, R. (1973). Male–female wage differentials in urban labor markets. *International Economic Review*, 14, 693–709.

- O'Sullivan, M., Rao, A., Banerjee, R., Gulati, K., & Vinez, M. (2014). Levelling the field: Improving opportunities for women farmers in Africa. World Bank, Washington, DC.

- Palacios-Lopez, A., Christiaensen, L., & Kilic, T. (2017). How much of the labor in African agriculture is provided by women? *Food Policy*, 67, 52–63.

- Sheahan, M., & Barrett, C. B. (2017). Ten striking facts about agricultural input use in Sub-Saharan Africa. *Food Policy*, 67, 12–25.

- Suri, T., & Udry, C. (2022). Agricultural technology in Africa. *Journal of Economic Perspectives*, 36(1), 33–56.

- World Bank. (2021). Women's economic empowerment in the Democratic Republic of the Congo: Obstacles and opportunities. Washington, DC: World Bank.

- World Bank. (2022). Closing gaps, increasing opportunities: A diagnostic on women's economic empowerment in Nigeria. Washington, DC: World Bank.