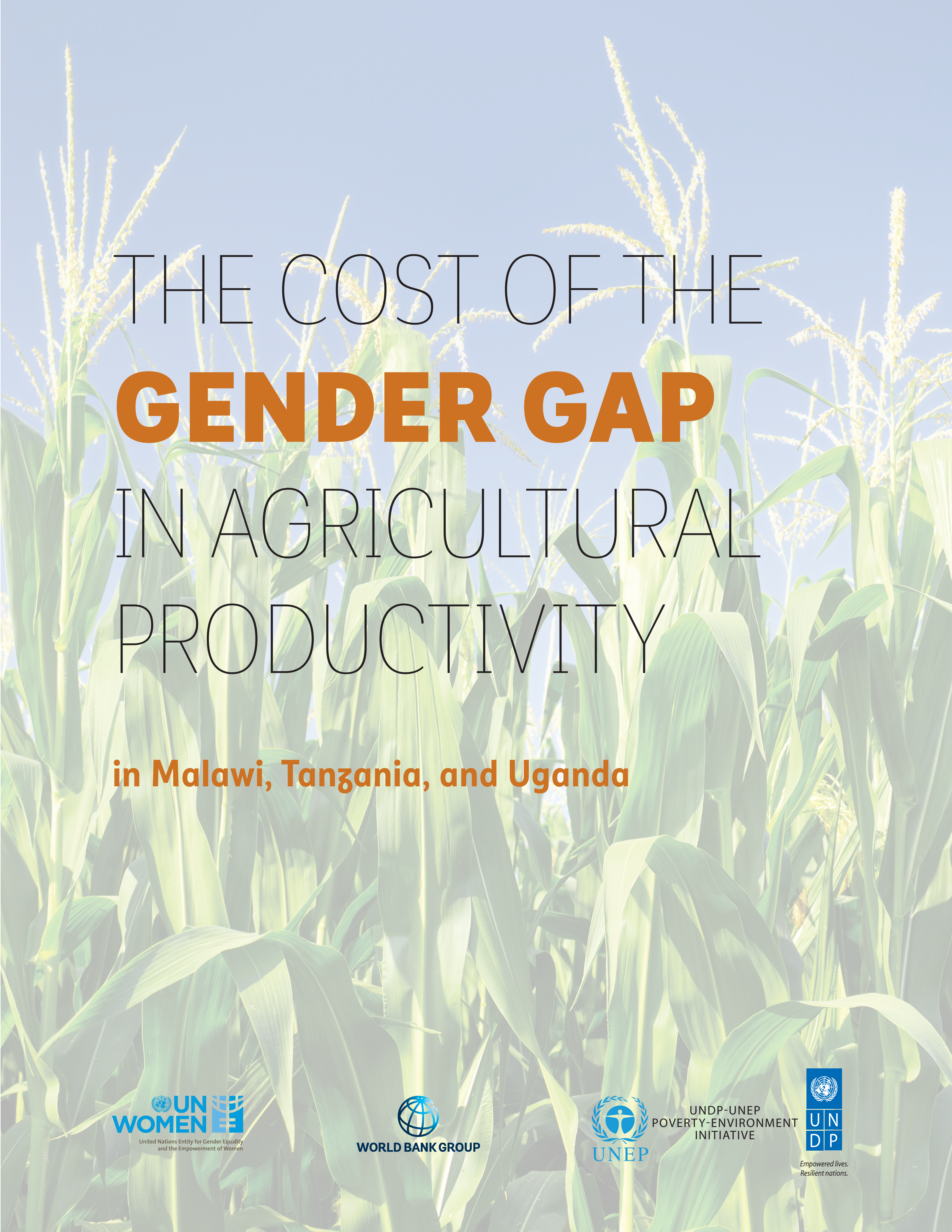

THE COST OF THE **GENDER GAP** IN AGRICULTURAL PRODUCTIVITY

in Malawi, Tanzania, and Uganda

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This report is a joint product of UN Women, the United Nations Development Programme–United Nations Environment Programme Poverty-Environment Initiative (UNDP-UNEP PEI) Africa, and the World Bank. The collaboration was led by UN Women, Eastern and Southern Africa Regional Office (ESARO).

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Design and editing: Nita Congress

Contents

Foreword

Women form a large proportion of the agricultural labor force in Sub-Saharan Africa and thus play a vital role in ensuring family nutrition and food security. In Eastern and Southern Africa, agriculture continues to be a key engine for local and regional economies, represents a critical source of income and ensures food security and nutrition. However, as has been widely documented, gender-based inequalities in access to and control of productive and financial resources inhibit agricultural productivity and reduce food security. A new study measuring the economic costs of the gender gap in agricultural productivity in three African countries—Malawi, the United Republic of Tanzania (hereafter Tanzania), and Uganda—provides further evidence that reducing the gender gap plays a significant role in poverty reduction and improved nutritional outcomes.

While there is mounting evidence on the link between promoting women's equality and economic empowerment and other development outcomes, such as sustainable agricultural and economic growth, gender issues are being inadequately reflected in agricultural policy strategies and programs. At the same time, a changing climate means that there is a shrinking window of opportunity for action, and it is imperative that climate-smart approaches to agriculture help close the gender gap and promote women's empowerment, economic development, and societal resilience to shocks.

Recognizing the need for more specific evidence of the economic gains from closing the gender gap, UN Women, the joint United Nations Development Programme–United Nations Environment Programme Poverty-Environment Initiative, and the World Bank collaborated on this study which measures the size of the gender gap in monetary terms.

The report provides a unique quantification of the costs in terms of lost growth opportunities and an estimate of what societies, economies, and communities would gain if the gender gap in agriculture is addressed. The findings of this report are striking, and send a strong signal to policy makers in Africa as well as development partners that **closing the gender gap is smart economics.** Consider this: closing the gender gap in agricultural productivity could potentially lift as many as 238,000 people out of poverty in Malawi, 80,000 people in Tanzania, and 119,000 people in Uganda.

The Sustainable Development Goals (SDGs) offer a historic opportunity to shift from development in silos to a more integrated approach. This work provides evidence and policy recommendations that can support the achievement of the SDGs—which include a specific goal on achieving gender equality and empowering all women and girls—as well as the objectives of the Comprehensive Africa Agricultural Development Programme (CAADP). The report also provides guidance on the factors that must be targeted in order to close the gender gap and improve opportunities for women farmers. It concludes with a set of general policy recommendations on how women's empowerment, agriculture productivity, and economic growth can be addressed in an integrated manner in order to achieve the SDGs at the national level.

It is our hope that the report will be used by policy makers and practitioners to propose and implement gender-sensitive—and environmentally sustainable—agriculture-related policies and programs.

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1 Introduction: the gender gap in agricultural productivity

Women comprise a large proportion of the agricultural labor force in Sub-Saharan Africa, ranging from 30 to 80 percent (FAO 2011).[1] Yet women farmers are consistently found to be less productive than male farmers. The gender gap in agricultural productivity—measured by the value of agricultural produce per unit of cultivated land—ranges from 4 to 25 percent, depending on the country and the crop (World Bank and ONE 2014).[2]

Agricultural productivity = the gross value of output (in local currency) produced per hectare of land

This gap exists because women frequently have unequal access to key agricultural inputs such as land, labor, knowledge, fertilizer, and improved seeds.[3] The fact that the gender gap persists suggests that the underlying constraints are still inadequately tackled in agricultural policy strategies and programs. Low agricultural productivity tends to reduce per hectare yields and leads to more intense farming—resulting in overcultivation, soil erosion, and land degradation. These in turn further undermine agricultural productivity and environmental sustainability. The evidence presented in this report addresses this situation and offers guidance to policy makers on how to increase agricultural productivity and national economic growth, strengthen food security, and support poverty reduction across Sub-Saharan Africa.

[1] Using individual-disaggregated, plot-level labor input data from nationally representative household surveys, Palacios-Lopez, Christiaensen, and Kilic (2015) report the female share of agricultural labor for Malawi, Tanzania, and Uganda to be 52, 52, and 56 percent, respectively.

[2] Additional information on gender-disaggregated productivity estimates for these countries can be found in Akresh (2005); FAO (2011); Gilbert, Sakala, and Benson (2002); Goldstein and Udry (2008); Hill and Vigneri (2014); Peterman, Behrman, and Quisumbing (2014); Tiruneh et al. (2001); and Udry (1996).

[3] Sheahan and Barrett (2014) report for their sample of six Sub-Saharan countries that female-headed households statistically significantly apply, use, and own less modern agricultural inputs compared to male-headed ones; and that plots owned or managed by women are less likely to receive modern agricultural inputs and receive lesser amounts when applied. However, the sex of the plot manager or owner appears to be a lesser determinant of input use in Tanzania and Uganda compared to Malawi.

In this report, we estimate the **monetary value of the gender gap in agricultural productivity** in Malawi, Tanzania, and Uganda. Box 1.1 presents a profile of female farmers in these countries. We then look at what the size of this gap means relative to gross domestic product (GDP) and poverty reduction.

BOX 1.1

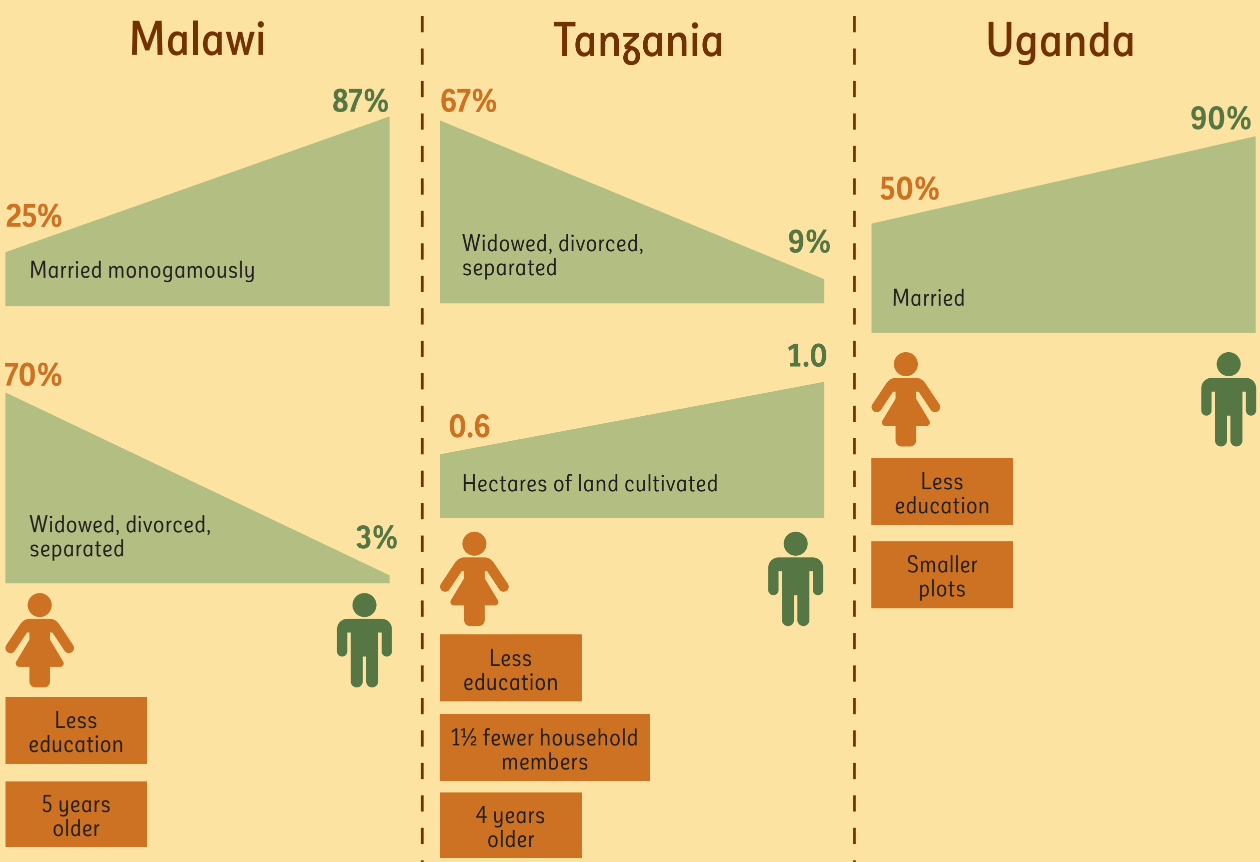
Who is a woman farmer?

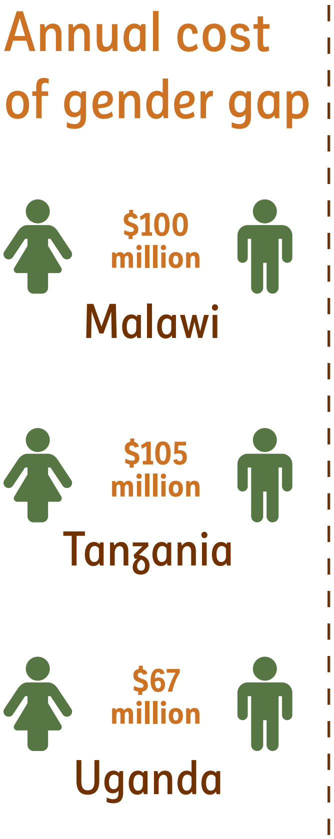
In the three countries profiled in this report, female farm managers are found to have lower levels of education and a smaller average family size, and to be less wealthy compared to all other plot managers.

In **Malawi**, women farmers are older by over five years, on average, and also have lower levels of education as compared to male managers. Only 25 percent of sole female managers are married monogamously, as compared to 87 percent of male managers. Seventy percent of them are widowed, divorced, or separated, compared to only 3 percent among male managers.

In **Tanzania**, women farm managers are about four years older than all other managers, have a lower educational attainment (roughly two years' less schooling), and live in households with about 1.5 fewer household members. This latter statistic may be partly explained by the fact that 67 percent of the sole female managers are widowed, divorced, or separated compared to only 9 percent in the sample of other plot managers. While women managers cultivate about 0.6 hectares of land on average, all other managers cultivate more than 1 hectare—a difference that is statistically significant.

In **Uganda**, women managers cultivate plots that are on average about 0.23 hectares smaller than those managed by males. They average about two years' less schooling than male managers. And only 50 percent of the female managers are married, compared to 90 percent of the male managers.





We estimate that the gender gap amounts to $100 million in Malawi, $105 million in Tanzania, and $67 million in Uganda per year.[4] Throughout this study, we express monetary values in terms of 2010 prices. These estimates can help policy makers understand the scale of the gains that could be made from designing better policies to improve women's ability to use agriculture to lift themselves and their families out of poverty and to contribute to economic growth (box 1.2). It is important to stress that these potential gains to do not come without cost. Closing the gender gap will require changing existing or designing new policies, which may require additional resources.

We then go beyond these figures to estimate the **costs associated with gender gaps in access to individual agricultural inputs**. This evidence can help policy makers decide where efforts are most needed. For example, understanding that 97 percent of the gender gap in Tanzania is due to women's lower access to male labor can help decision makers—especially national governments, international organizations, and development partners—better focus their efforts. For policy makers from countries not covered in this study, our analysis could be replicated using data from their own country. (See boxes 3.1 and 3.2 for more details on the methodology and data used for the costing exercise presented in this report.)

BOX 1.2
Linking the gender gap in agricultural productivity to poverty and food security

In addition to impacts on overall national income, closing the gender agricultural productivity gap could reduce poverty and improve nutrition: directly, because many poor people work in agriculture; and indirectly, because higher agricultural output may increase income for people employed in sectors linked to agriculture. At the same time, higher agricultural output can also lead to lower food prices. The combined impact of increasing the incomes and agricultural productivity of the poor and lowering food prices could help improve nutrition by enabling poor people to purchase more and better food, and by increasing their access to food from their own production.

Also, although no attempt is made to quantitatively capture these in this report, there would likely be impacts on women's empowerment and time use (Chung 2012; Ruel, Alderman and the Maternal and Child Nutrition Study Group, 2013). The factor by which higher growth reduces poverty has been estimated in economywide models developed for Malawi, Tanzania, and Uganda. We use this poverty-agricultural growth conversion factor (also referred to as elasticity) to compute the potential reduction in poverty and malnutrition from narrowing the gender gap (Benin et al. 2008; Pauw and Thurlow, 2011).

Finally, we review existing evidence from impact evaluations and other sources on the **effectiveness of specific policies and interventions in closing the gender gap** in access to different agricultural inputs. Such evidence is essential for helping policy makers think about how they can put the lessons from this analysis into practice. Unfortunately, existing knowledge of effective—let alone cost-efficient—policy instruments to resolve hurdles faced by women farmers is still nascent. For policies to work,

[4] All dollars referred to in this report are U.S. dollars.

it is crucial to recognize that both men and women may face different constraints that hinder them from improving their agricultural practices and that it may be necessary to rethink, innovate, and pilot in order to adequately address women-specific constraints and to document what works and what does not. The list of possible policy approaches can be split into two main groups:

- Making current agricultural policies more **gender responsive**. Such policies may include tweaking existing policies, such as agricultural extension services, to purposely include both women and men.

- Designing new agricultural policies that are **gender targeted**. Policy makers can design agricultural policies that focus specifically on the needs of women farmers, for example, by promoting time- or labor-saving and sustainable technologies.

2 Three takeaways on the gender gap in agricultural productivity

Three key policy lessons emerge from the evidence presented in the remainder of this report.

The gender gap in agricultural productivity is large

Even with the conservative assumptions used in this study, we find that there are large gains to be achieved if policy makers address the gender gap effectively. Annual crop output could increase by 2.1 percent in Tanzania, 2.8 percent in Uganda, and 7.3 percent in Malawi. Taking into account the contribution of crops to total agricultural output, the size of the agricultural sector in the overall economy, and spillover effects of higher agricultural output to other sectors of the economy, we estimate the potential gross gains to GDP to be $100 million in Malawi (or 1.85 percent of GDP), $105 million in Tanzania (0.46 percent of GDP), and $67 million in Uganda (0.42 percent of GDP).[1] While achieving these gains would in itself require additional investments from governments, their magnitude is sufficiently large to justify significant attention.

The potential economic gains from reducing the gender gap translate into significant poverty reduction and improved nutritional outcomes

Increasing GDP by closing the gender gap in agricultural productivity has the potential to lift as many as 238,000 people out of poverty in Malawi, approximately 80,000 people in Tanzania and 119,000 people in Uganda. In Tanzania, for example, this gain also translates into a 0.7 percent reduction in the incidence of undernourishment, which implies that roughly 80,000 people would be lifted out of malnourishment per year. However, closing the gender gap could result in additional improvements as these estimates do not capture all the likely agriculture-nutrition linkages and other spillover effects. For example, increased income in women's hands has implications for the intergenerational

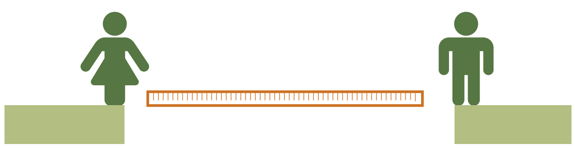
[1] The key empirical step we take to translate the estimated gross gains from closing the gap in agricultural yields between male and female farmers into gains of aggregate value addition (GDP) is to assume that the fraction of agricultural GDP associated with crop production would rise proportionally with the gains in total gross crop production. For more detail, see box 3.1.

transmission of hunger and malnutrition, as women tend to spend more of their income on children's health and education (Ruel, Alderman, and the Maternal and Child Nutrition Study Group 2013; Smith et al. 2003).

To ensure the biggest "bang for the buck," governments should identify and focus on the most costly constraints to women's productivity

This report helps lay the groundwork for deeper analysis as to where to invest for the most effective and cost-effective policies. Our analysis finds that women's lower access to farm labor is one of the most important constraints contributing to the gender gap in Malawi and Tanzania. Closing the gap in the quantity of male labor used could yield gross gains of over $45 million in Malawi and over $100 million in Tanzania. In Uganda, one priority should be improving women's access to agricultural machinery and other production technologies, which has the potential to increase GDP by over $11 million. However, our knowledge of what works is far from complete. Further research should therefore be undertaken to look at the relative impacts of specific policies and interventions as well as their cost-efficiency in order to quantify their net benefits.

Three takeaways



1 The gender gap in agricultural productivity is large.

2 Reducing it may reduce poverty and improve nutrition.

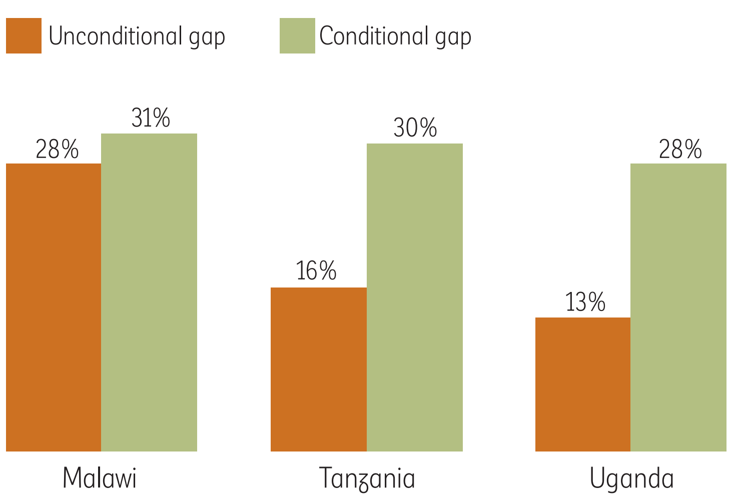
3 Reduce the gap by focusing on most costly constraints.

3 Measuring the cost of the gender gap in agricultural productivity

This section presents estimates of the foregone income (total GDP and agricultural GDP) and poverty reduction potential that result from the gender gap in agricultural productivity in Malawi, Tanzania, and Uganda. Box 3.1 outlines the methodology, which is presented in more detail in appendix A.

In order to make these estimates, we compute the unconditional and conditional values of the gender gap in agricultural productivity. In this report, agricultural productivity is defined as the value of output per hectare. The difference in this measure between male and female farmers constitutes the **unconditional gender gap**, as described in box 3.1. But this unconditional gender gap does not take into account the fact that, on average, women work on smaller plots than men. Generally, farmers are more productive on smaller plots; one reason postulated for this is that they are able to use physical and labor resources to cultivate their plots more intensely (see, for example, Carletto, Gourlay, and Winters 2013 for robust evidence on this inverse relationship for several African countries). But despite cultivating smaller plots relative to men, women are still less productive; this implies that the gender gap would be even larger if we take the smaller size of their plots into account. We do this by calculating the **conditional gender gap**, which is estimated conditional on plot area and agro-climatic conditions. Figure 3.1 shows that the unconditional gender gap ranges from 13 to 28 percent for the three countries studied. The conditional gender gap is even more substantial, ranging from 28 to 31 percent. These findings echo earlier analysis (World Bank and ONE 2014).

FIGURE 3.1
Unconditional and conditional gender gap in agricultural productivity in percentages



BOX 3.1
Methodology: Measuring the economic costs of the gender gap in agricultural productivity

1 Traditionally, agricultural productivity is measured based on household-level analysis. In contrast, we here look at the plot level and identify the plot manager, measuring the difference in productivity between plots cultivated by women and men. We convert the agricultural output produced by women and men farmers on their plots into monetary values by multiplying the output obtained per unit of land with the median unit and crop-specific price in the respective enumeration area (or at a higher level of aggregation if needed). In Tanzania and Uganda, output was measured in kilograms; in Malawi, a wide range of measurement units was employed. We then aggregate the total value of all crops per unit of land associated with each gender. The difference in this value between women's and men's plots constitutes the unconditional gender gap in agricultural productivity. This is the first step in estimating the national income that is foregone because of the gender agricultural productivity gap.

2 As a next step, we calculate the fraction of land cultivated by women and men, after accounting for the fact that women cultivate smaller plots than men. For example, in Tanzania, women cultivate 20 percent of the cultivated plots but because their plots are on average smaller by 0.47 hectares, women manage only about 13 percent of the land. Combining this fraction with the estimated gender gap in agricultural productivity, we compute the percentage difference between harvested value of output in two scenarios. In the first scenario, we assume that there is no difference between male and female agricultural output—that is, there is no gender gap and agricultural productivity of women's plots is equal to plots cultivated by men. In the second scenario, we use the actual productivity estimates obtained in the first step to calculate the value of output obtained from female plots in the presence of the gender gap. The difference between the no gender gap scenario and the gender gap scenario gives the additional output value from closing the gender gap in productivity.

3 The final step includes computing the size of the gap relative to agricultural GDP. To do this, we first need to know what fraction of agricultural GDP comes from crop production. Second, we need to know the share of agricultural GDP in overall GDP. Because growth in the agricultural sector influences other sectors of the economy, the cost of the gender gap is likely higher than just the foregone agricultural GDP. To take this into account, we use an estimate of the multiplier between agricultural sector growth and the rest of the economy obtained from other studies in Malawi, Tanzania, and Uganda (Benin et al. 2008; Mabiso, Pauw, and Benin 2012; Pauw and Thurlow 2011).

A more technical description of the methodology is given in appendix A.

Because agriculture also employs more than two-thirds of the population in these countries—including some of the poorest citizens—increasing agricultural production can make a significant contribution to reducing poverty. Moreover, improvements in the agricultural sector may have considerable spillover effects for other sectors of the economy. Therefore, the analysis presented here extends to outcomes related to poverty and nutrition; we here define the poor as those living on less than $1.25 a day. Note that low agricultural productivity can also lead to more intense farming, resulting in overcultivation, soil erosion, and land degradation—which in turn further undermine agricultural productivity and environmental sustainability.

We treat the plot of land, with identification of the gender of the plot manager or decision maker, as the unit of analysis. This identification was made possible by the data structure of the Living Standards Measurement Study—Integrated Surveys on Agriculture; see box 3.2 for more detail. Using this gender-disaggregated, plot-level data allows us to capture differences in agricultural productivity even

BOX 3.2
Data used for costing the gender gap in agricultural productivity

For our analysis, we use data from the World Bank's Living Standards Measurement Study—Integrated Surveys on Agriculture (http://go.worldbank.org/BCLXW38HY0). Specifically, the analysis presented here uses data from Malawi's third Integrated Household Survey collected in 2010/11, the second wave of the Tanzanian National Panel Survey collected in 2010/11, and the 2011/12 wave of the Uganda National Panel Survey.

These surveys are nationally representative and link welfare, agriculture, and income. The data are disaggregated at the plot level and contain information on which member of the household makes agricultural decisions about each of the plots cultivated by the household. There are some differences across these data sets in terms of assigning responsibility for each plot cultivated by the household. The Malawi questionnaire allows only one person to be listed as the decision maker, while the Tanzanian and Ugandan data allow for multiple decision makers. Plots can be managed by women only, by men only, or by women and men jointly. In this study, we only consider the difference in crop output obtained between women-only managed plots and all other plots. In Malawi, for example, women make decisions on about 26 percent of all agricultural plots; 76 percent of these plots are also actually owned by them, suggesting a strong relationship between ownership and decision-making power, but there is no one-to-one correspondence between plot management and land ownership or household headship.

All other macrolevel statistics, such as agricultural GDP and national GDP, are obtained from the 2015 World Development Indicators.

among women and men who belong to the same household but cultivate different plots. The main advantage of this level of analysis is that it explicitly measures the productivity of women farmers who are frequently neglected in analytical work that only looks at the gender of the household head.

The motivation for plot-level analysis rests on the assumption that female farmers face a different (and possibly larger) set of constraints relative to male farmers which may hinder them from accessing inputs and output markets to similar degrees or at the same prices. If households were to act as a single unit that allocates resources such that overall welfare is maximized, these market imperfections might not matter as much. If, however, we consider a collective household model in which individual preferences matter, it becomes imperative to conduct analysis at the plot level with identification of the plot manager. The economic literature (such as Duflo and Udry 2004) provides a multitude of examples suggesting that the collective household model may indeed be the more appropriate approximation of reality; these include evidence on the importance of the gender of the recipient of cash transfers to household-level outcomes.

To express the gender gap in agricultural productivity in monetary terms and to put these numbers into perspective relative to each country's GDP, this study maintains an additional set of assumptions. One key assumption is the absence of general equilibrium effects. For example, in the calculations presented, increased productivity of women farmers affects neither male farmers' productivity nor agricultural prices. While there are good reasons to believe that general equilibrium effects such as these exist, the direction of these effects can go either way. For instance, while standard economic theory would predict lower prices when increased supply of agricultural produce meets unchanged demand in a closed economy, household nutrition may benefit from both the price and the income effect of increased agricultural productivity.

Malawi

In Malawi, the unconditional gender gap is estimated to be 28 percent. The costs of this unconditional gender gap equate to

- ▲ 7.3 percent of current crop production; or
- ▲ 6.1 percent of agricultural GDP (or about $90 million);[1] or
- ▲ 1.85 percent of total GDP (or approximately $100 million), including the multiplier effects of benefits to other sectors in the economy.

If we base the estimates on the conditional gender gap of 31 percent instead, then the costs of the gap equate to

- ▲ 8.1 percent of current crop output, or
- ▲ 6.7 percent of agricultural GDP, or
- ▲ 2.1 percent of total GDP (or about $110 million).

[1]Crop output accounts for 83 percent of agricultural GDP in Malawi.

In Malawi, closing the unconditional gender gap equates to a 2.2 percent reduction in the poverty headcount, which is equivalent to more than 238,000 people being lifted out of poverty each year.[2]

Given the small difference between the unconditional and conditional gender gaps in Malawi, the corresponding figures for closing the conditional gender gap are very similar: a 2.4 percent reduction in poverty, with nearly 264,000 people lifted out of poverty every year.

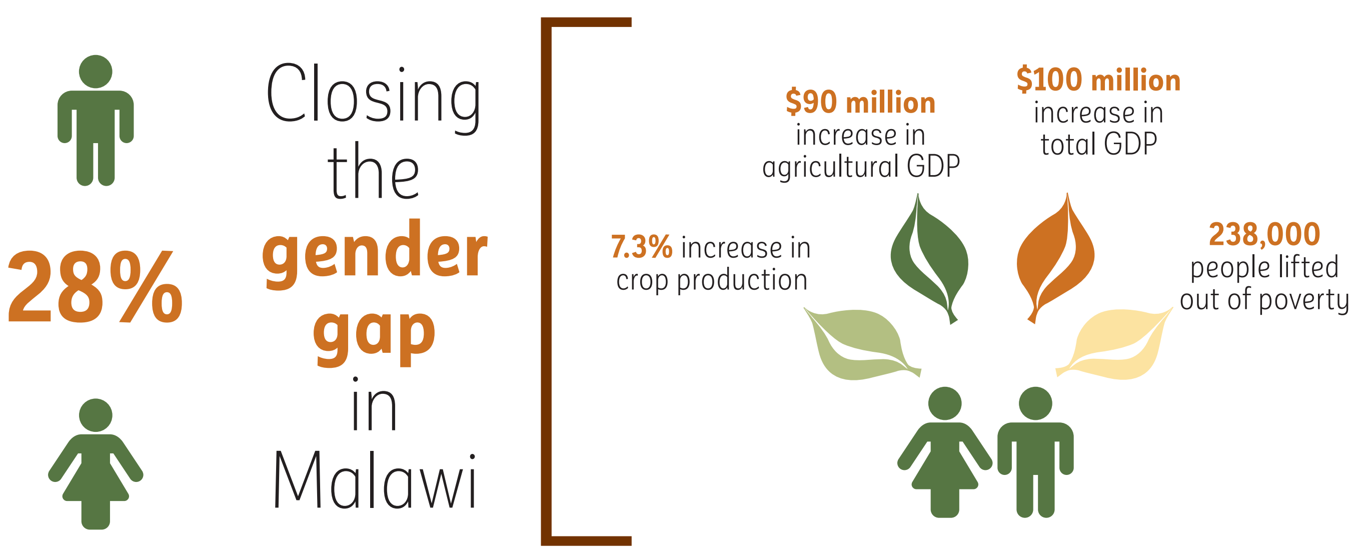
Tanzania

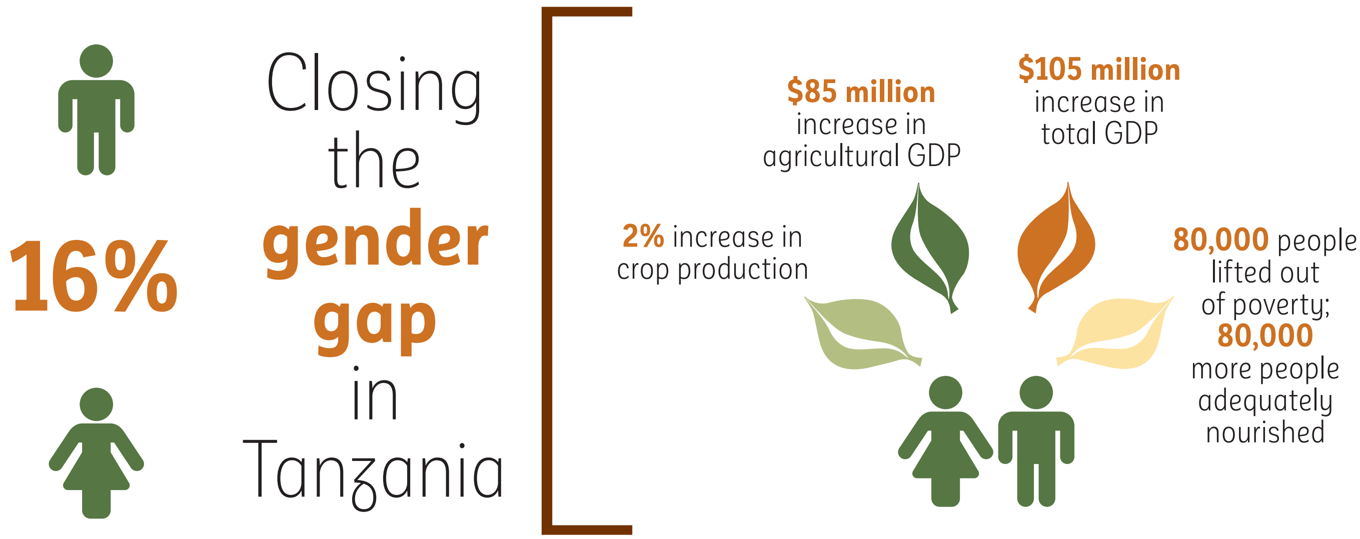
In Tanzania, the unconditional gender gap of 16 percent represents

- ▲ 2.1 percent of current agricultural output; or
- ▲ 1.5 percent of agricultural GDP (or over $85 million);[3] or

[2]The poverty growth elasticity used in the all-sector growth scenario is −0.76; that used in the agriculture-led growth scenario is −1.19 (Dorosh and Thurlow 2014).

[3]Crop output makes up approximately 70 percent of agricultural GDP in Tanzania.





- 0.46 percent of total GDP (or about $105 million), including the multiplier effects of benefits to other sectors in the economy.[4]

The above estimates only take into account the benefits to women who manage their own plots. However, gendered agricultural policies may also benefit women farmers who jointly manage their plots with men—which is the case for about 54 percent of the plots. Even if only about one-fifth of these jointly managed plots also realize higher productivity, then the costs of the gender gap would equate to 3.8 percent of the current level of crop production, 2.7 percent of agricultural GDP, and 0.84 percent of total GDP.

If we consider the conditional gender gap of 30 percent, the estimated costs are almost twice as high, equating to

- 3.9 percent of crop output, or
- 2.7 percent of agricultural GDP, or
- 0.86 percent of total GDP (or about $196 million).

Building on poverty-growth elasticities derived from an economywide general equilibrium approach reported in Dorosh and Thurlow (2014), we calculate the potential benefits of closing the gender gap in terms of poverty reduction and nutrition. The gross gains from closing the unconditional gender gap in agricultural productivity translate into an annual 0.41 percent reduction in the poverty headcount, which is equivalent to nearly 80,000 people being lifted out of poverty every year.[5]

Closing the gender gap could lead to a 0.72 percent reduction in the incidence of undernourishment, which equates to more than an additional 80,000 people being adequately nourished every year.[6]

[4]For Tanzania, this multiplier effect is estimated to be around 1.23.

[5]These estimates are based on poverty-growth elasticity for Tanzania experienced in all sectors of the economy, which is −0.49.

[6]Undernourishment is defined as the share of the population consuming less than 2,550 kilocalaries available per male adult equivalent (Pauw and Thurlow 2011).

Uganda

The unconditional gender gap in agricultural productivity in Uganda is 13 percent.[7] The costs of this unconditional gender gap equate to

- 2.8 percent of current crop output; or
- 1.6 percent of agricultural GDP (or about $58 million);[8] or
- 0.42 percent of total GDP (or nearly $67 million), including the multiplier effects of benefits to other sectors in the economy.[9]

[7] In Uganda, 27 percent of plots and 20 percent of all cultivated land is under the sole management of women; the remaining 73 percent of plots and 80 percent of all cultivated land is managed either jointly by women and men or solely by men.

[8] Crop production accounts for 59 percent of agricultural GDP in Uganda.

[9] We use a multiplier of 1.11 as the benefits of raising agricultural production also include spillovers to other sectors in the economy. We also assume that closing the gender gap influences all agricultural sectors equally in Uganda.

If we use the conditional gender gap of 28 percent, then the costs of the gap equate to[10]

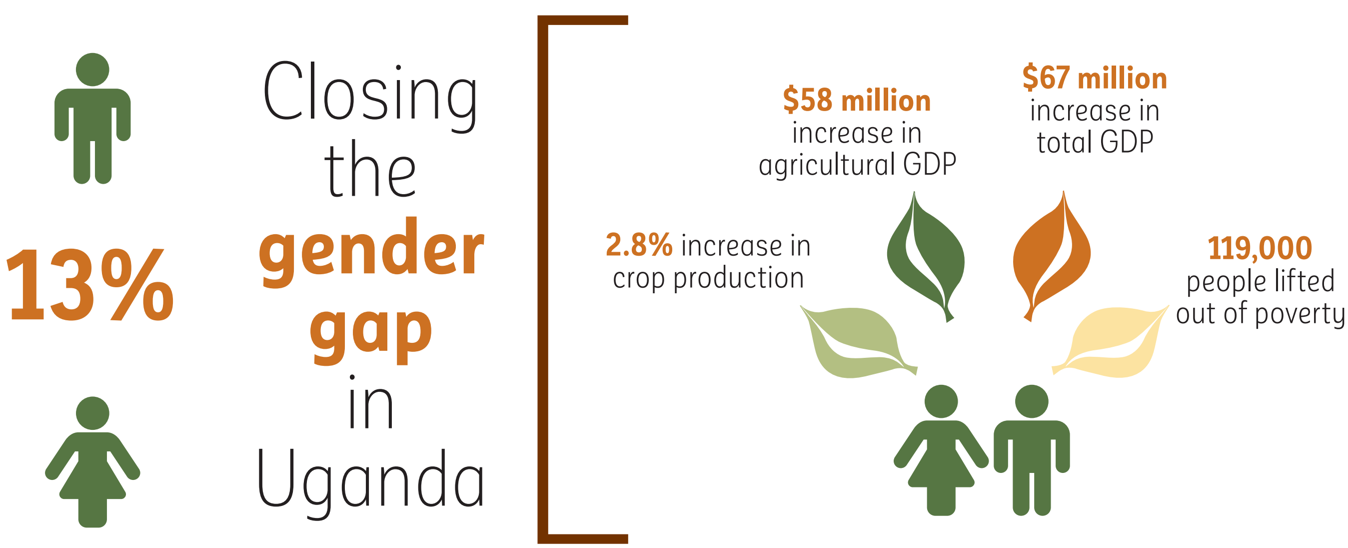
- 6.1 percent of current crop production, or
- 3.6 percent of agricultural GDP (or about $126 million), or
- 0.9 percent of total GDP (or about $145 million).[11]

Combing the gross gains in GDP with the poverty-growth elasticities reported by Dorosh and Thurlow (2014), we estimate that potential poverty reduction benefits of closing the unconditional gender gap equate to a 0.9 percent reduction in poverty in Uganda, or approximately 119,000 people being lifted out of poverty.

Basing the estimates on the conditional gender gap, closing the gender gap would be equivalent to a 2.0 percent reduction in poverty or nearly 260,000 people being lifted out of poverty.

[10] In Uganda, women cultivate plots that are on average 23 percent smaller than those of male farmers.

[11] Spillover effects and economywide linkages are taken into account in estimating this GDP benefit.



4 Costing the factors that contribute to the gender gap in agricultural productivity

In this section, we provide the results from decomposition analysis to identify which constraints to women's agricultural productivity contribute most to the gender agricultural productivity gap. This information can help governments prioritize those policies that are likely to have the biggest impact on closing the gap in agricultural yields.

The decomposition analysis (see box 4.1) extracts the importance of specific determinants of agricultural productivity in terms of potential gross gains in GDP.[1] We study several determinants, including manager characteristics, household demographics, household wealth, plot characteristics, crop choice, use of fertilizer, farming techniques, and labor inputs. The policy recommendations are framed by the choice of these determinants. Table 4.1 provides an overview of those determinants that stand out in terms of impact potential. The choice of determinants was based on data availability. It is recognized that a number of these determinants are proximate

[1] This analysis builds on earlier work by Kilic, Palacios-Lopez, and Goldstein (2015), Slavchevska (2015), and Ali et al. (2015). Similar analysis is carried out for Ethiopia, Niger, and Nigeria by Aguilar et al. (2015), Backiny-Yetna and McGee (2015), and Oseni et al. (2015), respectively.

BOX 4.1
Quantifying the benefits from narrowing the gender gap in agricultural productivity by specific determinants

Plots managed by women may be less productive than those managed by men due to observable factors, such as differences in experience and education, land quality, quantity of agricultural inputs used, and the choice of crops grown. However, an agricultural productivity difference could persist even when women and men have similar observable characteristics and use the same quantity of inputs, as women may derive lower returns from using these inputs. The Oaxaca-Blinder decomposition approach (Blinder 1973; Oaxaca 1973) has been widely used in other areas of the economics literature such as in studies analyzing the wage gap between male and female workers (see, for example, World Bank 2011). This decomposition method can also be employed to determine how much of the gender gap arises from the different levels of agricultural inputs used by women and men and how much arises from the lower returns that women obtain from using these inputs. For more detail on the Oaxaca-Blinder decomposition method, see appendix B.

TABLE 4.1

Relationship of selected determinants to the gender gap in agricultural productivity and to GDP

Determinant	MALAWI			TANZANIA			UGANDA		
	% of gap	In terms of GDP ($)	% of GDP	% of gap	In terms of GDP ($)	% of GDP	% of gap	In terms of GDP ($)	% of GDP
Qty of male family labor per household	**45.19**	45,110,180	0.84	**97.34**	102,180,543	0.45	n.a.	n.a.	n.a.
High-value crops	**28.43**	28,378,296	0.53	3.00	3,153,441	0.01	**13.29**	8,872,253	0.06
Agricultural implements	**17.76**	17,722,900	0.33	**8.18**	8,591,710	0.04	**9.02**	6,021,846	0.04
Pesticide use	**0.97**	964,601	0.02	**12.03**	12,630,384	0.06	**4.45**	2,973,106	0.02
Inorganic fertilizer use	**5.32**	5,313,775	0.10	6.39	6,707,789	0.03	3.04	2,026,367	0.01
Wealth index	**3.29**	3,288,461	0.06	−0.10	−106,908	0.00	n.a.	n.a.	n.a.

Note: n.a. = not available. Statistically significant factors are marked in **bold**. GDP values are 2010 dollars. Percentages may not sum to 100 because a number of determinants can be negative. Only a selection of those that reduce the gender gap are shown here, and together, they may overcompensate.

causes that can be linked to ultimate causes of the gender gap. A key challenge for future research will be to understand which of these may be at play by focusing on these ultimate determinants. Note that, except where stated, the interventions discussed in this section have not yet been rigorously evaluated.

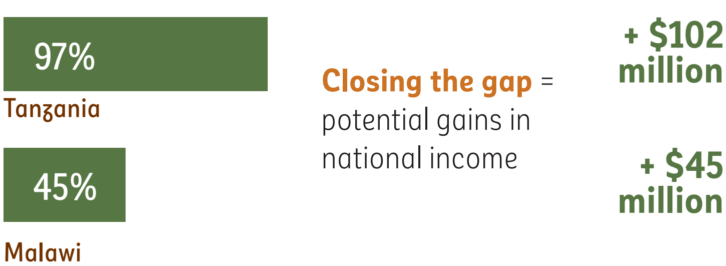
Women and men farmers have very different levels of access to male family labor

A large part of the gender gap can be attributed to differential access to male family labor in Tanzania and Malawi. Equalizing the access to male family labor would reduce the estimated gender gap 97 percent in Tanzania and 45 percent in Malawi. For example, 97 percent of the gender gap is related to unequal access to male family labor in Tanzania. This could potentially be linked to a number of other factors including the segregation of tasks, rural women's limited voice and agency, their lack of access to finance to hire male labor and invest in machinery, and limited time-saving infrastructure. One key reason that women farm managers have less access to male family labor is that the majority of them are widowed, separated, or divorced: this is the case for 67 percent of sole female plot managers in Tanzania. In fact, it is quite possible that these women became plot managers entirely because of their head-of-household status. These high rates of widowhood, separation, and divorce mean that women have fewer people in the household to draw on for farm labor. In Tanzania, the households of female farm managers have an average of one fewer person than all other households.

In Malawi, women try to compensate for their lower use of male family labor with more intense use of female labor, including themselves and, occasionally, their children. However, these additional inputs are not sufficient to offset the lost productivity brought about by lower use of male family labor. Closing the

Access to male family labor

makes up much of the gender gap in Tanzania and Malawi



gap in the use of male family labor alone would lead to gains equal to 0.80 percent of national income in Malawi ($45 million in 2010 prices) and 0.45 percent in Tanzania ($102 million in 2010 prices).

POLICY IMPLICATIONS

Designing policies that directly reduce inequality in access to male farm labor can take two avenues. One option is to tackle constraints related to women's access to household male labor. Another option is to think about policies that help women farmers access substitutes for household labor, such as hired workers and labor-saving technologies.

Women and men farm different crops

Women farmers are less likely to grow cash or export crops that men sell to the market for higher incomes. In Malawi, the primary cash crop, tobacco, is only planted on 3 percent of women's plots compared to 10 percent of men's plots. Overall, there is a 28 percent gender gap between women and men in the fraction of land devoted to export crops in Malawi. Closing these gender gaps in the cultivation of cash crops has the potential of raising GDP over $28 million in Malawi, $3 million in Tanzania, and $8 million in Uganda.

POLICY IMPLICATIONS

Several complementary policies can play a significant role. First, improving women's control over marketed output so they can better take charge of the income they earn has the potential to shift the underlying conditions in which women farmers operate (Hill and Vigneri 2014). Second, strengthening women's groups and networks so that women can sell in larger quantities can help women reach markets and sell their produce at a lower cost. Box 4.2 further explores the issue of market access.

BOX 4.2
Role of market access in gender agricultural productivity gap

In Uganda, we examine whether selling more than 50 percent of crop output in the market also contributes to the gender gap in agricultural productivity. We find that this factor alone explains 40 percent of the unconditional gender productivity gap in Uganda, equating to $26 million (in 2011 prices) of potential gross gains in GDP. A multitude of factors could explain why women sell less of their output to the market. First, they may face imperfect markets and thus prioritize their families' food security by cultivating crops for home consumption. Moreover, because women tend to cultivate smaller plots, they may not have enough produce left to sell to the market after fulfilling their families' consumption needs (World Bank 2008). Second, women may lack access to various inputs, such as intensive labor, required for cultivating marketable crops (World Bank 2008). Third, social norms may dictate which type of crops women cultivate.

Women are disadvantaged in accessing agricultural machinery and production technologies

In all three countries profiled, women's access to agricultural implements and machinery is significantly lower than that of men.[2] Differences in the use of implements and machinery explain 18 percent of the gender gap in Malawi, 8 percent in Tanzania, and 9 percent in Uganda. In Malawi, women own fewer agricultural implements and machinery,

[2] For Malawi, the agricultural implements index is based on ownership of a hand hoe, slasher, ax, sprayer, panga knife, sickle, treadle pup, watering can, ox cart, ox plow, tractor, ridger, cultivator, generator, motorized pump, grain mill or other implements, chicken house, livestock kraal, poultry kraal, storage house, granary, barn, and/or pigsty. For Tanzania, the agricultural implements index includes ownership of carts, animal carts, wheelbarrow, livestock, donkeys, hoes, spraying machine, water pump, reapers, tractor, tractor trailer, plow, harvesting machine, hand miller, coffee pulper, and/or fertilizer distributor.

such as weighing machines, spraying pumps, panga knives, axes, and irrigation equipment. In Tanzania, ownership of livestock, spraying machines, water pumps, and plows is lower among women.

In addition to this gender mechanization gap, women also use lower levels of advanced agricultural technologies, such as pesticide and inorganic fertilizer. About 12 percent of the gap, or $13 million, in potential gross gains in Tanzania can be accounted for by the gender difference in pesticide use. Lower use of inorganic fertilizer by women is equivalent to potential gross gains in GDP of over $2 million in Uganda. In Tanzania, average use of inorganic fertilizer continues to be low, irrespective of whether it is a female- or male-managed plot, so the difference between women and men is not significant.

Overall, the gender gap in the use of agricultural mechanization and technology equates to national income of approximately $24 million in Malawi, $11 million in Uganda, and $21 million in Tanzania.

POLICY IMPLICATIONS

Cash vouchers or in-kind transfers may help women increase their use of machinery. However, women are unlikely to purchase and operate heavy units of machinery if it is inadequate for their needs or if it is deemed culturally or socially inappropriate (Njuki et al. 2014). Therefore, it will be critical to carefully understand women's machinery needs and, where appropriate, challenge the existing social norms (for example, via female-led tractor provision services). If the binding constraint for women farmers stems from the heavy upfront investment typically required to purchase machinery, providing them with rental or leasing options is a policy alternative. In addition to promoting efficient and targeted use of pesticide and fertilizer use through voucher programs, small nudges such as timeliness of delivery and smaller packages of fertilizer and seed more appropriately sized for women's smaller plots can potentially have a huge impact (Duflo, Kremer, and Robinson 2009).[3]

Along with these short-term policy shifts, broader policy changes such as reforming land rights in favor of women have the potential to increase women's long-term agricultural investments, even if unrelated to machinery or fertilizer (Ali, Deininger, and Goldstein 2014). This may further help address the problem of small fragmented farms that affect smallholder farmers of both sexes and that can render the use of agricultural machinery uneconomical.

[3] Efficient and targeted use of pesticides should be restricted to legal chemicals applied with caution to reduce risks to farmers and ecosystems.

5 Finding the biggest bang for the buck: cost-effective policy interventions

Now that we know the costs of the gender gap in agricultural productivity in Malawi, Tanzania, and Uganda, as well as the factors that contribute the most to this gap, it is critical to identify the most cost-effective policies. There may be many policy options available, but clearly these will be of little practical use to policy makers if their implementation is more costly than the value of the benefits they are able to achieve. By identifying some of the policies that may have the highest benefit-to-cost ratio, we hope to provide a useful starting point for further analysis that could offer practical guidance for policy makers who need to work out how to respond to the gender gap while making best use of limited resources.

This report has highlighted that lack of access to adequate labor, crop choice, and low use of machinery and nonlabor technological inputs contribute to the majority of the gender gap across the three countries studied. In the remainder of this section, we outline some policy priorities that could address these constraints; these policy options are summarized in table 5.1. The next step for policy makers is to engage in this cost-benefit analysis to identify where the benefit of closing the gender gap outweighs the cost of the respective policy option. Naturally, the relative cost-benefit ratio of various interventions should also be weighed against other factors, such as ease of implementation and cultural and social context.

Identify where the benefit of closing the gender gap outweighs the cost of the respective policy option

Policy priority 1: Narrow the gender productivity gap due to lack of access to labor

First, it is possible to increase women's labor productivity by enabling them to **adopt labor-saving technologies** on farm or by freeing up their time by adoption of labor-saving technologies at home such as the use of energy-efficient and environmentally friendly improved cooking stoves. These stoves are widely regarded as a means to reduce the amount of time required for fetching firewood and thus increase the time available for productive work—

TABLE 5.1
Summary of potential policy options for addressing the gender gap in agricultural productivity

Policy priority	Policy instrument	Potential GDP gains to: Malawi	Potential GDP gains to: Tanzania	Potential GDP gains to: Uganda	Research priority
LABOR POLICIES					
Enhance women's use of technologies that save time on farm and off farm	Cash vouchers/discounts on purchase	High	High	Low	▼ Effective substitutes for male labor ▼ Constraints that prevent women from hiring labor ▼ Women's needs and preferences for technology adoption
	Doorstep delivery and training				
Improve access to hired male and female labor	Agricultural cash vouchers				
	Queue-jumping incentives for labor to provide services to women farmers first				
CROP CHOICE POLICIES					
Improve access to markets and agricultural groups	Encourage formation of groups so women can have access to markets	Medium	Low	Medium	▼ Understand what makes women adopt certain crops ▼ Examine the constraints women face in cultivating high-value crops and determine if those are different from constraints farmers generally face
Encourage crops that match women's preferences	Provide crops with nutritional benefits and related training				
Market crops as women's crops	Promote crops so they are considered to be both women's and men's crops				
NONLABOR INPUT POLICIES					
Improve access and incentivize use of inorganic and organic fertilizer and pesticide	Package fertilizer in small amounts	Medium	Low	Medium	▼ Understand women's machinery and equipment needs ▼ Examine constraints that particularly influence women's use of nonlabor inputs ▼ Understand mechanisms and policy packages that might particularly work for women
	Innovative delivery mechanisms such as free delivery				
	Information and communication–based nudges such as mobile phone reminders about using inputs				
	Cash and in-kind transfers for input purchase				
Expand the use of culturally appropriate machinery for women	Agricultural cash or discounts on purchase				
	Where direct use is inappropriate, encourage machinery custom-hiring markets				
	Machine-use training tied to women's working schedule				

with the additional potential benefits of reducing deforestation rates and respiratory diseases.

Second, policies could focus on enabling women's **access to hired labor**. Prevalent cultural norms may prevent women from hiring male labor, especially if specific agricultural tasks are performed by women and men separately (Fafchamps 2001). Hence, policies involving both women and men, such as awareness and sensitization campaigns, may be needed to reform existing structures.

Little direct evidence exists of policies that directly help remove the labor shortages that women face. Potential policy options include cash vouchers for hiring labor, price discounts on the purchase of labor-saving machinery, and doorstep delivery of machinery and training (Duflo, Kremer, and Robinson 2009; Seidenfeld et al. 2014). However, the lack of evidence on the effectiveness of these programs means that it will be necessary to experiment with and rigorously evaluate pilot programs that determine which policy innovations work and which do not.

Policy priority 2: Enable women farmers to move into cultivation of high-value cash crops

A key finding of this report is that women are less likely to grow cash crops and that this plays a significant role in the gender productivity gap. Too often, women may shy away from growing higher-value crops due to labor or cash shortages, especially if growing cash crops is culturally seen as a male activity (Hill and Vigneri 2014). Because women cultivate smaller plots, they may not be inclined to cultivate cash crops because of the need to scale up (Fafchamps 1992). Moreover, because women seldom own land and/or have weak land tenure rights, they may be less motivated to make investments in cash crop cultivation (Goldstein and Udry 2008; Morrison, Raju, and Sinha 2007).

Lack of labor availability, as established by this report, may prevent women from undertaking the cultivation of crops that demand heavy time burdens. Women are more time constrained than men in many countries due to their domestic care and child-rearing responsibilities. Moreover, differences in agricultural know-how, risk-taking ability, and preference toward ensuring household food security constitute some other reasons for women's preference for food crops. In fact, evidence from cocoa production in Ghana and coffee production in Uganda—both of which are cash crops for these countries—suggests that differences in productivity between women and men disappear when women have the same access to productive inputs and sell their produce in the same way as men. Yet the reality in which women operate seldom gives them the same access to markets and methods of cultivation (Hill and Vigneri 2014). Accessing markets may also be problematic for women due to cultural norms and women's lower access to transport, both of which restrict their mobility. In light of these cultural and social circumstances, engaging men in promoting gender equality and challenging these social norms with women will be key to progress.

Engage men in promoting gender equality and challenging social norms together with women

There are a number of policy options for either enabling women to raise their productivity for the crops they already grow or for incentivizing them to shift into more profitable crops. Strengthening female farmer groups may allow women to not only scale up investments but also **access markets** by reducing unit costs. Such interventions can also allow women to address labor shortages by receiving help from others in the group (Hill and Vigneri 2014). **Understanding what women want in terms of crop cultivation** is also crucial, especially if they prefer growing crops that embody certain characteristics such as nutritional value.[1] In such cases, a gradual introduction of cash crops may be required. Another option is to **promote certain crops as women's crops**, although the policy design for this intervention is somewhat complicated given the shifting cultural norms with women taking up roles that traditionally fell within a man's domain (Saito et al. 1994).

Policy priority 3: Improve women farmers' access to and use of nonlabor inputs in agricultural production

Several policies, both gendered and not, have been implemented and evaluated to **improve the uptake of technologies** such as fertilizer, pesticide, and improved seed varieties (Peterman, Behrman, and Quisumbing 2014), as well as other rural technologies that can save time and increase farm productivity. When it comes to policies aimed at improving the adoption rate of such technologies, we know more about what does not work than about what does work, especially for sustained, long-term use of these nonlabor inputs. First, we know that even if fertilizer is given free to women farmers, it may not necessarily improve farm profit since it increases spending on other complementary inputs as well—which has huge consequences for the sustainability of such a policy (Beaman et al. 2013). Second, we know that giving vouchers for fertilizer may still lead to low uptake. For instance, in Mozambique, an experimental evaluation of the fertilizer subsidy program found that farmers' uptake of fertilizer was relatively low and had varied impact on farmers' incomes and yields. Relatively low uptake may not only be related to lack of credit but could be because farmers do not know how to use the technology effectively (Carter, Laajaj, and Yang 2013). Third, we know that fertilizer subsidies may not be as successful in improving uptake as small, time-limited discounts, such as free delivery of fertilizer right after the harvest season (Duflo, Kremer, and Robinson 2009).

Despite the diversity of evaluation work done in this area, much remains to be learned about what works. For example, information and communication–based nudges in the form of mobile phone reminders could be tried. Similarly, packaging fertilizer and improved seed varieties in smaller quantities (to prevent spoilage and to make it more convenient for women to use on their smaller plots) could be tried to see if such an intervention would improve uptake of fertilizer. Moreover, farmer training on sustainable input use could be scheduled at a time that fits with women's household and farm schedules to see if it improves learning about technologies. Needless to say, these policies should be formulated and evaluated with careful consideration of the larger constraints within which women farmers operate, such as low access to land and credit, insecure land tenure, limited access to appropriate technologies, mobility-related challenges that may prevent women's ability to reach input dealers and markets, and risk-taking abilities.

[1] See, for example, evidence on women's preference for growing orange flesh sweet potato in Uganda in Quisumbing et al. (2014).

6 Moving from recommendations to implementation

This report has highlighted the importance of fully including women in the agricultural development process. The three countries profiled in this report are meant as an illustration of the kinds of cost-benefit analyses that donors, governments, and international organizations should be undertaking before investing their scarce resources in various policies. Yet we know very little about what exactly works in narrowing the gender gap and how much it costs.

The next stage needs to be to find cost-effective solutions through combining the implementation of innovative pilot interventions with careful evaluation. Because the gender gap in agriculture operates within the broader context of the bigger gender gap in society, it is important that policy makers, donors, and development partners carefully consider their understanding of which key problems women face, why particular policies would work, and what operational challenges they may face when trying to actually implement policies. Because the gender gap is deeply cultural and societal, it is imperative that policy makers use a combination of economic and behavioral shifts to narrow the gender gap in agriculture.

So what are some characteristics of good and cost-effective policies that narrow the gender gap in agriculture?

> We know very little about what exactly works in narrowing the gender gap and how much it costs.

Good policies work on improving choices

If the aim of development policy is to ensure that women become more productive, then policy makers should carefully consider if women are operating out of choice or constraints. Since there is a thin line between the two, agricultural gender policy should be cognizant of how women farmers make their agricultural decisions. Various policy instruments affect women's constraints and choices differently.

Good policies are built upon refined and redefined problems

Investing in carefully diagnosing and refining the scope of problems can significantly reduce implementation costs and ensure that policies are cost-effective. Lessons can be learned from experiments and research in other development efforts. For example, lack of access to clean water was diagnosed as one of the factors leading to a high number of cases of diarrhea among children in rural Kenya. One intervention implemented was to cover water springs at the source in order to avoid contamination. Yet the intervention only moderately helped improve the quality of water at home (Ahuja, Kremer, and Zwane 2010). Closer diagnosis revealed that the problem was in fact the contamination of the water at home.

Similarly, it is quite possible that the gender gap in agricultural productivity is not caused by a lack of access to fertilizer per se, but to a lack of fertilizer marketed in small quantities so women can use them on their smaller plots. Carefully refining and redefining policy scope is critical to maximizing benefits from closing the gender gap.

Good policies may have to shift cultural norms

Government agencies, donors, and development practitioners work within embedded social and cultural norms. Attacking the problem of the gender gap in agricultural productivity first begins with shifting the mindset through which policy is framed and implemented. It requires making it acceptable for women to cultivate cash crops and agricultural machinery. It means that it must be acceptable for women to hire male labor and that men find it acceptable to work for a woman. Tools that may be particularly useful here are behavioral policy instruments such as identity cues and framing, microincentives, and reminders. Policy makers, donors, and international agencies must reassess the realities under which they frame agricultural policies.

APPENDIX A

Methodology for quantifying the cost of the gender gap in agriculture

We estimate agricultural productivity in terms of gross value of output (in local currency) per unit of land (in hectares). We obtain the quantity produced of each crop on each plot and multiply total crop quantity by the median crop sale value per appropriate unit in the respective enumeration area. If village-level unit sale prices are not available for some crops, we use the prices available for the next higher level geographical area. Next, we add the values of output of all the crops grown on the plot and divide the aggregate value of output by the plot size in order to obtain the gross value of output per hectare.[1] The difference in these values of output per hectare obtained on male- and female-managed plots constitutes the unconditional gender gap in agricultural productivity.

Based on the identified gender gap in agricultural productivity and the estimate of the share of land under women's control, we can monetize the gender gap in terms of potential gains in agricultural production and total economic output. To do this, the following formula to estimate the total quantity of output obtained by women and men at the national level is useful (FAO 2011):

$$Q = Y^{*}A \qquad (A.1)$$

Here *Q* is the total harvested output (in local currency units for the year of the survey), *Y* is the mean harvest value per hectare, and *A* is the total arable land,[2] which can be obtained from the World Bank's World Development Indicators (http://data.worldbank.org/products/wdi). We express the mean harvest value per hectare on female plots (female productivity, Y_f) in terms of the mean harvest value per hectare on male-managed plots (male productivity, Y_m) using the estimate of the gender gap—say 28 percent in Malawi—in the following manner:

$$Y_f = 0.72Y_m \qquad (A.2)$$

Total harvested value obtained from women's and men's cultivated land at the national level is expressed as below.

$$Q = Y_f PA + Y_m(1-P)A \qquad (A.3)$$

Here *P* represents the proportion of land controlled by female managers based on the fraction of plots controlled by women. This fraction is based on the average area of their plots relative to the average area of men's plots. In Malawi, for example, women plant 26 percent of all plots, but because theirs are,

[1] Ideally, plot size data measured by global positioning system (GPS) should be utilized, but GPS-measured area data are usable only in the case of Malawi. GPS-measured data were collected for about 80 percent of the plots in Tanzania; thus, using GPS data would drop about 20 percent (1,312) of the plots from the analysis.

[2] Arable land includes land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or pasture, land under market or kitchen gardens, and land temporarily fallow. For more information, see the World Development Indicators table notes (available at http://data.un.org/_Docs/WDI%20definitions.pdf). Since arable land includes plots that are temporarily fallow, it may be useful to adjust the estimate by obtaining an estimate of fallow land from the microlevel surveys and subtract that fraction from the total arable land to better estimate cultivated land. Often, farmers' reports of fallowing are rather low. For example, in the Malawi data only around 1 percent of the 18,990 plots are listed as fallow.

on average, 0.046 hectares smaller than men's plots, the proportion of area under women's control is about 24 percent.

Substituting equation A.2 into equation A.3 gives the total harvested value, Q, in the presence of the identified gender gap in agricultural productivity. We term this scenario the baseline. We can also obtain the potential harvest value, Q^*, under the scenario of no gender gap in agricultural productivity, that is, when $Y_f = Y_m$.

The additional output from closing the gender gap in agricultural productivity, as a proportion of the baseline harvest value, is expressed as follows.

$$\Delta = (Q^* - Q)/Q \qquad \text{(A.4)}$$

In Malawi's case, closing the unconditional gender gap will lead to an increase of total crop harvest of 7.3 percent.

To link the increase to agricultural GDP and total GDP, we need a few more pieces of information. First, we need to know what fraction of agricultural GDP comes from crop production.[3] For example, in Malawi crop production forms 83 percent of total agricultural GDP. This 7.3 percent higher crop output translates to a 6.06 percent higher agricultural GDP, which is roughly around $89.9 million (in 2010 prices).

Because of the many economywide spillover effects between the agricultural sector and the rest of the economy, total GDP is expected to be higher by more than the $89.9 million. We need an estimate of the multiplier between the agricultural sector and the rest of the economy. Here we draw on economywide models for each country. For instance, the multiplier for Malawi is about 1.11, implying that each additional dollar generated in the agricultural sector leads to an additional $0.11 in benefits in the non-agricultural sector (Benin et al. 2008). Consequently, the $89.9 million higher agricultural GDP in Malawi due to closing the agricultural gender productivity gap results in a total benefit of $99.8 million added to total GDP. Overall, total GDP will be higher by 1.85 percent if the gender gap in agricultural productivity is closed.

[3] Agricultural GDP includes forestry, hunting, finishing, livestock, and crop production (again, see the World Development Indicators table notes available at http://data.un.org/_Docs/WDI%20definitions.pdf). We separate the specific contribution of each subsector of agriculture to total agricultural GDP from the national account statistics of each country. For Malawi, the national accounts report a combined figure for crop production, livestock production, and hunting. A 2005 FAO country brief reports that livestock constitutes 9.9 percent of agricultural GDP. We therefore assume that livestock production as a percentage of agricultural GDP has remained largely unchanged since those earlier studies and is about 10 percent. In 2010, fisheries and forestry constituted about 7 percent of agricultural GDP in Malawi. We subtract the contributions of livestock, fisheries, and forest production from agricultural GDP to obtain an estimate of crop GDP, which is about 83 percent of agricultural GDP. Using the Malawi Social Accounting Matrix for 2004, Benin et al. (2008) estimate that crop GDP is close to 86 percent of agricultural GDP. The difference between the two sources is small and is driven by the different estimates of the size of the livestock sector. As is our practice throughout the paper, we report results with the more conservative estimates.

APPENDIX B

Methodology for costing the factors of production contributing to the gender gap in agricultural productivity

Plots managed by women farmers may be less productive due to observable factors including inequalities in manager attributes such as experience and education, plot characteristics, agricultural technology and input use, and crop choice. A gender gap may persist even after accounting for these factors. For example, after controlling for manager characteristics, plot characteristics and size, input use, and geographical features, the gender gap in Malawi decreases to 0.02 percent and is no longer statistically significant at any level. The portion of the gap that cannot be explained by observable factors may be associated with differences in the returns associated with using these factors of production on women's plots as compared to men's. To determine exactly how much of the gap is due to levels of inputs used and how much is because of returns to those inputs, we employ an Oaxaca-Blinder-type decomposition. The central piece in the Oaxaca-Blinder decomposition approach is the following production function.

$$1n(Y_{ih}) = c_0 + \alpha F_{ih} + M_{ih}\gamma + X_{ih}\delta + 1n(I_{ih})\eta + 1n(L_{ih})\theta + C_{ih}\vartheta + \lambda_h + \varepsilon_{ih} \quad \text{(B.1)}$$

Here i denotes the plot planted by a member of household h; Y is the value of agricultural output per unit of land (hectare);[1] F equals 1 if the plot is managed by a woman, and 0 otherwise. M is a vector of explanatory variables pertaining to other characteristics of the plot manager; X is a set of plot-level characteristics including size and quality; I is a vector of plot-level controls for nonlabor input use; L is a set of plot-level controls for labor inputs; C is a vector of indicator variables accounting for whether the primary crop cultivated on the plot is a cash crop;[2] ε is an error term. The term λ_h captures community and geographical characteristics.

To closely compare results across the three countries, we define the variables in a similar way and control for the same set of variables wherever possible and meaningful. By doing this, we develop a comparable framework for analysis and discussion so that differences in outcomes across countries are not linked to differences in definitions of the variables or set of variables included, but instead to differences in the levels and coefficients associated with those variables. This is not always possible because survey questions may not be structured in the same way. For example, the agricultural implement indexes that we construct for each country are based on different agricultural assets. In some countries, we account for livestock and oxen power; in others, we do not. This difference in definition may perhaps capture

[1] There are two agricultural seasons in all countries. But we estimate the gender gap using data for the long rainy season or the main season only, as the majority of households cultivate land then. We assume that the gender gap will be similar in the shorter rainy season. Such an assumption may not hold perfectly, but it is quite likely that farmers reserve most of their limited resources for production during the long rainy season. If women's access to productive resources is even more limited when total resources are generally low, then the gender gap in productivity may be even larger.

[2] The primary crop is often identified by the respondent of the survey.

the varying significance of agricultural implements in explaining the gender agricultural productivity gap in different countries.

The Oaxaca-Blinder decomposition attempts to explain how much of the mean outcome difference between two groups (female- and male-managed plots) are accounted for by group differences in the predictors. The aggregate decomposition follows from the linear model specified below.

$$Y_l = X_l'\beta_l + \varepsilon_l, E(\varepsilon_l) \quad (B.2)$$

where $l \in (f, m)$ and stands for female-managed plots (f)or male-managed plots (m),[3] X is a vector of predictors (and a constant term), and β is a vector of slope coefficients including the intercept. We can write the gap as

$$R = E(Y_m) - E(Y_f) = E(X_m)'\beta_m - E(X_f)'\beta_f \quad (B.3)$$

where $E(\varepsilon_l) = 0$.

Using algebraic manipulations, the expression in equation B.3 can be rewritten into a part of the differential due to differences in the levels of the predictors and a part due to differences in the coefficients associated with the predictors. The latter part is often referred to as the discrimination component, especially if it is linked to an immutable characteristic such as gender (Fortin, Lemieux, and Firpo 2011). We assume that there is some nondiscriminatory coefficient vector β^* through which the difference in the predictors is weighted so that

$$R = \big(E(X_m) - E(X_f)\big)'\beta^* + \big(E(X_m)'(\beta_m - \beta^*) + E(X_f)'(\beta^* - \beta_f)\big) \quad (B.4)$$

The expression in equation B.4 provides a twofold decomposition,

$$R = Q + U \quad (B.5)$$

where

$$Q = \big(E(X_m) - E(X_f)\big)'\beta^*$$

gives the proportion of the gender productivity gap that results from group differences in the predictors (referred to in the literature as *level effect*); and

$$U = \big(E(X_m)'(\beta_m - \beta^*) + E(X_f)'(\beta^* - \beta_f)\big)$$

is the residual or unexplained part that results from unequal returns to the predictors (*structural effect*) (Aguilar et al. 2015; Blinder 1973; Fortin, Lemieux, and Firpo 2011; Jann 2008; Oaxaca 1973).

The nondiscriminatory vector of coefficients β^* can be estimated in a number of ways (Fortin, Lemieux, and Firpo 2011; Jann 2008). Here $\hat{\beta}^*$ is estimated from a pooled regression over all plots, with a dummy variable identifying group membership (plots managed by a woman versus plots managed by a man as suggested in Jann 2008 and Fortin, Lemieux, and Firpo 2011).

The primary focus from the decomposition results is on the contribution of differences in the levels of factors of production to the gender agricultural productivity gap. The main goal is to estimate how much additional output could be obtained from closing the gender gap in accessing the various factors of production that contribute most to the gender productivity gap. For example, if differences in fertilizer use explain a significant fraction of the gender gap in agricultural productivity, then we discuss how much of the benefits associated with closing the gender gap in productivity could be achieved by closing the gender gap in access to fertilizer. While equitable access to production factors such as land, physical inputs, machines, and livestock may have benefits beyond increasing agricultural productivity, the approach taken here only focuses on the benefits obtained from improved agricultural productivity by equalizing access to these factors.

[3] Under male-managed plots, we also include jointly managed plots, wherever joint management data is available such as in Tanzania and Uganda.

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