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Asymmetric Information, Sorting, and the Gender Price Gap

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Abstract This paper analyzes transaction data from agricultural surveys carried out in five countries in low-and-middle-income countries to test for a difference in the prices received by men and by women marketing the same crop in the same village. In a unique finding, we identify a gap between the price received by women and the price received by men on three separate continents. Echoing similar results from other countries in sub-Saharan Africa, using mobile phone ownership and use data, we provide evidence to suggest that women farmers likely suffer from unequal access to information. The presence of asymmetric information is therefore indicated to be a limiting factor in women's ability to receive a fair unit price.

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Introduction

Regardless which country around the world is analyzed, the gender pay gap, meaning a difference in wages between women and men who work the same job and who have similar demographic backgrounds, is present and quantifiable (OECD 2022). In low-income countries, formal labor markets are much less accessible, and agriculture remains a significant source of income and labor. In the context of countries where access to formal jobs is scarce, and agricultural production still plays a dominant role, how do biases against women manifest in women's economic interactions? Though true for all countries, in particular in low-income countries, women and women-headed households face significant discrimination. Women face biases due to socio-cultural beliefs around gender roles and related practices which can result in women being marginalized, isolated and often subject to violence.

We find that, in the case of the countries in our sample, this social discrimination and bias against women manifests in the form of women receiving a lower price for their marketed crops. More specifically, although agriculture is a significant source of income for women-headed households, in this paper we document for the first

time that women-headed households in Bangladesh, Malawi, Peru, Tanzania and Uganda receive lower prices than comparable households, headed by men, who sell the same crop in the same village. We call this wedge between women's agricultural sales prices and men's agricultural sales prices the "gender price gap" to echo the phrase used to describe wage discrimination against women in labor markets around the world. In this paper, we provide evidence indicating that unequal access to information likely contributes to this price gap. An important implication of a gender-based price gap is that interventions or policies such as indiscriminately targeted input subsidies or agricultural credit provision may widen the gap between men-headed households and their women-headed counterparts. In that type of informational and social context, men who participate stand to capture relatively greater benefit from these programs. For women-headed households who do not have equal access to output markets, or who receive a lower price, the effects are likely to be dampened.

The price discrepancy we have described significantly inhibits women's ability to improve their economic status[1, 2]. If women-headed households cannot leverage agriculture effectively to generate income and "catch up" to comparable households headed by men, they have relatively few other places to turn for

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[1] Women-headed households, the primary focus of this paper, are typically formed due to divorce, separation or widowhood. In order to distinguish women who market agricultural goods from men marketing agricultural goods we isolate exclusively transactions carried out in women-headed households and households headed by men. Often, divorce comes with negative social costs. Due to the prevalence of norms around divorce and widowhood, women-headed households are among the most marginalized groups in low-income countries (Van de Walle, 2013; Milazzo and Van de Walle, 2017; World Bank, 2019

[2] A recent report by the World Bank (2019) titled Profiting from Parity: Unlocking the Potential of Women's Businesses in Africa outlines the need to focus on women-run businesses and highlights key constraints women entrepreneurs face. The authors emphasize the importance of internalized social norms which are hostile to women or inconsiderate, at best, of women's needs as entrepreneurs.

resources. If women household heads struggle to support their families with food and tuition expenses, then this can have effects not only for seniors, children and others in the household but also neighbors, relatives and others in the village in the form of negative externalities. Reducing technological, social and other barriers to information about market prices could therefore reduce the vulnerability of women-headed households to the negative economic effects caused by situations of asymmetric information.

If women receive a lower price for comparable agricultural outputs, a natural question is: what is the source of the difference in the price received by men and the price received by women? Rather than there being a single factor driving a gender price gap, it seems likely that different factors may drive a wedge between men's sales and women's sales prices. In different contexts the gender price gap may be larger or smaller. In Card et al. (2016) the authors identify the infamous gender pay gap as coming from at least two channels: bargaining effects, meaning women in general operate with lower social capital and less bargaining power, and sorting effects, meaning women have a preference for working at firms where other women work, and those firms tend to be lower-profit firms. In the case of a gender price gap and an agricultural marketing context, the analogous sorting effects would be that women and men transact with different purchasers due to various factors including where they get the best price, how easy it is for them to interact with the seller and the probability of not making a sale as well as the energy and opportunity cost of time associated with a market sale. We find that households headed by men are more likely to sell in the village market, for

example, while women prefer to sell to their family or neighbors in order to capture a particular price for their outputs and to reduce their transport costs.[3]

Households headed by men and households headed by women appear to operate with different levels of access to information. In the process of marketing crops, both women and men must gather information about market prices, transport their goods to market and secure a buyer for their quantity of agricultural outputs. Unfortunately, without purpose-collected survey data it is very difficult to distinguish if women sellers have direct knowledge of the market price or if they have knowledge of the sale prices of other sellers in their vicinity. If women have knowledge of the market price this improves their bargaining position. If gendered information networks similar to those documented in Mekonnen et al. (2018) are present, meaning men-headed households or men's social networks do not share information with women-headed households marketing the same crop, this could negatively influence women-headed household's ability to receive fair price. This idea builds on the literature analyzing the influence of asymmetric information on individual well-being and on firm performance (Akerlof, 1978).

One paper which highlights important informational gaps related to agriculture is Miura et al. (2020), who use a randomized intervention in Zambia and conclude that husbands and wives do not disclose to one another their receipt of a free voucher covering the cost of trans- porting agricultural goods to market. Even husbands and wives, individuals within the same household, may operate their enterprises and household activities with different information. If men and women within the same household fail to share relevant economic information then, we argue, the same

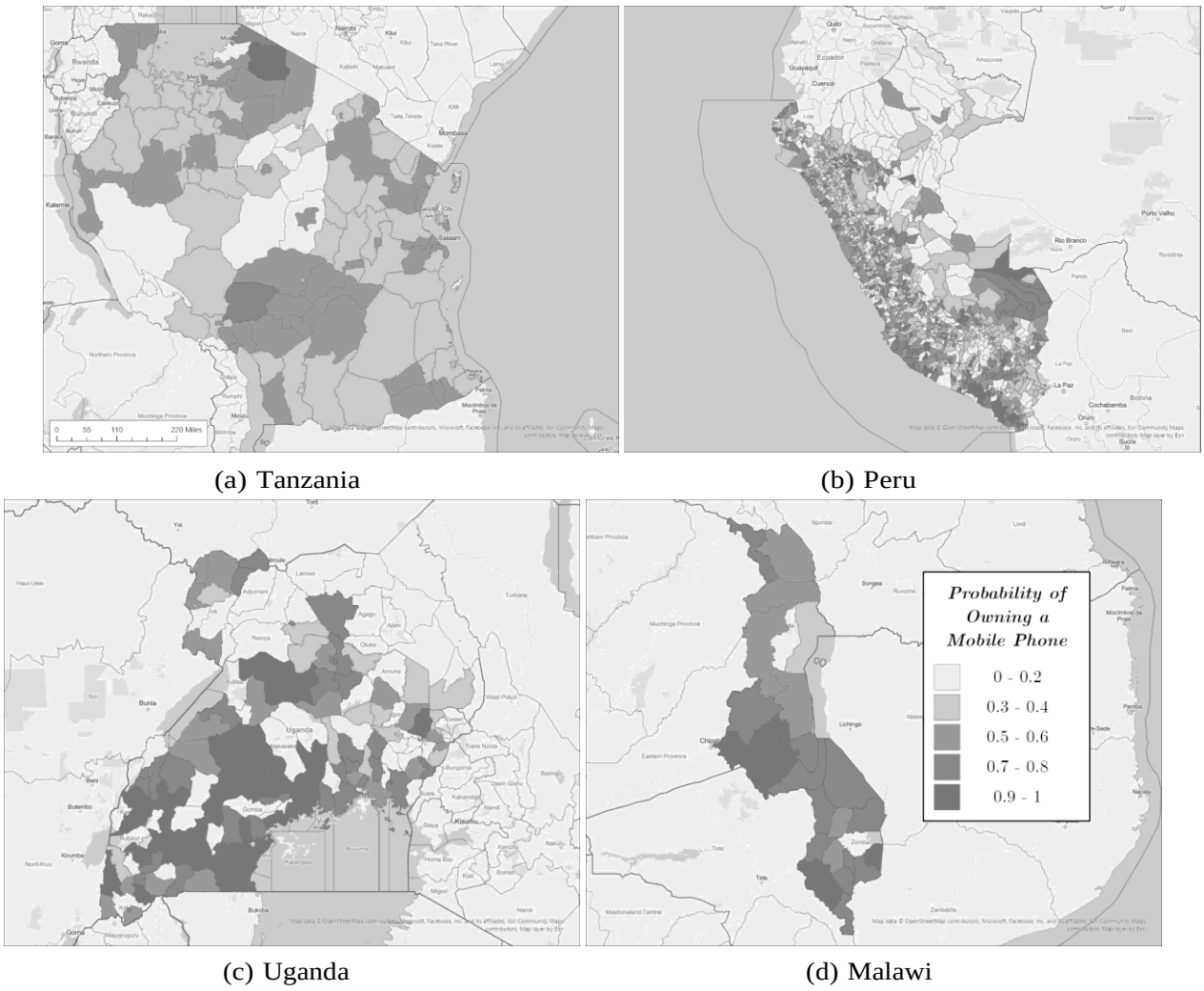
[3] Descriptive details about the location of sales of our sample households can be found in Appendix B

could be true for households headed by men and households headed by women. Mekonnen et al. (2018) use agricultural survey data to measure individual's information networks, and find that only 23% of women-headed households in Ethiopia have a man in their information or social network compared to 93% of men. From their data, the authors in Mekonnen et al. (2018) find that only 50% of women household head's social networks contain another farmer versus 84% of men household heads and, likewise, only 63% of women household heads discussed agricultural practices with their information/social network versus 87% of men. These patterns are indicative of information networks that are segregated by gender, or where women household heads have relatively less access to contacts, farmers and men who are in a position to relay information about agriculture. A recent paper from Germany, which collected primary data on 15 cartels, finds that cartels rely primarily on social and peer networks to form and be maintained. Only 2 of the 156 surveyed (1.2%) cartel participants were women. This demonstrates that, for majority of cartels, information and peer networks dominated by men are an important factor (Haucap et al., 2022).[4]

The presence of an asymmetric information problem implicates an immediate policy solution: whenever possible, reduce asymmetric information. The introduction of mobile phones and mobile phone networks has been shown to reduce price dispersion, which suggests increased information flows (Aker, 2010;

[4] A recent paper by Halvarsson et al. (2022) has analyzed the effects of interpersonal contacts and networks on wages for women in export sectors. Supporting the idea that asymmetric information and disparate access to information networks reinforces economic inequality, the authors find that for sectors where interpersonal contacts are more important, an increase in exports widens the gender pay gap. This suggests men and women are benefiting differently from increased exports based on their network of interpersonal contacts. Another recent paper by Hjort et al. (2020) finds that informational constraints are a significant limiting factor for about 25% of firms in a randomized study carried out in Liberia.

Aker and Fafchamps, 2015). Do women and men benefit equally from existing flows of agricultural information via mobile phones? It has been documented that women in general, have greater barriers to accessing technology. This discrepancy in access is also known as "the digital divide" (World Bank, 2019). A map of the probability of mobile ownership of women household heads can be seen in Figure 1. We see that mobile phone ownership by women household heads varies greatly across our sample. Importantly, if women do not benefit equally from flows of information, as suggested by the findings in Mekonnen et al. (2018), then the introduction of mobile phones as an intervention could exacerbate unequal outcomes unintentionally by reinforcing gendered information networks and consolidating the gains for households headed by men relative to those headed by women. Recent evidence has shown that women can benefit economically from access to knowledge and training through mobile devices in an agricultural setting, and that agricultural information is indeed transmitted within social networks which favor men farmers over women farmers (Mekonnen et al., 2018; Mullally et al., 2022; Caldarola et al., 2022). If asymmetric information is a primary barrier, then increased access to information and communication technologies, reducing the digital divide, as well as transparent market information, could improve the market prices women receive and, ultimately, could improve the well-being of women-headed households who rely on agricultural sales as a key source of income.



(a) Tanzania (b) Peru

(c) Uganda (d) Malawi

Figure 1: The Digital Divide Mapped: Women's Probability of Owning a Mobile Phone
Layers: Basemap: Open Street Map, CC License

The contributions of this paper are therefore to identify and confirm the presence of a gender- based price gap. Second, where the data permit, we analyze the influence of the sorting effects by applying controls for purchaser type and place of sale. If controlling for the purchaser type and place of sale substantially reduces the point estimate for the gender price gap parameter, this indicates that sorting effects could be in effect and be a significant source of unequal prices. Last, we use descriptive data on mobile phone ownership and mobile phone use to buttress our

argument that women and men have differential access to information shared within gendered information networks.

Theoretical Context

Potential Drivers of a Gender-based Price Wedge

In order to best address the price gap issue from a policy perspective it is important to dissect where the gender-based price differences might originate. Figure 2 is a kernel density plot of regression coefficients from all five countries. Each data point used in this graph corresponds to a coefficient estimated by regressing the log of men's prices on the log of women's prices. Each point is therefore a coefficient for a particular crop in a country in a village, in what is essentially a between-village regression. We can see from the graph that in the case of all five countries, differences in the log women's price do not explain a significant share of the men's price. If there were no difference between men and women sellers, and women's and men's prices thus move together, then this coefficient should not be different from one. Given that we have reason to believe this price gap exists and it is persistent across countries, what are the proximate causes or the significant drivers of gender-based price differences? The two primary channels, we theorize, are through sorting into different purchasers and low bargaining power.

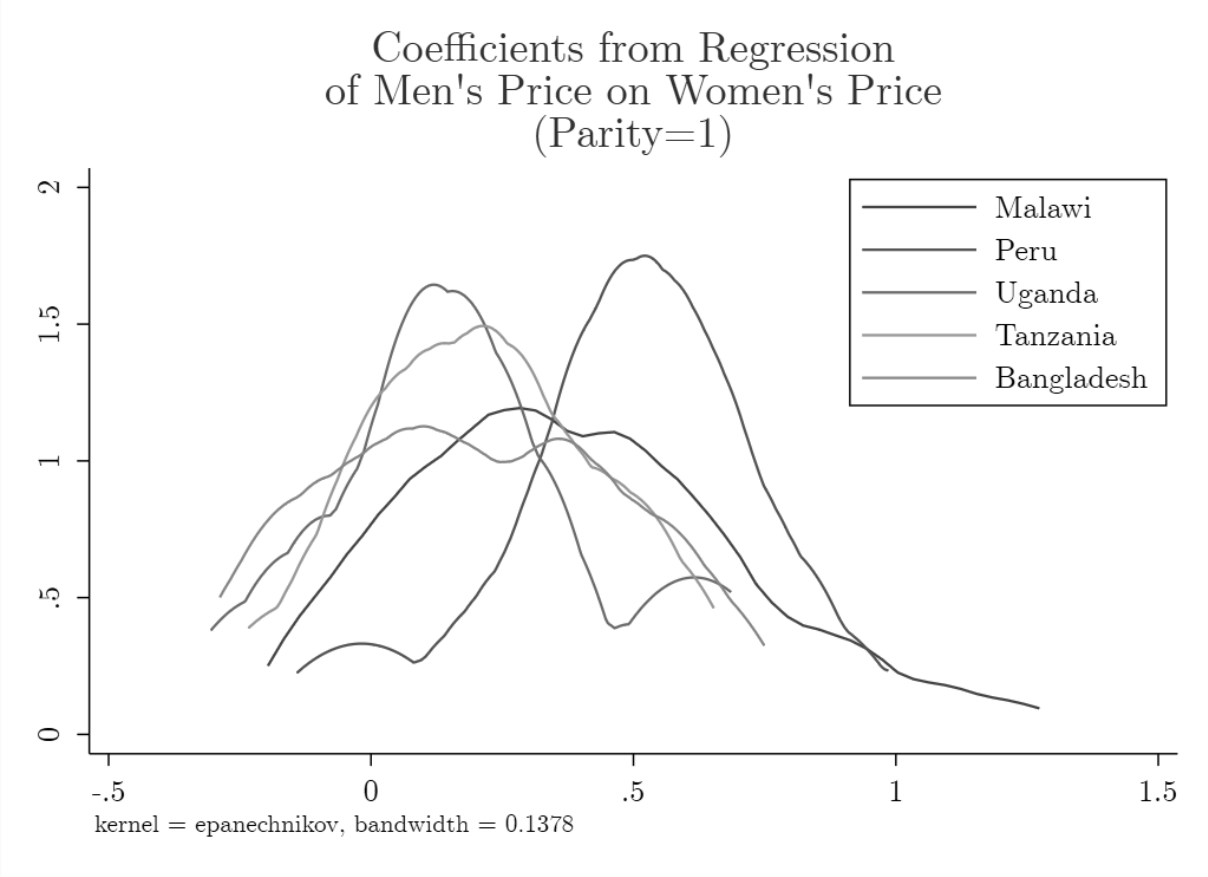


Figure 2: Kernel Density Plot of Coefficients

Low Bargaining Power

Building from David Card's explanation of the gender pay gap, low bargaining power of women engaged in agricultural sales and marketing could be a significant factor in the agricultural marketing context as well.

As an example, the idea of the "digital divide" refers to the situation where certain groups have access to technology and gain an advantage, while others who do not have access to technology are "left behind." We believe that women are one of the groups likely to be most disparately affected by the digital divide, or the lack of access to technology and communication. This concept is relevant to women-headed households because these barriers to accessing technologies and

information contributes to women's lack of capacity to expand their agricultural income. Put simply, a lack of access to information lowers women's bargaining power when marketing crops. Again, if women-headed households cannot generate revenue from agriculture, they have few other places to turn for resources. Reducing the influence of asymmetric information by improving access to technology could, given the right context, be a critical piece of supporting women-headed households to raise their level of well-being and invest in their households and in their children.

Other recent literature highlights how gender and gaps in technological access intersect. A paper by Gray et al. (2017) indicates that, in Latin America, men use the internet more than women. Beaman and Dillon (2018) find that technologies diffuse slower to women-headed households in Ethiopia as women are excluded from relevant information networks. In other parts of the world women farmers also lack access to markets and related telecommunications infrastructure (Chassin, 2022). In the case of our data, we find that men are much more likely to access extension services both in-person and via mobile for all the countries in our sample where extension data were included.[5] Women are much less likely to send SMS messages regarding farming activities than they are to send and receive phone calls.

Men who reside or farm around women-headed households may not share price information with other men or women who are their geographic neighbors. Women-headed households in our sample, with a few exceptions, have much lower rates of mobile ownership than households headed by men. Based on Mekonnen et al. (2018), we hypothesize that women in our sample have limited access to

[5] Results of this descriptive analysis are included in Table 7 and Appendix C.

information networks where agricultural information is shared and primarily discuss agriculture with other women. Women may effectively be isolated from relevant social networks where price and other information is communicated.

Given that a situation of asymmetric information could be present, women may have no "anchoring" point or reference point for their price. If women sellers do not have any reference point, they may accept a lower price due to the uncertainty associated with finding another buyer and the risk of total loss. To indicate the presence of gendered information networks, we first assess differences in mobile ownership between men household heads and women household heads at different levels of consumption per adult equivalent.[6] Mobile ownership data is presented by gender and for different levels of concentration of women's information networks. In the absence of primary survey data, we define villages with larger women's information networks as villages where women household heads own a higher relative share of the village phones than men heads.

Lower quality produce or outputs could also be a significant factor influencing women's ability to capture a fair market price. If women lack access to laborers and to credit to hire labor, if labor is being rationed, then women have less capacity to prepare their land for farming. Differential returns to investments such as seeds, fertilizer and irrigation might induce lower quality produce for women-headed households as a result of the high demand and low supply of manual labor on farms headed by women. There is some evidence that women typically hold low

[6] In low-income countries, consumption per adult is often used in place of income per capita as a primary measure of well-being

quality or marginal land which also could lower the quality of their produce.[7] In this context, a man who is a household head may spend more time working the soil in preparation for planting which may lead to higher yields. This would lower women's bargaining power at market because their crop is of lower quality. One recent paper even suggests that even if women's crops are similar quality, men could perceive them to be lower quality, which would also lower bargaining power (Feld et al., 2022).

This quality differential could be more pronounced with annual crops than with tree crops. Annual crops require a larger physical cost at planting time, as the land must be tilled (aerated) and loosened-up to accept the planting of seeds or seedlings. In the case of tree crops, trees are already planted, and thus only require a small amount of labor for maintenance prior to the harvest time.

It is an unfortunate truth that women are less financially literate than men (Lusardi and Mitchell, 2008, 2014). The difference in financial literacy between men and women has been demonstrated to be strongly correlated with gender stereotypes and differences in numeracy. Based on the available literature it seems likely that this disparity is present in most or all of the areas included in our sample. Women are also known to be more risk-averse which could drive them to accept a lower price in order to avoid the uncertainty of a total loss (Charness and Gneezy, 2012; Croson and Gneezy, 2009). Recent literature from sub-Saharan Africa has demonstrated that individuals from firms that are less liquid accept lower prices for the goods they sell (Hardy et al., 2022). A lack of liquidity, often synonymous with a

[7] An example would be that alone a woman-head might have trouble tilling the soil to prepare for the planting. Tilling the soil allows the plant's roots to grow freely and allows air to penetrate to the roots of the plants.

great deal of uncertainty, may drive women to accept lower prices considering the urgency of their needs and the lack of available alternatives.

Women face more challenges bringing their goods to market as they benefit less from men family members that might help shoulder the burden. Women household heads face a high opportunity cost of time as they also often have no other adults in the household to support the activity of the household including generating income sufficient to feed and care for all household members. Women may therefore feel the need to accept a lower price, as it is more costly for them to return home with the goods and bring them to market yet again or to another market.[8]

There is strong social stigma around women who work and women-headed households that typically form as the result of a divorce or widowhood (Van de Walle, 2013). Interacting or transacting with women could be a social "bad" causing negative reputational effects for men among other members of the community. These biases could be stated and explicit or there could be implicit biases, meaning sub-conscious influences on behavior and economic interactions (Bertrand et al., 2005). Due to the fact that women are considered to have a lower social status, this may influence their capacity to negotiate for higher prices (Goldstein and Udry, 2008).

[8] If women-headed households tend to be physically on the margins of the population centers, meaning a greater distance from the nearest population center, this imposes an additional cost for women relative to men in delivering goods to market. This, in turn, could induce women to accept a lower price once they have brought their goods to market. We present analysis from our sample in appendix D which shows very little quantitative evidence that women do tend to live further from population centers.

Sorting Effects and Buyer-specific Rents

In the case of women who market agricultural goods, sorting effects would manifest as buyer- specific rents. This translates into men having access to purchasers that are able to pay a higher price. This type of dynamic is noted in recent work by Halvarsson et al. (2022). Using Swedish data, the authors find that the export of goods that are intensive in interpersonal contacts widens the gender wage gap. This implies that women have less access to social networks that facilitate economic activity. In an agricultural marketing context, women are often obliged to sell to neighbors and relatives, and they may therefore accept a lower price. This is exactly what we see in our data, and the tables describing to whom women and men sell their crops can be found in the Appendix section B. In the context of an econometric estimate, this could be represented with the inclusion of buyer-specific fixed effects. Once these fixed effects are included, if the gender price gap declines, that indicates the "sorting" effect is in action. The size of the change may indicate the importance of the sorting effects relative to the bargaining effects.

Policy Implications of a Price Wedge

If women are receiving a lower price for their agricultural outputs, they have little access to formal labor markets, and they can't get access to capital to start their business where are they supposed to turn? The gender-based price wedge, ostensibly a tax on women's outputs, seems to erode women-headed household's margins. Women still farm their land likely because they have few options in terms of income streams and it provides a (relatively) consistent source of food, particularly in remote areas with little or no market for services. Literature which analyzes the yield gap, that is the differential between the productivity (yield) on plots cultivated by women vs those cultivated by men, could be problematic without

considering the unobserved price differential. If women know they will receive a lower price they may plant less land and perhaps farm less intensively as there is less incentive to turn out crops for sale, and the marginal product of labor/time may be higher elsewhere. This is consistent with results from Udry (1996), a seminal work on gender in sub-Saharan Africa, which found that women are able to generate highly productive plots though only for very small plots of land.

Methodology

This analysis follows two principal approaches. The first is to analyze the price differential between men's and women's prices as measured via transaction data using a simple crop and village fixed effects procedure. In certain cases, additional fixed-effects dummy-variables are included. The second step is to analyze mobile phone ownership using descriptive statistics and basic regressions to evaluate the presence of asymmetric information in the form of gendered information networks. The primary empirical model for the transaction data is the transaction price, p_i, regressed on a dummy for the gender of the household head (individual i), plus, α_k, a dummy representing individual crops, k, and an area fixed effect, γ_d, for village v. x_i is a dummy variable that takes one if the head of the household is a woman. The regression equation is as follows:

$$p_i = \beta x_i + \alpha_k + \gamma_d + e_i$$

If a seller's gender does not affect the transaction price the coefficient β on this variable should be statistically indistinguishable from zero. If a price wedge exists then this variable will have a negative impact on the transaction price, demonstrating that women receive lower prices.

In a separate procedure, illustrated earlier in Figure 1 with a kernel density plot, we regress the log of the men's transaction price on the transaction price received by

women marketing the same crop in the same village. The universe of observations is therefore restricted to villages for which we observe both a man and a woman transacting in the same crop and the regression tests how strongly the men's price and the women's price are related.

$$p_{cv}^{m} = \psi p_{cv}^{w} + e_i$$

In words, this can be thought of as "how much of the men household head's price does the women's price explain?" If the two prices are equal, and they move in sync, then the value of this coefficient should be unity. There should naturally be some variation across villages and crops.

To better understand women-headed household's access to information we analyze the mobile ownership patterns of women-headed households and men-headed households using descriptive statistics, as well as regressions of mobile ownership on a dummy representing the gender of the household head. We then divide the sample by tercile of consumption per adult equivalent. We find that women-headed households in a higher consumption bracket are less likely to own a mobile phone relative to households headed by men with similar levels of consumption.

Using geographic information systems, we map out differences in mobile phone ownership between women-headed households and households headed by men. We selected a choropleth to indicate areas where the concentration of women's phones is higher.

Data and Results

Data

Data have been taken from household surveys from around the world. The primary datasets used here are from the World Bank's Living Standard Measurement Study

project. Survey data from the LSMS program that are included in the analysis here are from Uganda (2005, 2009, 2010, 2011, 2013, and 2018), Tanzania (2008, 2010-11, 2012-13, 2014, 2019), and Malawi (2004, 2010, 2013, 2016 and 2019).

Malawi has a large sample of publicly available LSMS data over a small geographic area which lends itself well to detailed analysis. In Malawi the sample size is large enough to estimate the price gap with extensive controls for specific crops and crop varieties such as hybrid corn vs traditional varieties.

We pursued data from both Latin America and Southeast Asia to evaluate whether this hypothesis could be relevant in other areas rather than exclusive to sub-Saharan Africa. The two most conducive and comprehensive datasets with gender of the household head as well as transaction data were the Peruvian Encuesta Provincial a Hogares Rurales (2014) and the Bangladesh Integrated Household Survey. These data are freely available from the Peruvian Statistical Authority (Instituto Nacional de Estad´ıstica e Inform'atica) as well by IFPRI via the Harvard Dataverse. The Bangladesh Integrated Household Survey (2011, 2015, 2018) was a survey data collection undertaken by the International Food Policy Research Institute in partnership with the Government of Bangladesh, with funds from the United States Agency for International Development (USAID). These data are suited for our analysis given the sample size and the level of detail in the data. In Peru, unlike in some parts of Africa and Southeast Asia, there do not appear to be a large variety of different buyers. In this case, this reduces the possibility that a price differential in these areas is caused by sorting effects, middle-chain purchasers and other intermediaries. Both the Malawian and Peruvian data are large enough to permit controls (fixed effects) for buyer and place of sale.

Descriptive statistics of households headed by men contrasted with households headed by women can be found in Table 1. The top half of the table represents

household characteristics while the bottom half corresponds to the individual characteristics of the household head. The key differences that appear are that women tend to have fewer adults in the household and, except in Bangladesh, tend to be older than men who are household heads. The average age of individuals other than the head is much lower for women than for men. We can also see that women clearly plant less land, which is one way they are able to maximize their use of resources.

Table 1: Household characteristics by country and gender of household head.

	Bangladesh		Malawi		Peru		Tanzania		Uganda	
Characteristics of the Household	Men	Women	Men	Women	Men	Women	Man	Woman	Man	Woman
Adults (Other Than Head)	2.4	1.5	1.4	0.8	1.5	0.8	1.8	1.2	2.4	2.0
Adult Men	0.4	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.8	1.0
Dependents	1.9	2.0	1.8	1.4	1.2	0.6	2.0	1.4	3.0	2.5
Dep. Ratio	0.80	1.31	1.27	1.86	0.80	0.82	1.08	1.16	1.28	1.28
Average Age Household	30	28	24	27	36	45	25	28	22	25
Average Household Age (no head)	25	16	18	14	29	24	19	16	16	15
Hectares Planted	12.5	2.3			2.7	1.6	1.1	0.7		
Hectares Planted per AE	4.3	1.1			1.1	0.8	0.3	0.2		
Net Cash Revenue per Hect. (in LCU)	1158.4	857.4			-209	-817	260021.8	185119.2		
Net Cash Revenue per Hect. (in Nom. USD)	16.22	12.00			-69	-270	156.0	111.1		

	Bangladesh		Malawi		Peru		Tanzania		Uganda	
Characteristics of the Household Head	Men	Women	Men	Women	Men	Women	Man	Woman	Man	Woman
Age	46	42	41	47	49	56	44	49	44	48
Has Mobile	0.98	0.96	0.52	0.34	0.49	0.39	0.70	0.57	0.50	0.36
Literacy	0.50	0.51	0.79	0.51	0.71	0.34	0.82	0.59		
Head Has Primary Educ	0.71	0.70	0.37	0.18	0.64	0.34	0.56	0.41	0.31	0.18
Head Has Seconday Educ	0.55	0.50	0.14	0.06	0.26	0.13	0.12	0.08	0.07	0.04
Never Married	0.02	0.00	0.05	0.24	0.06	0.22	0.04	0.10	0.04	0.05
Married	0.97	0.59	0.84	0.15	0.88	0.16	0.91	0.17	0.85	0.33
Widowed	0.01	0.36	0.09	0.20	0.04	0.43	0.03	0.30	0.06	0.20
Divorce	0.00	0.01	0.02	0.41	0.03	0.19	0.02	0.42	0.06	0.42

For certain countries we have included additional variables measuring area planted and net revenue per hectare, as well as area planted per adult equivalent. Net revenue per hectare is a measure of marketed surplus divided by total planted acres. This cannot exactly be equated with profit because, though expenses have been 'netted out,' there are other uses besides sales for crops such as consumption, in-kind contributions, using for seed and so on. Because of this, the marketed surplus value does not include the value of crop used for any of those other purposes. Furthermore, we have not made an effort to value the family labor by giving family members a wage. For our purposes this is sufficient, however, to capture how much return women are making on their land relative to male counterparts. Across all countries women make only a small fraction of what make in terms of net revenue per hectare. This is owing to the factors outlined above, a lack of access to men to engage in heavy physical labor, restricted access to inputs due to cost or working capital constraints and receiving a lower price than men who sell at market.

Turning to the characteristics of the household head in all cases except Bangladesh the age of women household heads is older than that of household heads who are men. Men are, in all cases, more likely to own a mobile phone than women. In general, women household heads tend to have lower literacy rates and be less educated though the difference between men's education and women's educational attainment is smaller in some countries, like Bangladesh, and larger in others, like Malawi. A majority of the women-headed households list their marital status as divorced or widowed. Much fewer men than women fall into those categories while men mostly fall into the married category which itself is a of representation of the social status of men relative to women.

Primary Results

Primary results from the price regressions are included in Table 2. Crop fixed-effects are included in all the columns, village fixed-effects are also included. Across all columns except

for one there is a strong and statistically significant negative effect of being a woman on observed transaction prices. This is striking because it seems to be consistent, at least in sign, across countries and across continents. The most pronounced effect comes from Bangladesh where women appear to receive prices 40 percentage points lower than men. In Peru, there are three columns. The first column includes all observations for which a price is recorded. In columns 4 and 5 the sample is restricted to only those sales where the quantity is also recorded. Despite the fact that quantity sold was omitted for those 8,573 observations the unit price received at sale was included. Unit values for Peru were recorded for each transaction rather than unit values being backed out from the amount received divided by the quantity sold. Nonetheless, in column 3 for Peru there is a negative and statistically significant effect of the gender of the household head on the price received of about 7.8 log points. In Tanzania women and men tend to plant different crops. As such this is a reason, we might not achieve identification since there are not a woman household and a man household transacting in the same crop in the same village very frequently. Nonetheless at least in the specification including quantity sold, women headed households receive a 20% lower price relative to households headed by men selling the same crop in the same village. The negative effect of the household head being a woman on the transaction price appears to be consistently estimated, at least in sign and significance, for Bangladesh, Malawi and Uganda.

Table 2: Principal regression results

	Bangladesh		Peru		
	(1) Log of Sale Price	(2) Log of Sale Price	(3) Log of Sale Price	(4) Log of Sale Price	(5) Log of Sale Price
Log of Quantity Sold		0.958***			0.119***
		(0.00372)			(0.0159)
Head is a Woman	-0.402***	-0.0228*	-0.0786***	-0.0247	0.0166
	(0.0432)	(0.0126)	(0.0302)	(0.0318)	(0.0323)
Head Owns Mobile	0.346***	0.00875	0.0602***	0.0199	-0.00475
	(0.0430)	(0.0103)	(0.0211)	(0.0220)	(0.0225)
Observations	18,137	18,137	24,009	15,436	15,436
Number of Villages	606	606	1,251	1,158	1,158
Robust standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

	Malawi		Tanzania		Uganda	
	(6) Log of Sale Price	(7) Log of Sale Price	(8) Log of Sale Price	(9) Log of Sale Price	(10) Log of Sale Price	(11) Log of Sale Price
Log of Quantity Sold		-0.425***		-0.220***		-0.117***
		(0.0114)		(0.0142)		(0.0148)
Head is a Woman	-0.0803***	-0.115***	0.000546	-0.0789***	-0.0600***	-0.0989***
	(0.0271)	(0.0257)	(0.0199)	(0.0196)	(0.0215)	(0.0217)
Head Owns Mobile	0.0477*	0.112***	0.0273	0.122***	0.107***	0.148***
	(0.0244)	(0.0234)	(0.0200)	(0.0201)	(0.0189)	(0.0198)
Observations	24,719	24,719	11,639	11,639	25,013	25,013
Number of Villages	2,019	2,019	665	665	864	864
Robust standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

In order to evaluate the presence of sorting effects and how they might influence the difference in price received by women and men, in one specification controls for buyer

type and place of sale are included. These estimates can be found in Table 2. For each country, the original estimate without supplementary controls is represented in the left column while the estimate with the controls is on the right. In the case of Bangladesh, Malawi and Uganda including additional controls decreases the size of the coefficient on woman household head. This is consistent with the idea that sorting effects are contributing to the gender price gap.

To further describe the nature of the price gap we also split the sample into permanent crops and annual crops and re-ran the regression model. If women are struggling more with annual crops, that might mean they are labor or otherwise resource constrained, or they may have lower quality land that yields poorer results. These regressions are included in Appendix Table A.1. In Uganda and Peru, the price gap is estimated to be larger for annual crops than for permanent crops. In fact, in the case of Peru the price gap is not detected at all for the permanent crops. This strongly suggests that in the case of Uganda and Peru it is likely that programs that target tree crops or permanent crops, which require less planting labor and less manual labor overall, could benefit women

Asymmetric Information Problem

This section addresses whether or not men who are marketing crops may access different in- formational networks than women who marketing crops, a question which was raised based on the finding of asymmetric information between husbands and wives marketing crops in Zambia (Miura et al., 2020) and based on Mekonnen et al. (2018) 's findings using primary data on gendered informational networks. Another very recent paper by Haucap et al. (2022) finds that, in the formation of cartels women are all but excluded, also suggesting the presence of gender-influenced business networks or gender-based professional and social networks. We first analyze descriptive statistics of mobile ownership for different groups in the population. We then test whether the gender of the

head influences the probability of mobile phone ownership. We regress the probability of mobile ownership on the share of phones in the village belonging to women. Areas where there are a higher ratio of women heads to men heads with phones are likely to have larger networks of women providing economic information to one another. Last, we present maps of the gap between men's and women's mobile phone ownership as well as survey evidence that women household heads use their mobile phones less than men household heads. In Table 3, descriptive statistics on mobile ownership are divided into households headed by men and households headed by women. The probability of owning a mobile phone is broken into three separate rows which are categories for levels of consumption per adult, low, medium and high consumption per adult equivalent. This allows us to compare women- headed households and households headed by men which are roughly similar in terms of level of consumption. The columns represent different concentrations of women household heads, low, medium and high concentration. As the concentration of women heads in the area goes up, so does the probability that a women household head will own a phone. The descriptive analysis is suggestive that when more women are around, women are more likely to purchase mobile phones since it also allows them to access to a larger informational network. Put differently, the marginal product of a woman owning a mobile phone is higher while the marginal product of owning a phone for men presumably does not change due to different concentrations of women household heads.

Table 3: Regression of mobile ownership dummy on gender of household head

	Bangladesh		Peru	
	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price
Head is a Woman	-0.402***	-0.409***	-0.0786***	-0.0766**
	(0.0432)	(0.0438)	(0.0302)	(0.0302)
Head Owns Mobile	0.346***	0.345***	0.0602***	0.0567***
	(0.0430)	(0.0426)	(0.0211)	(0.0212)
Buyer FE				
Place of Sale		Yes		Yes
Observations	18,137	18,137	24,009	24,009
Number of union	606	606	1,251	1,251

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	Malawi		Tanzania		Uganda	
	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price
Head is a Woman	-0.0803***	-0.0724***	0.000546	-0.00101	-0.0598***	-0.0543**
	(0.0271)	(0.0271)	(0.0199)	(0.0200)	(0.0215)	(0.0216)
Head Owns Mobile	0.0477*	0.0424*	0.0273	0.0259	0.107***	0.104***
	(0.0244)	(0.0245)	(0.0200)	(0.0200)	(0.0189)	(0.0189)
Buyer FE		Yes		Yes		Yes
Place of Sale		Yes		Yes		
Observations	24,719	24,719	11,639	11,639	25,013	25,013
Number of union	2,019	2,019	665	665	864	864

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Turning to the regression table, Table 4, each cell represents the regression of a mobile ownership dummy on the share of women household heads in a particular area. So, for example, in column 1, the first cell is the coefficient estimate for the effect of the share of

women in the village on the probability of a household head who is a man. Column 2, cell 1 shows the same regression restricted to only women-household heads. Across the top are the different categories of consumption per adult equivalent. We can see that these effects persist across all levels of consumption per adult. This is highly indicative of the presence of gendered information networks which also implies asymmetric information. As the share of women's phones increases, women are more and more likely to have mobile phones as they benefit from having access to other women with phones. A larger share of women household heads with phones does not increase incentives for men who are household heads to have phones, which is what the coefficients show.

Table 4: Regressions with buyer and place of sale fixed effects

	Uganda	Tanzania	Malawi	Bangladesh	Peru
	Head Owns Mobile	Head Owns Mobile	Head Owns Mobile	Head Owns Mobile	Head Owns Mobile
Head is Woman	-0.104***	-0.140***	0.143***	-0.0708***	-0.129***
	0.0168	-0.0142	-0.00922	-0.00666	-0.00357
Terc. of Cons. FE	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Districts	108	173	32	64	195
Observations	3,116	4,883	11,434	34,031	114,571

Table 5: Mobile ownership per household head by gender: Peru

	Concentration of Women Heads	Low	Medium	High
Low income	Phones per woman	0.2	0.3	0.4
	Phones per man	0.4	0.5	0.5
Middle Income	Phones per woman	0.2	0.4	0.5
	Phones per man	0.5	0.5	0.5
High Income	Phones per woman	0.3	0.5	0.5
	Phones per man	0.5	0.6	0.6

Table 6 shows women's use of mobile phones in Peru. The women-headed households are divided into categories of income and three categories that represent the concentration of women's mobile phones. In areas where there's a higher share of women household heads with mobile phones, the marginal product of having a phone is higher as the network women potentially have access to is much larger. As we see, going down the rows in the low income and middle-income sections there is not much difference between low, medium and high concentration of women's phones. In general, women seem to prefer sending and receiving voice phone calls to sending SMS as they send very few SMS messages relative to the number of phone calls sent and received. The fact that, for the highest income category women in areas with a higher concentration of phones send and receive more phone calls lends additional evidence to the idea of the presence of gendered information networks in Peru.

Table 6: Mobile phone regressions

Cons. per Adult	Low		Medium		High	
	(1)	(2)	(3)	(4)	(5)	(6)
HH Head is a:	Man	Woman	Man	Woman	Man	Woman
BGD	**-0.102**	**0.436**	**-0.111**	**0.605**	-0.0388	0.133
TZA	0.0214	**1.045**	-0.0571	**0.691**	0.0465	**0.797**
UGA	-0.233	**0.56**	-0.1	**0.728**	0.0345	**0.438**
MWI	**-0.343**	**0.264**	**-0.292**	**0.566**	**-0.147**	**0.453**
PER	**-0.0999**	**0.983**	**-0.134**	**0.906**	**-0.118**	**0.95**

Each cell represents a regression coefficient from a different model dependent variable: dummy for mobile ownership independent variable: Share of phones in the village owned by women bolded coefficients

Table 7: SMS and phone calls sent and received by women household heads in Peru

	Share of Phones Belonging to Women	Low	Med.	High
Low income	SMS Sent	0.9	1.2	0.8
	SMS Received	1.9	1.7	1.6
	Calls Sent	3.3	3.0	3.1
	Calls Received	4.7	4.8	5.0
Middle Income	SMS Sent	1.7	1.4	1.2
	SMS Received	2.4	2.3	2.4
	Calls Sent	4.4	4.6	4.1
	Calls Received	5.8	6.5	6.0
High Income	SMS Sent	3.4	3.1	3.3
	SMS Received	4.4	4.2	3.8
	Calls Sent	6.6	7.5	7.5
	Calls Received	8.5	10.0	10.1

Table 8. Descriptive statistics for primary regressions

		(1) Observations	(2) Mean	(3) Std. Dev.	(15) Median
Bangladesh	Quantity of Crop Sold	18,137	981.2	2,805	400
	Log Quantity of Crop Sold	18,137	5.806	1.548	5.994
	Unit Price at Sale	18,137	15,146	29,400	6,300
	Log Unit Price at Sale	18,137	8.627	1.543	8.748
	Head is a Woman	18,137	0.361	0.480	0
	Head Owns Mobile Phone	18,137	0.902	0.297	1
	Number of Villages	606	606	606	606
Peru	Quantity of Crop Sold	15,436	1,322	13,157	216
	Log Quantity of Crop Sold	15,436	5.344	1.958	5.380
	Unit Price at Sale	15,436	13,012	1,138,000	6.800
	Log Unit Price at Sale	15,436	2.529	1.679	2.054
	Head is a Woman	15,436	0.102	0.302	0
	Head Owns Mobile Phone	15,436	0.485	0.500	0
	Number of Villages	1,158	1,158	1,158	1,158
Malawi	Quantity of Crop Sold	24,719	54.46	770.1	5
	Log Quantity of Crop Sold	24,719	2.254	1.395	1.792
	Unit Price at Sale	24,719	3,734	18,683	220
	Log Unit Price at Sale	24,719	5.784	2.004	5.398
	Head is a Woman	24,719	0.233	0.422	0
	Head Owns Mobile Phone	24,719	0.424	0.494	0
	Number of Villages	2,019	2,019	2,019	2,019
Tanzania	Quantity of Crop Sold	11,639	935.8	9,403	160
	Log Quantity of Crop Sold	11,639	5.158	1.554	5.081
	Unit Price at Sale	11,639	693.6	1,352	433.3
	Log Unit Price at Sale	11,639	5.971	1.134	6.074
	Head is a Woman	11,639	0.201	0.401	0
	Head Owns Mobile Phone	11,639	0.562	0.496	1
	Number of Villages	665	665	665	665
Uganda	Quantity of Crop Sold	25,013	2,144	167,452	120
	Log Quantity of Crop Sold	25,013	1,051	5,081	500
	Unit Price at Sale	25,013	0.563	0.496	1
	Log Unit Price at Sale	25,013	0.174	0.379	0
	Head is a Woman	25,013	6.164	1.179	6.217
	Head Owns Mobile Phone	25,013	4.914	1.487	4.796
	Number of Villages	864	864	864	864

Policy Implications

Policy solutions here depend on the context but the implications of a gender-based price wedge are significant. Women are facing a relatively more substantial barrier to improving their household's standard of living if they are facing this type of economic repression. One important implication is that many agricultural policies and projects might intend to assist women, but they have not resolved the price gap issue. This means that investments in, say, fertilizer, or composting will not benefit women in the same way it will benefit men who can capture a larger margin. For example, a recent paper Beaman and Dillon (2018) documents that women are isolated and less likely to benefit from the diffusion of agricultural information. While this alone is a sign of asymmetric information, consider that the diffusion does reach the women. The return on investment for composting and implementing other agricultural technologies is lower given that there is a price gap. Another paper recently evaluated the effect of business training programs on women entrepreneurs in Ethiopia (Bakhtiar et al., 2022). The authors found that the program training individuals in management practice yielded significant increases in profits for women entrepreneurs. It is worrisome that projects which are well-intended could be having a greatly diminished effect for women or they could be widening the gap between the well-being of women-headed households and households headed by men.

If the context is primarily driven by social norms and customs, these views may not respond directly to economic incentives. In that case, then educational programs such as the one in Haryana state and updating individual's understanding of the importance of equal access to economic opportunities would be the best approach (Dhar et al., 2022). It may be a major challenge to shake loose long-held social customs that would open the door to women seeking expanded access to agricultural markets.

The potential solutions to the asymmetric information scenario are quite evident. Would men voluntarily provide price data? Could we pay individuals to provide price data that would then be disseminated automatically (reducing the need for monitoring costs/managerial labor overhead)? Asymmetric information lends itself to solutions which offer transparency for all. However, most farmers do not yet have smartphones and some lack any phones at all. This lack of access to technology could be a major roadblock for any potential solution including reducing asymmetric information. We think this could be an interesting use-case for a blockchain solution which lists all agricultural transactions for certain crops in a particular area. Whatever the delivery system of new information, women-farmers need to be tapped in to information flows about prices and other agricultural activities. As another example, if the primary constraint for women is the capacity and time required to bring goods to market, then providing women with bicycles could reduce the cost of transporting their goods to and from market. A recent study found positive results of contributing bicycles to children to attend school. The bikes increased women's autonomy and empowerment (Moene et al., 2022).

If the buyer is a key factor in sale/transaction price, meaning women get a fairer price from some buyers rather than others, this presents an interesting way of resolving the price discrepancy. One approach might then be empowering the buyers who originally provided the fairest prices (relatives and neighbors) rather than encouraging women-farmers to work with new buyers who are potentially hostile to women.

Conclusion

By analyzing household survey data from five countries across three continents, we conclude that women receive a lower unit price for agricultural goods sold at the market. This finding has implications for policy for food security, gender equality, and food

security. Therefore, we argue that identifying the factors creating the gendered price wedge is crucial. To this end, we explored differences in price prediction error between men and women in times of low, average, and high rainfall and find that information flows appear to shift significantly during different states of nature. For women to remain food secure and invest in their farms and family, this significant barrier to income generation should be addressed. Potential remedies, e.g., providing women with market information via mobile phones, can effectively lead to gender equality.

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Appendix Tables and Maps

Appendix A. Additional regressions

Table A1: Regressions by annual and permanent crops

Country	Bangladesh		Peru	
Crop Type	Annual	Permanent	Annual	Permanent
	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price
Head is a Woman	0.0938***	0.295*	-0.104***	0.0151
	(0.0305)	(0.169)	(0.0353)	(0.0540)
Head Owns Mobile	0.437***	0.539***	0.0430	0.0647*
	(0.0448)	(0.129)	(0.0268)	(0.0336)
Observations	17,062	1,075	15,280	8,729
Number of villages	605	262	1,141	677

Country	Malawi		Tanzania		Uganda	
Crop Type	Annual	Permanent	Annual	Permanent	Annual	Permanent
	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price	(1) Log of Sale Price	(2) Log of Sale Price
Head is a Woman	-0.0372	-0.305***	0.0267	0.00141	-0.101***	-0.0908***
	(0.0269)	(0.106)	(0.0229)	(0.0362)	(0.0259)	(0.0316)
Head Owns Mobile	0.0442*	0.106	0.206***	0.127***	0.0474**	-0.0169
	(0.0238)	(0.102)	(0.0229)	(0.0325)	(0.0213)	(0.0433)
Observations	22,484	3,003	8,820	5,474	16,249	8,779
Number of villages	2,004	1,020	619	518	855	584

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B. Sales locations and buyers by gender

Table B1. Buyers by gender of seller, Malawi

	Men		Women		
	Freq.	Percent	Freq.	Percent	% Δ
Relative	459	2.41	205	3.56	0.48
Friend/neighbor	1,330	7	468	8.12	0.16
Roadside	522	2.75	191	3.31	0.20
Mobile Market	4,459	23.46	1,263	21.91	-0.07
Local Market	5,879	30.93	2,102	36.47	0.18
Private Trader in Local Market	1,438	7.56	414	7.18	-0.05
Local Merchant/Grocery	327	1.72	90	1.56	-0.09
Main Market	1,098	5.78	313	5.43	-0.06
Private Trader in Main Market	443	2.33	116	2.01	-0.14
Auction in Main Market	1,018	5.36	85	1.47	-0.73
Private company/businessperson	1,129	5.94	331	5.74	-0.03
Other	904	4.79	186	3.23	-0.33
Total Transactions	19006		5764		

Table B2. Buyers by gender of seller, Tanzania

	Man		Woman		
	Freq.	Percent	Freq.	Percent	% Δ
Relative	238	1.97	80	2.63	0.34
Neighbor	1,029	8.5	285	9.38	0.10
Market	491	4.06	86	2.83	-0.30
Open Market	1,101	9.09	267	8.79	-0.03
Cooperative Union	745	6.15	246	8.1	0.32
Farmer's Party	512	4.23	148	4.87	0.15
Main plot/farm	230	1.9	50	1.65	-0.13
Private Business Person	800	6.61	156	5.14	-0.22
Main Market	4,278	35.33	1,040	34.24	-0.03
Grocery/Local Merchant	491	4.06	130	4.28	0.05
Money Lender	1,347	11.12	367	12.08	0.09
Market	268	2.21	58	1.91	-0.14
Other	559	4.63	118	3.88	-0.16
Total Transactions	12089		3031		

Table B3. Buyers by gender of seller in Uganda

	Man		Woman		
	Freq.	Percent	Freq.	Percent	% Δ
Government	64	0.3	7	0.16	-0.47
Private Trader in Local Village/Local M	14,378	66.65	2,964	65.84	-0.01
Private Trader in District Market	2,323	10.77	386	8.57	-0.20
Consumer at Market	3,223	14.94	764	16.97	0.14
Neighbor/relative	1,293	5.99	333	7.4	0.24
Other	272	1.26	43	0.96	-0.24
Total Transactions	21553		4497		

Table B4. Location of sale by gender in Tanzania

	Man		Woman		
Location of Sale	Freq.	Percent	Freq.	Percent	% Δ
Within the village	6,811	56.25	1,795	59.1	0.05
Near the village	2,747	22.69	740	24.37	0.07
Near the town	1,242	10.26	281	9.25	-0.10
Other district	691	5.71	141	4.64	-0.19
Other region	559	4.62	65	2.14	-0.54
Across the border	58	0.48	15	0.49	0.02
Total Transactions	12,108		3,037		

Table B5. Location of sale by gender in Malawi

	Man		Woman		
Location of Sale	Freq.	Percent	Freq.	Percent	% Δ
Within the Village	7,012	36.87	2,351	40.76	0.11
Near the Village	7,220	37.96	2,362	40.95	0.08
Near the Town	2,835	14.91	662	11.48	-0.23
Near the District/Urban Center	784	4.12	189	3.28	-0.20
Outside the District	1,002	5.27	156	2.7	-0.49
Outside the Region	130	0.68	32	0.55	-0.19
Total Transactions	18,983		5,752		

Table B6. Location of sale by gender in Peru

Location of Sale:	Men		Women		% Δ
	Perennial Crops				
	Freq.	Percent	Freq.	Percent	
Farmers Union/Cooperative	12,967	94.62	1,524	96.7	0.02
Local Market	737	5.38	52	3.3	-0.39
Total	13,704		1,576		
	Tree/Woody Crops				
Farmers Union/Cooperative	7,505	94.72	771	95.66	0.01
Local Market	418	5.28	35	4.34	-0.18
Total	7,923		806		

Appendix C. Extension contact data by gender

Table C1. Extension contacts by gender and country ("Did you receive any visit or contact from an agricultural extension agent in the past year?")

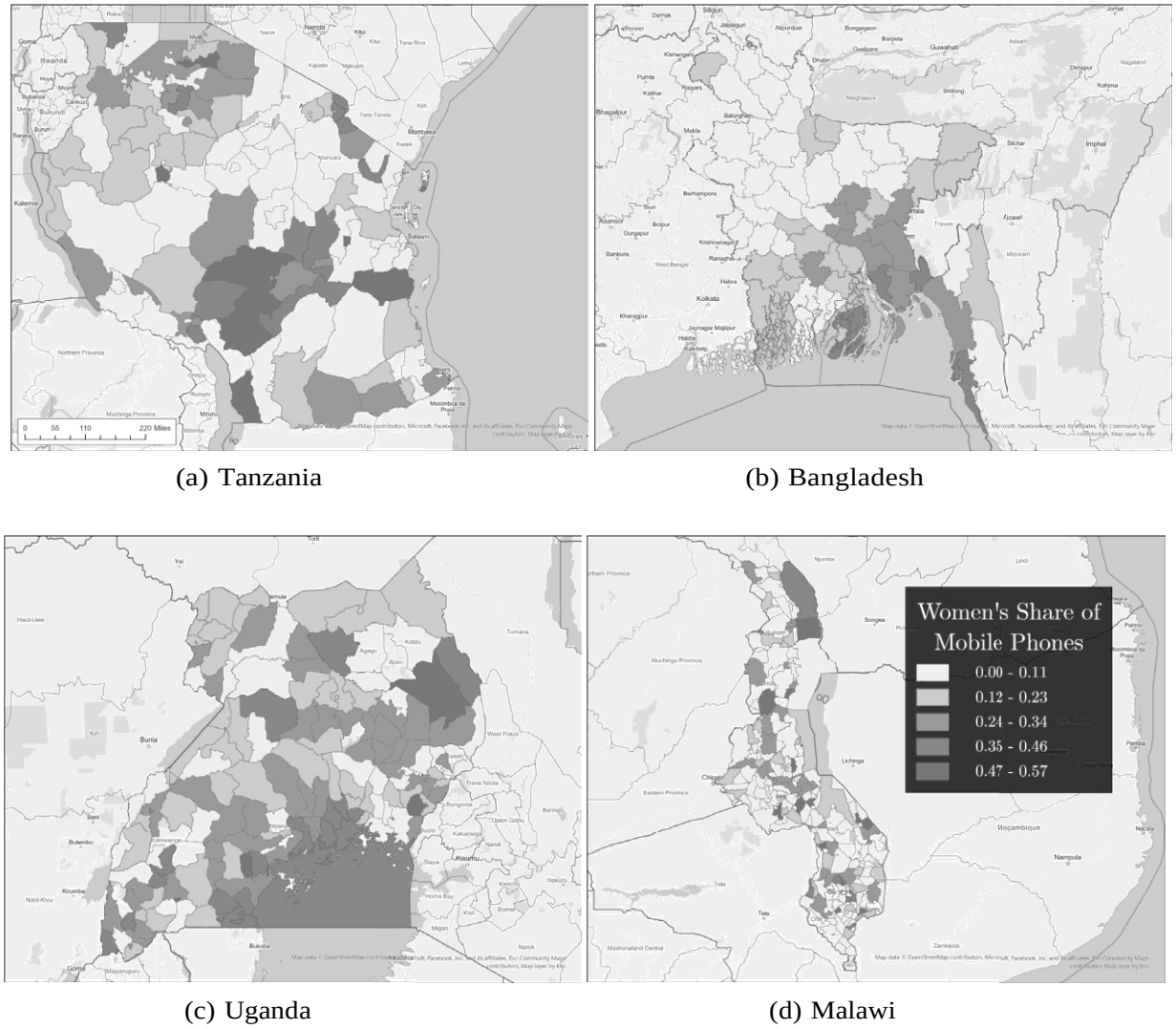
		Men		Women	
		Freq.	Percent	Freq.	Percent
BGD (2011-2018)	Yes	948	7.97	20	0.97
	No	10940	92.03	2032	99.03
	Total	11888		2052	
MWI	Yes	13,328	12.59	4,532	9.4
	No	92,544	87.41	43,660	90.6
	Total	105,872		48,192	
TZA	Yes	68	2.2	12	1.2
	No	3,024	97.8	987	98.8
	Total	3,092		999	
UGA	Yes	356	21.83	144	17.5
	No	1,275	78.17	679	82.5
	Total	1,631		823	

Appendix D. Distance metrics by gender

		Men	Women	
(Plot) Distance to Household*	Bangladesh	0.37	0.22	-0.39
	Malawi	1.3	1.0	-0.21
	Peru	8.14	10.01	0.23
	Tanzania	5.8	7.7	0.34
(Household) Distance to Nearest Town*	Bangladesh	103.9	107.5	0.04
	Malawi	20.0	20.1	0.01
	Tanzania	40.1	39.1	-0.02
	Uganda	21.8	22.5	0.03

*Kilometers

Appendix E. Maps of the digital divide



(a) Tanzania (b) Bangladesh

(c) Uganda (d) Malawi

Figure E1. The digital divide mapped: Women's share of mobile phones
(Basemap: Open Street Map, CC License)