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The Digital Divide in Rural Ethiopia

Determinants and Implications of Sex-Disaggregated Mobile Phone Ownership and Use

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Abstract

Mobile phones are rapidly being adopted in less developed countries, with widely acknowledged commensurate socio-economic benefits, including United Nations SDGs advocating for increased ownership of mobile phones to promote women's empowerment. While overall mobile phone ownership is rising quickly in Ethiopia, it is lagging for rural women, particularly married rural women. Overall, we find that married men are approximately five times more likely to own a phone than their wives even though married women with phones are more active in agricultural decision making. This lack of female mobile phone ownership should be considered within the broader context of several recent Ethiopian digital initiatives, including mobile banking and mobile payments. These initiatives are likely to provide greater benefits to those individuals that own a mobile phone. By applying gender analysis to phone ownership, we believe that we can anticipate some potentially unexpected negative consequences for women created by these mobile phone initiatives. This paper outlines current rural sex-disaggregated phone ownership trends, determinants of phone ownership, and related impacts on intrahousehold decision making. We believe that by identifying these gender differences in mobile phone ownership, policymakers can better target their digital economy initiatives.

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I. Introduction

Mobile phones are becoming one of the most extensively adopted technologies in the world. Some uses include general communication, acquiring information for economic decision-making, mobile payments, banking and accessing medical services. As a result, the mobile phone has proven to be a powerful tool to help reduce poverty, improve healthcare and education, and drive sustainable economic growth (GSMA 2019). Increasing female mobile phone ownership will help close digital divides, particularly for rural women. As a result, access to information and communication technology is one of the primary targets set by UN's Sustainable Development Goals (SDGs) to better achieve gender equality and help eradicate poverty. The prevalence of women ownership of mobile phones is proposed as one of 14 indicators to be used towards the achievement of gender equality. More specifically, SDG indicator 5.b.1 declares, *Enhance the use of enabling technology, in particular information and communication technology, to promote the empowerment of women.*[1] In support of attaining SDG goals, a recent Government of Ethiopia policy document declared that 100% ownership of mobile phones was a target to be reached by 2030 (PDC 2021), with the overall objective of building an inclusive digital economy for all Ethiopians (FDRE 2020). Another Ethiopian policy document stresses an inclusive digital economy through rural strategies that include building a digital agricultural platform and incentivizing ag-tech entrepreneurship (FDRE 2018). However, none of these Ethiopian policy documents make explicit reference to women and rural phone ownership.

Comprehensive reviews from low- and middle-income countries indicate that closing the mobile phone gender gap will have a positive overall impact on women's well-being, enhance women's overall empowerment, and has the potential to drive economic growth (GSMA 2019). Sub-Saharan African research also confirms these findings. For example, studies in Uganda found that increased female mobile phone ownership is positively associated with their empowerment (Sell and Minot, 2018; Sekabira and Qaim, 2017). This research found that phone ownership enables women to access important information and services, including financial services, allowing them to make better decisions. Further, women who owned phones were also more likely to have increased decision-making power in their households, including contraception use, over women without phones (Rotondi et.al 2020).

Women's ownership of mobile phones may increase their access to information and potentially enhance their networking and accumulate social capital at the household or community levels. Ownership may also influence intermediate variables such as household decisions on production, marketing, and subsequently increase the amount of resources for investment, consumption, health, and education. In addition, women's participation in decision making could also help her

[1] https://sdg.tracking-progress.org/wp-content/uploads/sites/9/2020/05/Global-SDG-Data-Indicators-at-Year-5-Indicator-Analysis.pdf

to direct household decisions to her children's advantage. In this regard, Reggio (2011) and Chakraborty and Prabal (2011) found that women's involvement in decision making on important matters in the household reduces child labor and increases child schooling which translate into better childcare and child wellbeing. Overall, the rapid expansion of mobile phone coverage would likely provide access to information for women, and positively transform their lives for the better.

However, gender relations are often not considered with the introduction of new technologies or interventions with resulting unexpected consequences experienced after their introduction. In terms of the introduction of mobile phones and analysis from a gender perspective in Ethiopia, little research has been offered. For example, there has been a significant push in Ethiopia for adopting mobile banking and payment systems. Recently, the World Bank stressed the need for privatizing/increasing competition in telecommunications and the mobile money market with no mention of gender (Dione 2021). Further, a recent USAID document omits gender considerations and declares:

> *The digital economy space in Ethiopia is clearly entering a "liftoff phase" thanks to a mix of both macro and ecosystem drivers (fast growth, rapid urbanization, growing internet penetration, improving networks, and better data affordability), improved public policies, and rising numbers of private entrants and funders (Cepheus 2019)*

As is the case concerning *gender-blind* documents, there is no mention of gender or women phone ownership in the entire document. However, this does not mean the potential impacts are gender neutral and while increasing mobile phone ownership will probably increase access to finance, payment systems, and economic information, these benefits will likely benefit those who own mobile phones (in this case, men). Further, these initiatives would likely further enhance existing male dominance of decision making within the traditional agricultural household.

While evidence from Ethiopia suggests that households with mobile phones are positively correlated with credit access (Gebremariam 2020) and generally improved marketing decisions (Tadesse & Bahiigwa 2015), the specific benefits of mobile phones are complex and, while probably beneficial, their high correlation to wealth, education and income, as well as other variables, makes the attribution challenging. Unfortunately, most Ethiopian mobile phone analyses fail to even consider gender in their research methodology. As discussed below, married Ethiopian women are significantly less likely to either own or access a phone, suggesting that men will be the primary beneficiaries of recent digital initiatives via the direct control/ownership of the phone in the household. Overall, the vast improvement in mobile phone services will mostly benefit those that own/control mobile phones.

Evidence presented here, explores sex-disaggregated mobile phone ownership and access, as well as phone use. Overall, we find male heads of households are three times more likely to own a phone compared to their female head counterparts and about five times more likely to own a phone

than their spouses. While most married women have access to a phone, data reveals that access, as opposed to ownership, generally limits use. Those women who do own phones tend to be younger, better educated, and have other women as neighbors who own phones. Additionally, there is some evidence that married women with phones have greater input into agricultural decisions. Generally, owning a phone empowers women decision-making by increasing access for obtaining information, such as extension services, market prices and health information. In addition, emerging mobile banking opportunities as well as mobile money (e.g. M-BIRR, M-PESA, Telebirr, etc.) could be directly accessed more readily by woman if they owned their own phones rather than using their husband's phone. With this research we seek to raise awareness about current rural phone ownership and suggest that creating gender sensitive policies would increase women's mobile phone ownership and improve participation in household decision making.

This paper is divided into four sections. Section I introduces the issue, Section II outlines data and research methodologies, Section III explores and discusses statistical and econometric results, and Section IV concludes.

II. Methodology-- Data sources and research methodologies

Several data sets were used in this research, including an Ethiopian household panel survey, GPS data sets acquired through UN's OCHA data repository, and remote sensed CHIRPS data for rainfall. Research methodologies include creating spatial distance matrices to determine households within 5km neighborhoods, compiling weighted intra-household decision making indexes based on individual responses, and probit regression models.

A. Data

Between 2012 and 2019, three large household panel surveys were collected under the supervision of IFPRI for Ethiopia's Agricultural Transformation Agency (ATA). This study is based, in large part, on the latter two Ethiopian Agriculture Commercialization Cluster Surveys conducted in 2016 and 2019. An initial survey, collected in 2012, was used to determine household mobile phone ownership but was excluded from further use because the questionnaire does not include a sex-disaggregated intra-household survey module, administered in the latter two surveys. Overall, the surveys cover 351 kebeles[2] in four principal regional states (Tigray, Amhara, Oromia and SNNP) and provided information on demographics, socio-economic, and institutional aspects of smallholder farmers production, marketing practices, and farmers' reported travel time to their plots, local markets and administrative centers. Beyond a sex-disaggregated module, survey questions were predominantly answered by the male head of household. For most of our analysis

[2] The kebele is the smallest administration level in Ethiopia, with approximately 16,000 comprising the entire country.

we created a subset of 3,104 households where both husband and wife were available and responded to the sex-disaggregated component of the questionnaire given in the 2016 and 2019 sample periods.[3] This gender module focused on decision making concerning agricultural production, use and marketing, off-farm employment, family planning, education, ownership of productive assets, as well as ownership, access and use mobile phones. All surveyed households were georeferenced with GPS coordinates for locational purposes.

GPS data were downloaded from OCHA's humanitarian data exchange (HDX 2022), using the GPS location of woreda capitals for most woredas in the country. These GPS coordinates are endorsed by the Inter-Cluster Information Management Working group (ICMWG) after cleaning and processing were performed by Information Technology Outreach Services (UGA n.d.).Travel distances were derived from least cost travel models measuring walking travel times from the household to the woreda center (considered the administrative hub for most farmers to access credit, pay taxes, etc.). We assume a walking speed of 6km/hr for paved roads and any of Ethiopia's innumerable walking paths, and 4km/hr otherwise. This is associated with a comfortable gait speed derived from the literature (Bohannon 1997). These travel times are then converted to a raster (grid) database showing the travel time from each point to the woreda administrative center using roads from the Open Street Map project (OSM 2022) with the spatial resolution of 250m. Least cost paths are then calculated using the R package gdistance (Van Etten 2017), with 16 direction resistance matrices.

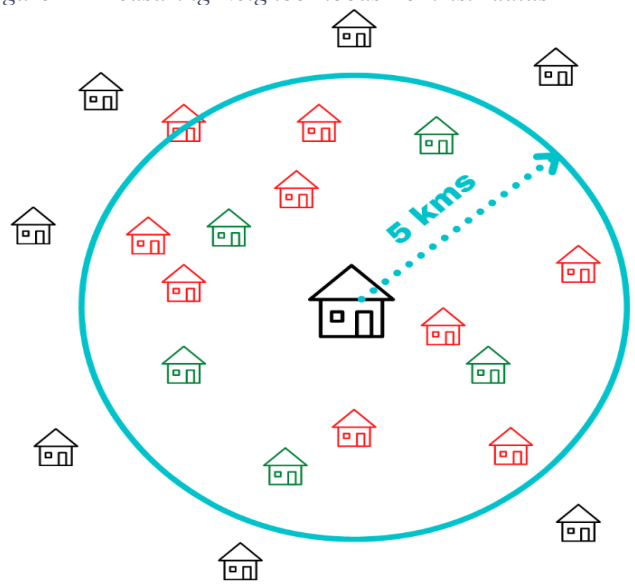
The paper also uses the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) rainfall data that provides decadal precipitation data (Funk et al. 2015). Monthly data are linked with sub-kebele areas by pixel weights and are then summed to monthly averages. Households are linked into their sub-kebele using GPS coordinates of their homes.

B. Research Methodologies

Neighbors of a household were defined as sample households living within a 5 km radius. Figure 1 depicts neighborhood households with phones (green), those without (red) and those outside the 5 kms radius (black). Centroid-placed households with less than 4 neighbors were dropped from the analysis. Households were determined to either have a mobile phone or not, disaggregated by sex of ownership between husbands and wives. Percent ownership in the neighborhood was calculated as the share of male or female neighbors owning a phone. We use this variable as a proxy for a localized *demonstration effect,* which may influence sex-disaggregated phone ownership in our econometric models presented later.

[3] Twenty, or 0.6% of surveyed households are identified as female headed with a male spouse. Given the relative size of this category it was omitted from our analysis, and we used a sample of 3,104 households which are self-reported as male headed with female spouse.

Figure 1—Measuring Neighborhoods—5 kms. radius



Author's calculation

For intra-household decision-making, both married men and women were asked about their levels of input in decisions[4] concerning 16 different economic activities using a 4-point Likert scale.[5] For our purposes, we use a somewhat informal measure for women's empowerment that is related to empowerment measures derived from WEAI methodology. As an empowerment indicator, we excluded those activities where both husband and wife did not indicate participation and we omitted households with less than five joint responses by both. The individual empowerment index was calculated by dividing the sum of respondent's score by the maximum possible score. For our purposes, we used a relative household measure which captures the weighted difference between the husband's and wife's role in decisions (Eq.1), we refer to as the difference in decision making index (DDMI).

$$DDMI_{Total,Agr,HH} = \sum_{n=5}^{16}\left(\left(\frac{\text{Individual score}}{\text{Maximum score}}\right)_w - \left(\frac{\text{Individual score}}{\text{Maximum score}}\right)_m\right)/n \quad (1)$$

Where *DDMI* is the weighted difference between wife's and husband's relative index in decision making. The score for each respondent is the value for input in decision making (values 1 to 4) divided by the maximum score (4) obtained for the various decision-making questions. That response is subtracted from their partner's response, summed and then divided by the total responses. Therefore, values can vary from -¾, where wives make almost no decisions and

[4] The response options are based on a Likert scale and include: 1=No input or input into few decisions, 2= Input into some decisions, 3= Input into most decisions and, 4=Input into all decisions. Fishing was dropped because of a lack of responses.

[5] When respondents indicated that the household participated in a categorical decision, but they gave no score, we assigned a value of 1 to the respondent. This occurred for approximately 11.5% of married women responses and about 2.9% of married men.

husbands make all the decisions (e.g. ((1/4 – 4/4)/n), to ¾ where wives dominate all decisions (4/4 – 1/4)/n). Similar methods are employed by Musonera and Heshmati (2017) and Gammage et al. (2011). To refine our analysis, we divided decision-making into two sub-categories[6] and ultimately have three decision making categories that include total, household, and agricultural decisions.

Probit models are used to estimate male and female phone ownership in the household. Of methodological concern are possible endogeneity relationships between phone ownership and income as well as potential spatial autoregressive influence from our neighborhood variables. For the income variable we used instrumental variable probit models (IV probit) that include a Wald test for exogeneity. More specifically, income per capita was estimated using a set of instrumental variables, and the estimated value of income was used as an explanatory variable in the model predicting phone ownership. Importantly, the IV probit model generates a Wald test that measures whether the error in the structural equation and the reduced-form equation for income are correlated. Failure to reject the null hypothesis suggests that the instrumental variable model is not needed, and a simple probit model can be used. We were also concerned about potential joint determination between individual and neighborhood phone ownership and used clustered robust standard errors at the kebele level to proxy neighborhoods and to adjust for possible local correlated prediction errors. These issues noted, the basic model takes the following form:

$$Phone_{F,M,HH} = \beta_0 + \beta_1 D + \beta_2 H + \beta_3 I + \beta_3 N + \epsilon \quad (2)$$

Where Phone is ownership by the wife (F), husband (M) or household (HH), D is a set of individual demographic characteristics (both wife and husband), H is a set of household characteristics, I represents kebele-level infrastructure variables (like electricity and relative remoteness), and N includes gender-disaggregated neighborhood influences of phone ownership. The βi are estimated coefficients and ε is the error term, assumed to be independent and identically normally distributed.

III. Data analysis

3.1 Descriptive Analysis

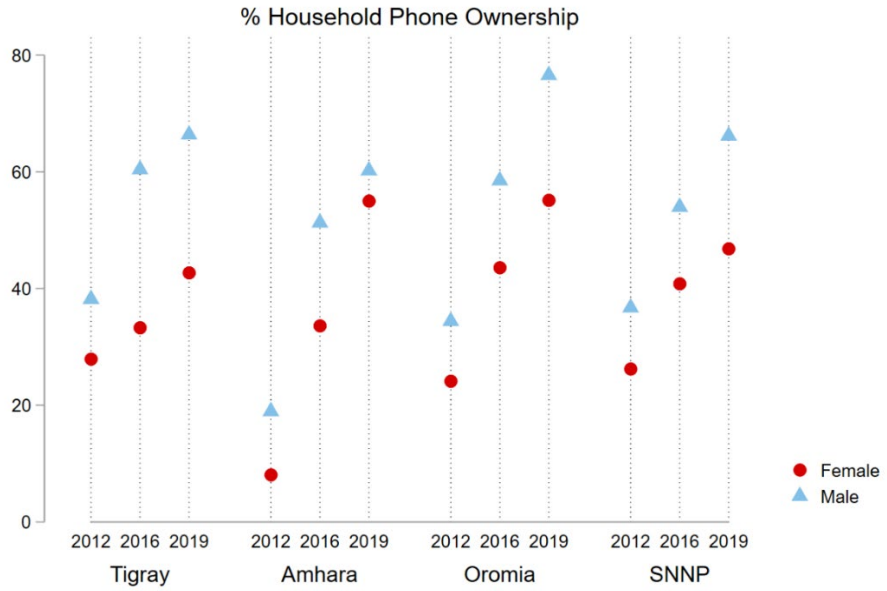
Household Phone Ownership

As outlined above, mobile phone ownership is important to improve gender equality through empowering woman and providing her with a degree of independence and autonomy. Existing data on the proportion of Ethiopian rural women owning a mobile phone suggest that far fewer rural women than men own a mobile phone. While household phone ownership has increased

[6] Agricultural decisions are based on ten questions including: selection of crops, selection of varieties, use of production, crop planting activities, use of household labor, use of food and cash crops, backyard plots crop, marketing and livestock raising. Household decisions were aggregated from six decisions that included: non-farm economic activities, wage and salary employment, major and minor household expenditures, education decisions and family planning. Summing all 16 comprised the total decision-making index.

rapidly over the last decade, ownership in male headed households continues to exceed female headed households (see Figure 2). Based on our 2019 survey data, 68.5% of rural households own at least one mobile phone, with mobile phone penetration rates lower than many comparable countries in Sub-Sahara Africa such as Kenya at 84%, Nigeria at 87% and Tanzania at 82% (GSMA, 2019). In Ethiopia, there has been relative progress in rural phone ownership with approximately two-thirds of rural households owning a mobile phone.[7] However, sex-disaggregated mobile phone ownership is not equally spread across the four major regions of Ethiopia. Rates of ownership are growing quickly for heads of household in Tigray, Oromia and SNNP, with rates of male heads slightly lagging in the Amhara region. Yet, female head mobile phone ownership is far less in the three aforementioned regions but is only slightly less in Amhara. More specifically, an approximate 20 percentage point ownership disparity favoring male over female headed households exists in the other three regions (Tigray, Oromia and SNNP).

Figure 2—Mobile phone growth by region and sex of household head—2012 to 2019



Author's calculation

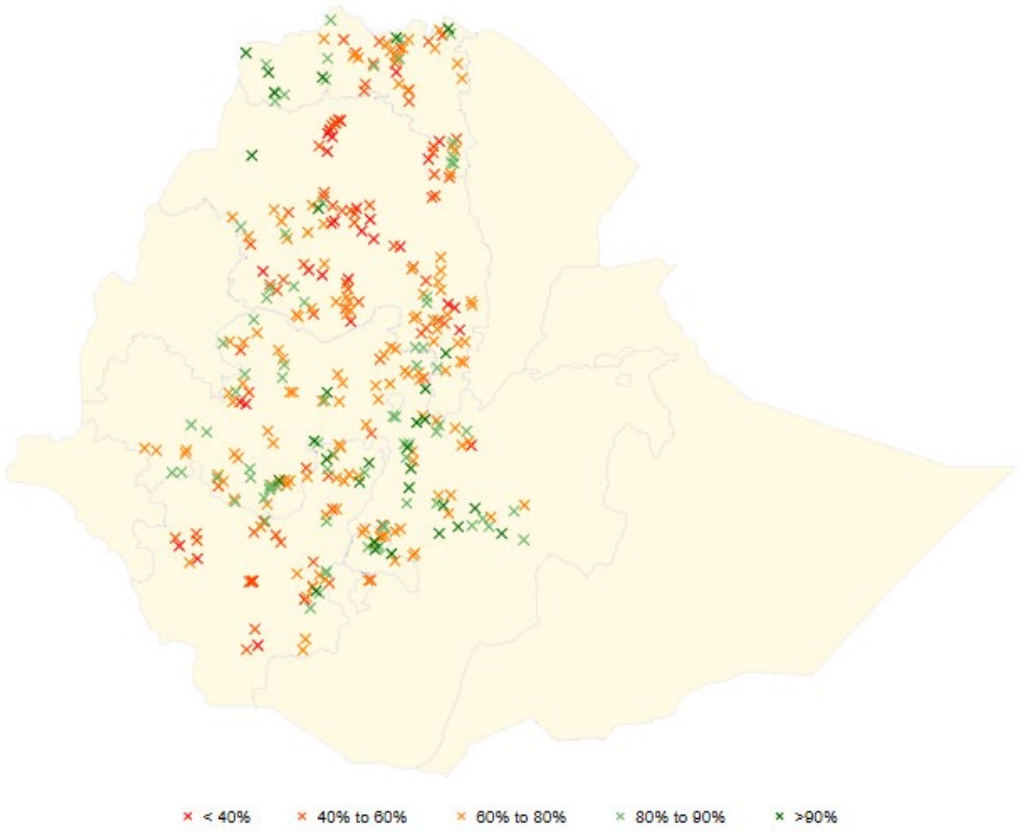
Estimated 2019 household mobile phone ownership, projected at the kebele site level, is depicted in Figure 3. Kebele-level estimated rates vary from less than 40% to over 80% but care should be given because the estimates are based on small, unweighted samples of approximately 30 households per site.[8] That caveat aside, higher rates of household phone ownership appear to exist

[7] Less than 1 in 200 households interviewed in our study indicated that they have a landline phone and therefore landline ownership was omitted from the analysis.

[8] We assume that mobile phone access to networks is similar across our sample areas, an assumption that seems reasonable because the survey was conducted in relatively more populated areas. While the survey could be improved by asking reasons for not owning a phone, a minimum of two households from each kebele survey area reported owning a phone and suggests some cellular coverage within all sampled areas.

in the northwest part of Tigray and southeastern parts of Oromia. Lower rates appear to be in central Amhara and SNNP regions. This suggests that there is some general clustering of phone ownership, and we later explore localized sex-disaggregated neighborhood effects of phone ownership.

Figure 3—Household Mobile phone ownership by sample area (% household ownership)



Source: Author's calculations

Table 1 outlines phone ownership for the entire 2019 sample, with Table 1C depicting the sub-sample of primary interest, households where both husbands and wives responded to the gender module questionnaire. Sex-disaggregated phone ownership indicates that about 56% of rural men and 13% of women surveyed own phones (Table 1A). The majority of phones (55%) are owned by the male household head, 19% by female heads, and 12% by females in male-headed households (Table 1B). In other words, male heads of households are three times more likely to own a phone compared to their female head counterparts and about five times more likely to own a phone than their spouses (Table 1C). Across the larger, 2019 non sex disaggregated, rural household survey, 32% do not own a phone, 40% have one phone owned by the household head, and 26% own 2 or more phones. Even among households with 2 or more phones, female spouses own a minority of the phones.[9]

[9] Some households have both the male head and older children owning phones, without female spouse ownership.

Table 1 Ownership of mobile phone by percentages (2019 sample)

	A. Overall, by sex		*B. By headship and spouse*			*C. Male headed household: both respond*	
	Male	Female	Male head	Female spouse	Female head	Male head	Female head
Yes (%)	55.9	13.3	55.3	11.7	18.6	54.5	11.1
N (total)	4,340	4,428	4,045	3,629	640	3,104	3,104

For our analysis we used the sex-disaggregated component of the questionnaire given in the 2016 and 2019 sample periods. Respondents were interviewed separately for a variety of questions including relative level of decision making and use of mobile phones. Table 2 represents a 2x2 matrix of all possible phone ownership combinations in these selected joint-respondent households.[10] Exclusive phone ownership by men in the household is the most-common response with about 46% of respondents reporting that only men own a phone in the household, about 43% of these sampled households report no phone, 10% of households reporting that both respondents' own phones, while only 1.4% of reported households report a woman owning the phone but the male head does not. The percentages in brackets are the relative trend compared to 2016 data. The trend suggests a relatively significant drop in non-phone ownership (9.1%), with about half of the gain being in joint phone ownership. Female spouse only ownership had a slight increase (0.6%). Important for our research, less than 10% of households have joint phone ownership by both husband and wife.

Table 2 Percent of households in each category of phone ownership (both 2016 and 2019)

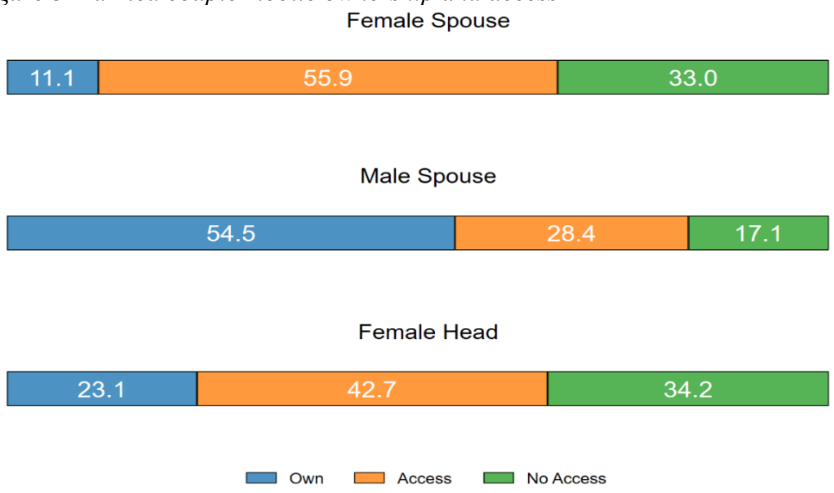
Husband owns mobile (%)	Wife owns mobile (%)	
	No	Yes
No	43.0 (-9.1)	1.8 (+0.6)
Yes	45.5 (+4.0)	9.7 (+4.5)

Source: Authors' calculations. %'s in parentheses represent change from 2016. N=1,164

While married women phone ownership is approximately 12%, over half (56%) of married women who do not own a phone, reported that they have access to a phone. Figure 3 depicts that a full one-third (33%) of married women indicated that they do not own or have access to a mobile phone, a figure that is twice that of what is reported by married men (16%).

[10] This section focuses on intrahousehold phone ownership derived from the gender module. A separate question, regarding overall phone ownership in the household is omitted here. This omitted question captures other household phone ownership, most likely older children.

Figure 3 Married couple mobile ownership and access



Authors' calculations.

Of course, simply owning a phone does not, in and of itself, provide increased empowerment. In the next section, we explore how phones are currently being used. We believe this provides some valuable insights for policymakers on why they should consider targeting the increase of female phone ownership. First, we provide some sex-disaggregated characteristics of mobile phone owners.

Large disparities between men and women's phone ownership exist by age, education and income status. Overall, both men and women mobile phone ownership is statistically different for several demographic and economic variables (Table 3). Mobile phone owning women and men tend to have larger family sizes and are wealthier than non-phone owners. The degree of commercialization, indicated by percentage of marketed crops sold, is also higher for phone owners. Comparing men and female mobile phone owners, households where women own a mobile phone tend to be wealthier and more involved in crop marketing. Relative remoteness, depicted by travel time, does not seem to have statistical significance. Somewhat unexpectedly, phone ownership is higher in areas that receive less rainfall. This may be indicative of unique phone ownership characteristics in certain areas rather than general economic issues.

Table 3 Household characteristics by mobile phone owner vs non-owner for married couples (2019)

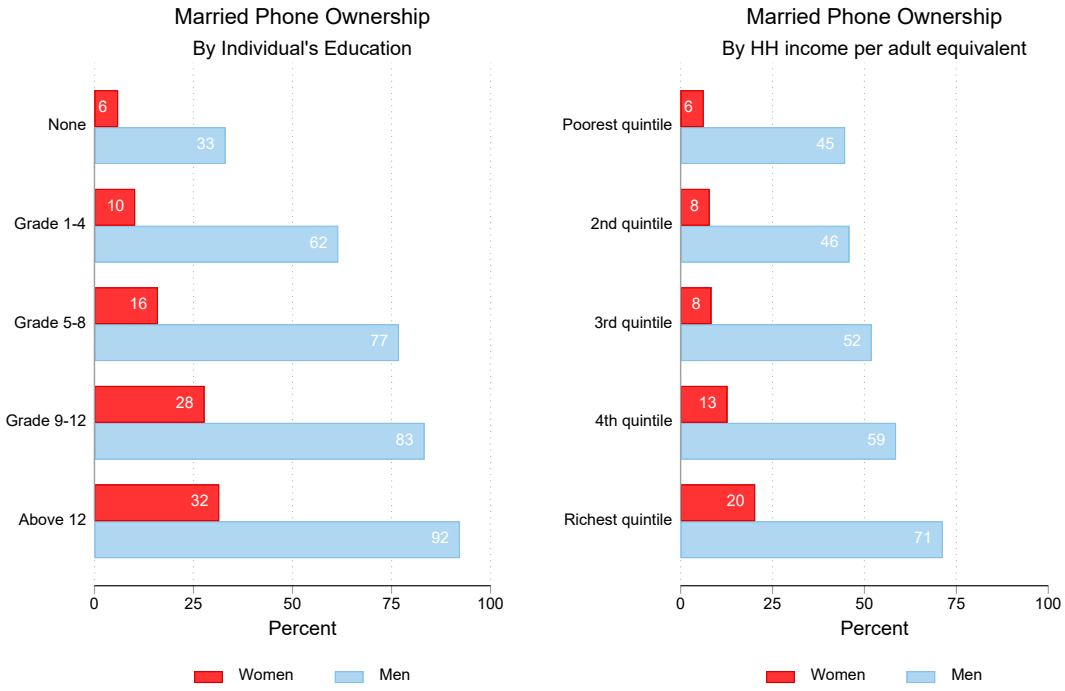
	Male mobile phone		Female mobile phone	
	Non-owners	Owners	Non-owners	Owners
Husband age	52.9	44.9***	48.9	45.7***
Wife age	43.0	36.9***	40.0	36.6***
Household size	5.8	6.3***	6.1	6.0
Land owned (ha)	1.6	1.9***	1.7	2.2***
Share of crops sold (%)	27.3	36.0***	31.0	40.5***
Household income per capita (ETB)	5,210	7,489***	6,040	9,746***
Travel time Woreda Admin. (mins)	128	126	128	120*
5-yr. avg. Meher rainfall (mms)	1,021	954***	998	877***

Authors' calculations. *** p<0.01, ** p<0.05, * p<0.1. The table indicates the results from t-tests on the equality of means between mobile owners versus non owners.

As to be expected, there is increasing ownership of mobile phones at higher levels of both education and income quintiles (Figure 4). Twenty percent of women in the richest income quintile own cell phones while only 6% to 8% own cell phone in the two poorest quintiles. Men are approximately 25 percentage points more likely to own phones in the richest quintile over the poorest quintile, or 71% versus 45%, respectively. Approximately 92% of men, with above grade 12 education, own a mobile phone, while the figure is only 32% for women. For those who do not have education, 33% of men and 6% of women own phones. At all levels of education and income, ownership of phones is higher for men than women.

The gender gap in mobile ownership increases with income as well. The proportion of men owning a phone in the richest quintile is only 3.5 times higher than the proportion of women owning phone in that quintile. For the lower quintiles, the percentage of male phone owners is about six times greater than female owners. According to a recent global report on mobile ownership, the gender gap is strongly correlated with GDP per capita, with the widest gender gaps typically in countries with the lowest income levels (GSMA 2019).

Figure 4 Mobile ownership by education and income per adult equivalent

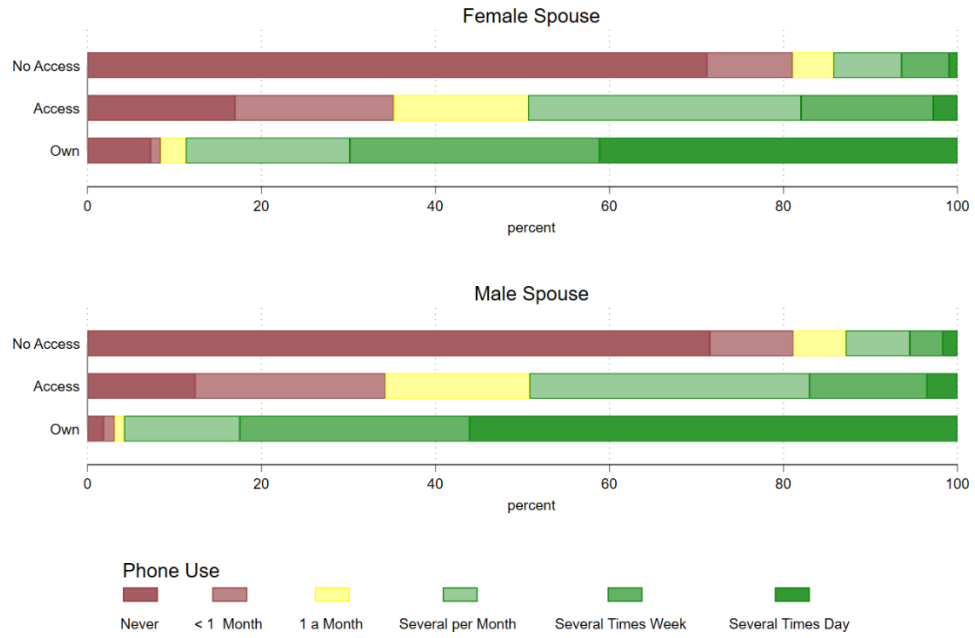


Authors' calculations.

How men and women currently use mobile phones provides insights as to the current relative importance of phones as well as areas that could be enhanced. While this analysis generally focuses on married intrahousehold dynamics, an additional section, concerning male and female heads of households, is provided for additional comparisons.

As would be expected, both men and women use phones less frequently depending on their ownership or access status. More specifically, only 20% of both men and women use mobile phones more than once a month, if they have no general access to a phone. Use is increased to approximately 60% of men and women if they have more regular access to a phone and greater than 90% use if they own a phone. These increases in specific uses of the phone are reflected in Figure 5. While there are comparable rates of use for men and women with no general access or access to phones, men who own phones, do use the phone somewhat more often as compared to their spouses.

Figure 5 Married women and men mobile phone use by ownership and access



Authors' calculations.

Beyond simple use, the gender module explored both men and women's use of mobile phones for information gathering.[11] The questions focused on agricultural management activities, with the exception of calling a medical facility, and are not exhaustive of how the phone might be used. Because women are typically less involved in agricultural decision-making, it is not surprising that women use the phone significantly less for most of these activities; calling a clinic has the only comparable use rate by both spouses. However, it should be noted that, men reported using their phone to call clinics more often than women (23% versus 19%, respectively).
Figure 6 shows that the percentage of men and women who use mobile phones for information searching is relatively small, on a case-by-case basis, with a maximum use of only 25% of male owners using the phone for crop sales price information. An earlier study in Ethiopia, hypothesized that this may be due to lack of relevant information that can be accessed through mobile phones (Tadesse and Bahiigwa 2014).

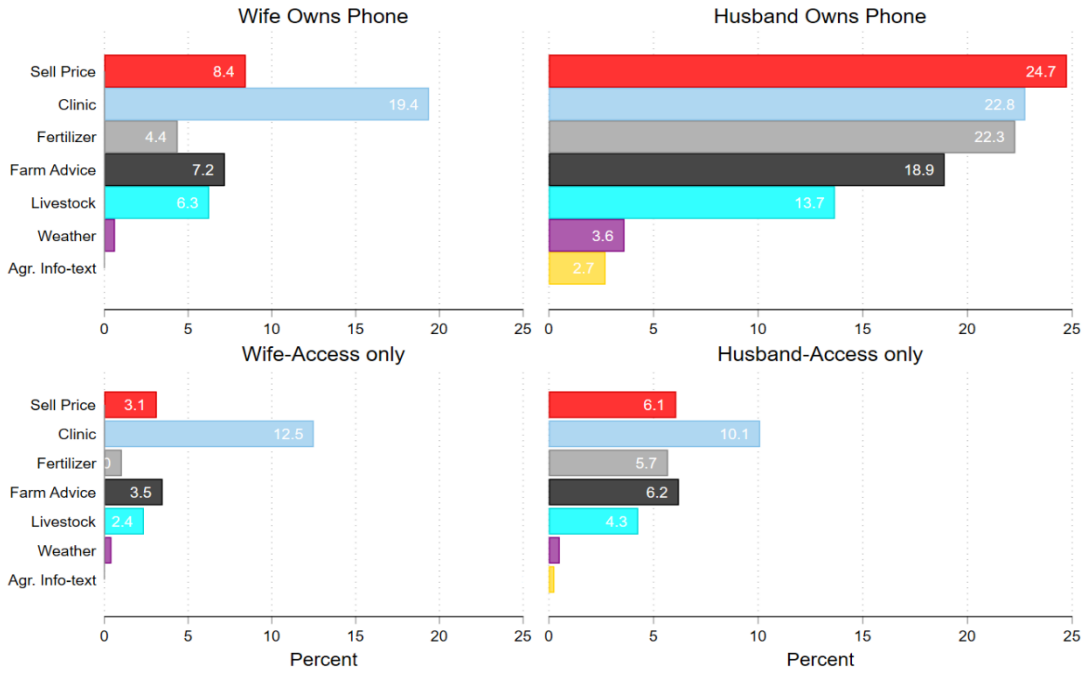
As depicted in Figure 5, both male/female spouses who own their own phones use them more often than those who borrow phones, and we highlight this at the use level in Figure 6. For example, men are four times as likely to check selling prices of crops with phone ownership versus borrowing a phone and women are over 2.5 times more likely, but the numbers are relatively low. For women, the number rises from 3% to 8% and for men it increases from 6% to 25%. Put simply, phone ownership dramatically increases information acquisition, albeit from a low individual use

[11] Seven specific questions were asked that focused on sale prices of farm products and fertilizer, weather, agricultural information, treating livestock and talking to health workers. The purpose of the survey was to depict phone use for specific economic activities, but future surveys should incorporate other uses of mobile phones for a more complete understanding of their relative importance as it relates to empowerment.

case percentage. Obviously, the ease of access when one owns a phone, versus borrowing a phone, for information acquisition, implies greater use with ownership.

Multiple phone ownership may not be possible for many rural households because of costs, and it could be argued that a better comparison may be between male and female heads of households. Figure 6 depicts phone use by female head and ownership status. While female heads of households use their phones approximately 50 – 80% as much as their male counterparts, it is important to remember that this usage is for the questions which focus almost exclusively on agricultural decision making. Both married women and female heads of household who indicated that they have regular access but do not own a phone, have similar use patterns consisting of about half that of those of wives who do own a phone.

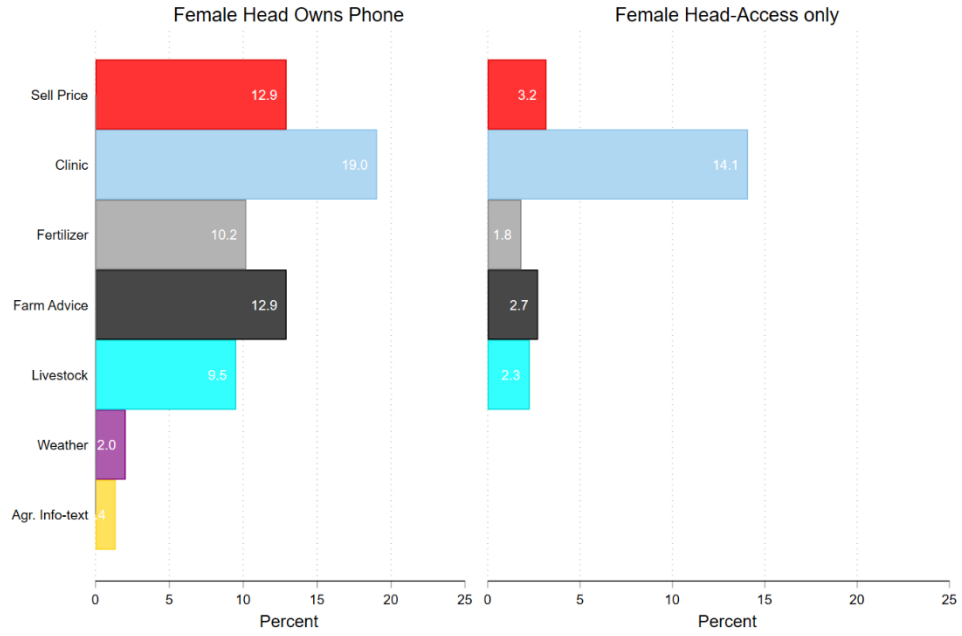
Figure 6 Use of mobile for information searching by husband/wife



Authors' calculations.

Figure 7 shows that female heads use mobile phone relatively more for seeking information related to prices of farm products, prices of fertilizers, farm advise and treating livestock than wife's who own mobile phones. However, compared to their male counterpart, female head's use of mobile phone is still significantly lower and when female heads only have access to mobile phones, and do not own a phone, their usage remains similar to a female spouse. Unlike husbands who use the phone for a variety of uses, calling a clinic is most important for both female spouse and female head of household, whether they own a mobile phone or merely have access.

Figure 7 Use of mobile for information searching by female head

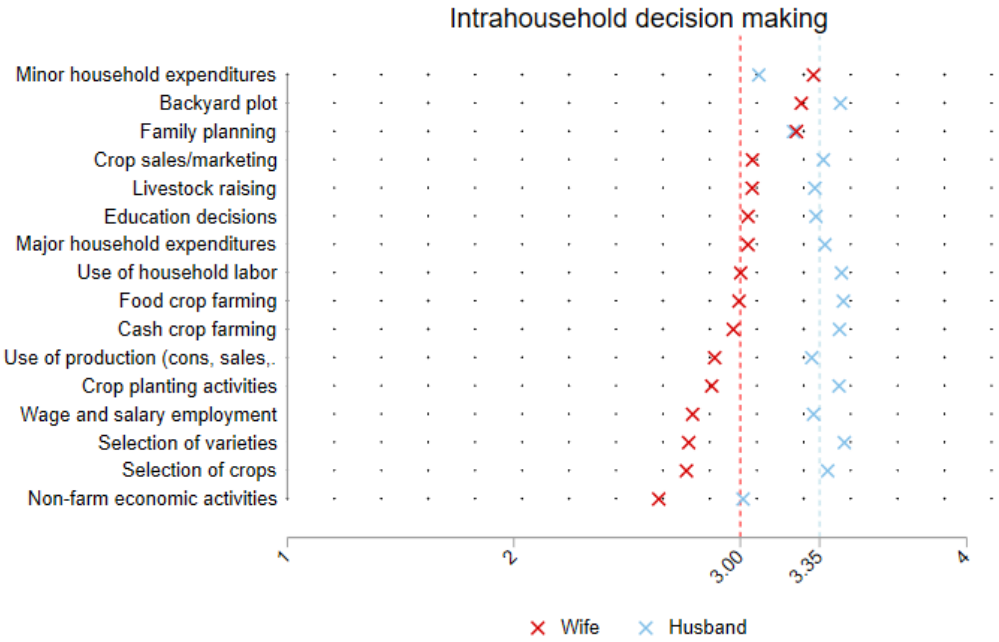


Authors' calculations.

Phone ownership, over mere access, significantly improves use rates for information gathering. For both women and men, their position in terms of information access on these matters improves with their ownership of mobile (as compared to just having access). However, providing phones for individuals who may not have use for a phone might not increase use. Put another way, correlation is not causation. Nonetheless, it seems likely that phone ownership would generally increase use for most recipients. Therefore, men use phones to gather information on important matters related to agricultural information which puts them in a better position for household decision making and may reduce the intrahousehold decision-making status of women. However, both wife's and husband's ownership matters more than access.

Figure 8 below shows intrahousehold decision making between husband and wife. Overall, women are less involved in decisions making than men. The average input into decision making for husbands is 3.35 (out of a possible 4) and for wives the average is 3.00. However, we see more equal levels of decision-making for certain more customarily regarded as female areas of decision-making, like family planning and minor household expenditures. For the remainder of decision-making activities husband's self-determined level of participation is higher than wife's responses, with the widest gap being in the area of selection of crops and varieties. This supports more traditional gender roles of decision-making in Ethiopia. These results indicate that women have greater or equal decision roles in activities that they are traditionally involved in, such as family planning and minor household expenditures, while men have greater influence in agricultural and other issues related to the household.

Figure 8 Intrahousehold decision making



Authors' calculations.

3.2 Econometric Analysis

Comparison of the decision indices for the head and spouse in the same household enables us to assess relative intrahousehold bargaining power both overall and on individual decisions. However, we are also interested to see what influences mobile phone ownership as well as the role mobile phone's relative women empowerment and the intrahousehold status of women. The next data section discusses regression findings around these issues.

For mobile phone ownership we hypothesize that age, education, wealth/income, infrastructure and neighborhood ownership are important determinants. In addition, we hypothesize that mobile phone ownership is positively associated with women empowerment. Given that women spend most of their time at home taking care of children and doing domestic chores, getting information is costly for them. But ownership of mobile could improve her choices and decision making within households.

The results from the probit regressions for mobile phone ownership are presented in Table 4. The three data columns give the results estimating husband ownership, wife ownership, and household ownership. Preliminary results using IV probit, with income per capita being estimated by four instrumental variables,[12] including household size, farm size, livestock ownership and percentage cereal crop marketed were performed separately and the Wald tests indicated that the null

[12] While the possibility of contemporaneous correlation between these IV variables and mobile phone ownership is acknowledged, these variables were obtained from other literature used for this purpose (Tadesse & Bahiigwa 2015).

hypothesis, of no endogeneity, was not rejected for all probit models tested. While endogeneity is likely still a problem and biased estimators are possible, basic probit models were used with robust errors at the kebele level to minimize these potential impacts.

A majority of included variables were statistically significant and of the expected sign. As expected, men's schooling, income per capita, non-farm income, the top asset tercile and access to electricity all positively and statistically contributed to phone ownership across all three models. The younger the age of the respondent the more likely they were to have a phone. While the husband's older age had a positive effect on wife ownership, the wife's age had no statistically significant effect on the husband's ownership. Interestingly, neither the age of the husband and wife nor the wife's education level had a significant impact on household phone ownership. Distance to either markets or farmer training centers had no measured statistical impact on ownership in any of the models. Both men's and women's neighborhood ownership contributed positively to their own ownership, and women's neighborhood ownership contributed to men's ownership, but men's neighborhood ownership did not contribute to women's ownership. Solar access was generally positive except for women's ownership. In terms of regional differences, Amhara appears to have lower phone ownership than other regions, but the results are mixed.

In general, literacy, youth, wealth and access to better infrastructure, such as electricity, are associated with higher phone ownership. Women who are less educated and poorer are in a disadvantaged position to own mobile phone which hinder the gender gap in mobile phone ownership. From a policy perspective, problems related to literacy, affordability and electricity should be addressed to enhance mobile phone ownership for both men and women. Reasons for statistically significant neighborhood effects need further exploration but potential reasons could include social influence because men and women already owning a mobile phone might be helping others become more aware of the benefits of mobile phones. A study from rural Bangladesh supports this hypothesis; Islam and Åke (2011) found that social influence is more important than the media influence and other individual characteristics in determining the adoption of mobile phone among farmers in rural Bangladesh.

Table 4 Determinants of Male and Female Ownership: Probit Average marginal effect

Dependent variable: *Mobile ownership*

Independent Variables	Wife	Husband	Household
Age of Wife	-0.003***	-0.002	0.000
Age of Husband	0.002**	-0.007***	-0.001
Wife schooling (yrs.)	0.008***	0.002	0.008
Husband schooling (yrs.)	0.005***	0.034***	0.034***
Income per capita (1,000 ETB)	0.003***	0.007***	0.004**
Non-farm income (=1)	0.049***	0.047**	0.056**
Asset - bottom tercile			
Asset – middle tercile	-0.004	0.078***	0.158***
Asset – top tercile	0.049***	0.249***	0.322***
Distance to market	-0.000	0.000	0.000
Distance to FTC	0.000	-0.000	-0.000
Neighbor females' % own phone	0.162***	0.189**	0.074
Neighbor males' % own phone	0.030	0.171***	0.164***
Access to electricity	0.049***	0.098***	0.081***
Access to solar	-0.004	0.126***	0.081***
Tigray			
Amhara (=1)	-0.021	-0.074**	0.016
Oromia (=1)	-0.018	0.025	0.140***
SNNP (=1)	0.010	0.129**	0.175***

Source: Authors' calculations.

Robust standard errors are adjusted for clusters at the kebele level. *, **, and *** significant at 10, 5 and 1 percent level, respectively.

Table 5 presents t-tests related to the difference in input in decision-making in the household between the wife and husband based upon individual phone ownership and type of decision-making.[13] The relative difference in decision making between husband and wife can be taken as a degree of unequal relationship in the household (the lower the better). The closer the values the more equal the relationship. Presented in Table 5 is the weighted index of spouses' decision-making differential, with positive values indicating a greater husband level of decision-making and a negative value indicating a smaller differential between husbands and wives. For example, the top left column indicates that when a married women owns a phone, her relative disadvantage in decision-making is reduced, at a 90% level of significance. While the results generally indicate that wives' relative decision making improves when either the husband or wife owns a phone, most values are statistically insignificant. Overall, the benefits of a women owning a phone are somewhat positive for more equal decision-making, with statistically significant impacts in the agricultural area that weakly contribute to total decision-making. Put another way, while husbands dominate all our household decision making indexes, that differential narrows somewhat when the wife owns a phone.

[13] The outputted value is based on Equation 1, depicted in the Methodology section.

Table 5 Levels of input in decision making (Overall)

	Decision differential (wife – husband) Total	Decision differential (wife – husband) Agriculture	Decision deferential (wife – husband) Household
Wife owns phone (=1)	**-0.0175***	**-0.0206****	-0.0044
	(1.81)	(1.98)	(0.38)
Husband owns phone (=1)	-0.0034	0.0012	-0.0032
	(0.56)	(0.18)	(0.41)

Source: Authors' calculations. t statistics in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

IV. Conclusion and policy recommendations

Mobile phone ownership is increasing rapidly across all of Africa with resultant communication and information benefits. These benefits are widely accepted and incorporated into the United Nation's SDG goals (Goal 5.b), with percentage female phone ownership as an important indicator of women's empowerment. As part of the growing importance of the digital economy for its citizens, the Government of Ethiopia has launched or encouraged several information technology initiatives to improve finance, payment apps and information access to Ethiopians. Supporting these developments are multilateral organizations, like the World Bank, who believe that information technology is positioning itself for "lift-off" in the country. While the general consensus is that mobile phones are important for improved access to information for economic decision-making, it is important to carefully consider who actually owns mobile phones. Our research goal is to provide a gendered lens to better understand rural mobile phone ownership and suggest possible drivers of ownership to better address the large digital divide that currently exists in Ethiopia. We do this by using relatively a recent panel survey of rural households that includes sex-disaggregated data.

We find that married rural women, are five times less likely to own a phone than their husbands and 25 times less likely to be the sole owner of a phone over their husbands in the same household. Using 2019 data, we find that less than 10% of our sampled married households report both members owning a mobile phone. In addition, approximately one-third of all married women report neither owning a phone or having access to a phone, a figure that is twice that of married men. Important for understanding who actually owns phones, our research suggests that younger, better educated, wealthier married household members, with access to energy infrastructure, are more likely to own phones. There is also evidence of spatial clustering of ownership which could suggest social demonstration effects of ownership as well. Consistent with other research, there is evidence that female phone ownership is associated with a larger role in agricultural decision-making, but additional research is warranted. All of this indicates that, relative to men, rural Ethiopian women lack phone ownership, and this lack of access may reduce their overall

participation as well as their role in decision-making with newer digital initiatives, such as mobile banking, payments, etc. Without better female access and ownership of phones, women's roles in making household decisions may continue to be limited. This fact is an important consideration for digital inclusivity, a major aspect of the Ethiopia Government's stated policy objective.

We argue that digital inclusivity starts with a detailed analysis of current phone ownership and understanding potential drivers for how to increase mobile phone ownership rates. Thus, efforts to empower women should work on the barriers for mobile phone ownership such as illiteracy, affordability, and access to services such as electricity. To achieve this objective, a concerted research effort is needed between various stakeholders including Ethiopian telecommunication companies, mobile phone assemblers/manufacturers, financial/credit organizations, business enterprises, donors, tax policy, as well as relevant government institutions. Through partnership and effective coordination between these stakeholders, more affordable mobile phones can be provided and create a conducive environment for women phone ownership and use.

In conclusion, women mobile phone ownership can enhance their access to information as well as their involvement in decision-making in the household, which would likely improve the wellbeing of women in the household and the welfare of the entire household. Disparate sex-disaggregated phone ownership in rural Ethiopia is not surprising given the lower phone penetration rates and the cost of acquiring this asset. However, women's lower phone ownership is a challenge for Ethiopia's stated SDG commitment. Phone ownership for women is a principal target indicator. that should be considered a central part of an inclusive digital economy to which the Ethiopian Government has committed itself to achieving over the next decade.

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