

Intra-household Perceived Bargaining Power and Agricultural  
Technology Adoption: A Case Study of Improved Cassava  
Varieties in Nigeria

A thesis

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## Abstract

This study explores men's perceived bargaining power of their spouses and its role on decision-making in the adoption of improved cassava varieties (ICV) in Nigeria. The primary data were collected in 2015 from 2,118 households in the four primary cassava producing regions of Nigeria, and were analyzed to develop variables measuring the bargaining power men in the household perceived their spouses to have in terms of economic and social asset control and/or access. Utilizing a double-hurdle model to measure the probability and intensity of adopting ICVs, the study shows that the more bargaining power the spouse is perceived to have the lower the probability and less intensely a household adopts ICVs. Evidence shows when women are members of cooperatives the likelihood of adopting ICVs decreases, and when women are perceived to have more bargaining power in terms of control of household assets and land the intensity of adopting ICVs decreases.

## Biographical Information

Trent Davis is an M.S. candidate of Applied Economics and Management at the Charles H. Dyson School of Applied Economics & Management at Cornell University in Ithaca, New York. Trent holds two degrees from Washington State University; a B.S. of Economic Sciences from the College of Agriculture, Human, and Natural Resource Sciences and a B.A. of International Business from the Carson College of Business.

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While pursuing his studies at Cornell Trent worked on projects ranging from coffee farmers in rural Colombia; small food producers outside Cartagena, Colombia; berry growers in New York state; vineyard managers across the Eastern part of North America; hops producers in the Pacific North West; as well as being an executive board member of Cornell Blockchain.

Trent's views of the future of agriculture stem from his time abroad, working with domestic producers, and an understanding of new technological opportunities producers, distributors, and customers may demand. An increase in transparency and traceability will become more and more prevalent with our ever increasing globalized agricultural supply chain. Integrating blockchain technology into our supply chains may be one of the key decisions helping drive this demand for transparency and traceability. Trent looks to help push for the adoption of these new technologies to help those who produce the food we eat on a daily basis.

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## List of Abbreviations

ICV(s).....	Improved Cassava Variety(ies)
CMS.....	Cassava Monitoring Survey
FAO.....	Food and Agricultural Organization of the United Nations
EA.....	Enumeration Area
IFAD.....	International Fund for Agricultural Development
Pro-WEAI.....	Women’s Empowerment in Agriculture Index



## Introduction

Cassava is a major staple crop in developing countries, with more than 500 million people depending on cassava as their main source of caloric intake (Lebot 2008). Farmers around the world use cassava as both a cash and subsistence crop. The root can be cooked after the peeling of the skin for direct consumption or used as an ingredient for other food products. In Nigeria, cassava is traditionally processed to make either garri or fufu (Bechoff et al. 2018). Studies have shown that cassava is one of the few crops that could benefit from climate change, thus, expanding its reach and potential adoption (Jarvis et al. 2012).

Analysis of the Cassava Monitoring Survey (CMS), a survey conducted in 2015/16 looking at traits affecting new variety adoption/disadoption, showed that socio-economic traits such as cell phone ownership, household size, access to credit and extension, and cooperative membership, all have statistically significant effects on the adoption of improved cassava (Wossen et al. 2017). Gender has also been found to significantly affect which cassava traits producers value. Women have been shown to value traits that make processing cassava easier and faster while men value higher yields and earlier maturation more (Teeken et al. 2018). While evidence shows that certain socio-economic factors and gender play a role in the types of traits desired by farmers, a relevant, unanswered question still remains: how does gender, in terms of the perceived bargaining power of women within the household, impact the adoption of improved cassava varieties (ICVs)?

There have been numerous studies looking at the factors impacting agricultural technology adoption (Beshir and Wegary 2014; Ndiritu et al. 2014; Zeng et al. 2018). However, many of these studies do not take into account the influence of bargaining power of women in

the technology adoption decisions. Some studies attempt to identify these impacts by using the gender of the head of the household to measure the role of gender in technology adoption decisions (Kassa 2013; Diiro et al. 2015; Nyasimi and Huyer 2017; Polar et al. 2017). This approach partially helps identify the impact gender has on the adoption of agricultural technologies. Evidence has shown this methodology of measuring gender and power within a household via who is considered the head of household may not accurately demonstrate household power dynamics and their impact on agricultural technology adoption (Peterman et al. 2014). It has been shown that the technology adoption decision may not be determined by the head of the household, especially when the head of household is female (Peterman et al. 2014).

One method to measure how households make decisions is to utilize the Bargaining Model (Doss 1996; Quisumbing and Maluccio 2003; Friedemann-Sánchez 2006; Lim et al. 2007). This model uses variables to measure the individual bargaining power members in a household have. The more bargaining power an individual holds, the more his/her preferences are realized through the choices the household makes (in this case, the decision to adopt or not improved cassava varieties). To fill this gap in the literature, I construct variables to measure the perceived bargaining power of women in Nigerian farm households using data collected from the CMS. The variables developed to measure perceived bargaining power within the household use ratios indicating how much land control and how much of the physical household assets the wife of the household controls, as well as variables measuring educational opportunities in terms of being a member of an agricultural cooperative. Control of assets within the household may have impacts on how likely, or how intensely, a household adopts new agricultural technologies like ICVs. For instance, in households where women control less land, they may be disincentivized to adopt a new technology as they have less options for crops due to land constraints (Bioye et al

2016). However, it has been shown when a wife has more control over land use the types of agricultural goods the household produces are significantly impacted to better mirror the preferences of the women (Bevan and Pankhurst 1996). Furthermore, evidence shows when women control more of the household's physical assets the household's expenditures are significantly changed (Hallman 2000; A. R. Quisumbing and Maluccio 2003).

Using data from the 2015/2016 Cassava Monitoring Study, conducted in Nigeria, I utilize a double-hurdle model (Gebre, 2019; Eakins, 2014) to identify how women's bargaining power impacts adoption of ICVs and how intensely households adopt ICVs when they do choose to incorporate them on their farms. The double-hurdle model utilizes both a probit model framework and a truncated regression to identify factors of adoption and intensity of adoption in the context of new technologies (Gebre et al. 2019). Using variables measuring perceived bargaining power of individuals in Nigerian households I analyze the potential impacts women's bargaining power within the household may have on ICV adoption.

My findings show when women are members of a cooperative, and thus have access to more educational opportunities regarding agricultural practices, the household is less likely to adopt ICVs, and if the household does choose to adopt ICVs it tends to adopt them less intensely than households where the wife is not a member of a cooperative. Furthermore, the findings suggests when women are perceived to control both more of the household's agricultural land and more of the household's physical assets the households that do adopt ICVs adopt them at a statistically lower intensity than households where the husband is perceived to control more of the land and physical assets. The three main variables developed to measure the wife's perceived bargaining power within the household (educational opportunities, perceived land control, and

perceived physical asset control) all indicate the more perceived bargaining power a wife has the less likely and less intensely the household is to adopt ICVs.

## Literature Review

The literature review is broken into three main sections. The first section discusses the concept of gender, and how the social constructs around gender impact agriculture in general. Second, I examine how gender specifically influences cassava production in a Nigerian context. Third, I analyze the idea of assets and their impact on intrahousehold bargaining power. This section specifically looks at how asset allocation within the household may impact perceived bargaining power of men and women within the household and how their perceived bargaining power may influence household decision making regarding the adoption of ICVs. I conclude stating the contribution of the study to the literature.

### Gender in agriculture

Gender is used to describe socially constructed characteristics of both men and women. The social construct of gender plays a significant part of everyday decision making. Gendered differences in economic opportunities and cultural expectations play large roles in developing countries and economies (Falk and Hermle 2018). Specifically, socially constructed gender norms impact decisions made within agriculturally focused societies (Udry 1996). Cultural gender norms in agricultural settings commonly form the basis of what crops to grow, when to harvest, deciding what crops are produced for in home consumption compared to for market sales, and to how household income and assets are distributed (Malapit et al. 2019). Power dynamics between household members, which are heavily influenced by cultural norms, should be taken into account when designing research questions and analysis. For decades, it was believed a household as a

unit would optimally allocate resources to maximize utility for all its members, however, research has shown this may not be true (Udry 1996; A. R. Quisumbing and Maluccio 2000).

Even projects with the best intentions can collapse if researchers fail to integrate gender inequality into the analysis (Mayoux 1995; Ransom and Bain 2011; Gates 2014; Bock 2015). In smallholder agricultural systems, it is shown that gender inequality due to income, asset ownership, education, etc., is linked to lower adoption rates of new technology and crop varieties by women (Doss and Morris 2000; Ndiritu et al. 2014; Peterman et al. 2014). Furthermore, social norms based on gender constructs often result in men and women allocating resources, labor hours, and household decision making power differently (The World Bank 2008; Ogunlela and Mukhtar 2009; Agarwal and Herring 2014). Consequently, women in agriculture commonly produce less<sup>1</sup> agricultural goods in general and/or goods of a lower value than their male counterparts (Doss 2014; wa Githinji et al. 2014; Doss 2018).

Within Nigeria, gender plays a significant role in who owns land. Men statistically have higher land ownership and more access to land (Adekola et al. 2013). For example, women in Nigeria have on average plots that are only 30% the size of the average plot of land owned by males (Saito et al. 1994). Cultural norms within Nigeria also play a factor in how land is allocated along gender lines. For example, laws like the Matrimonial Causes Act provide women the ability to obtain a share of the total assets, such as land, owned by the household upon divorce (Etomi et al. 2019). However, many women do not have the ability to pursue land as an owned asset after divorce as they are concerned of antagonizing in-laws, their lack of financial security to pursue the land through the law, or are simply unaware of their own rights (FAO 2020a). Women are able to purchase land under their surname and not necessarily their

<sup>1</sup> Smaller yields, lower variety of crops, and/or lower value crops.

husband's surname or household name while married, but they lose the ability to farm said land upon divorce, and instead the land is transferred to the head of household which is traditionally their husband (Abdulwahid 2005). Even in the case of the husbands' death, a wife may not inherit the household's land (Abdulwahid 2005). Although statutory law grants the wife the land owned by the household upon her husband's death, it is common for the land to instead be distributed among dependents of the husband and at times even to the husband's extended family members (Ikejiofor 2006). In agriculturally centered communities land is one of, if not the, most valuable assets one could own due to the economic potential agricultural land inherently has (Bioye et al 2006). Women may have a lower incentive or less opportunities to adopt new technologies or crops due to commonly having less land rights than those of their male counterparts resulting in smaller agricultural plots owned by them relative to the husbands (Neef and Heidhues 1994; A. Quisumbing 1998; Naved 2000; Quisumbing et al. 2001; Goldstein and Udry 2008).

### Cassava, Gender, and Nigeria

Just like with general land ownership and control, agricultural land dedicated to cassava production is owned disproportionately by men. Across Africa 60% of cassava producing land is owned by men, 15% is owned by women, and 25% belongs to the household commonly (Nweke and Enete 1999). The disproportional ownership over land along gender lines is even more prominent in Nigeria where women own 11% of cassava producing land while men own 80% and the household owns as a unit owns 9% (Nweke and Enete 1999).

Nigeria is the world's largest producer of cassava with 20% of the world's cassava, equaling roughly 50 million tons as of 2020 (FAO 2020). While men own more of the land dedicated to the production of cassava in Nigeria women reportedly are significantly more

involved in the cassava value chain process. 79.3% of women are reported to be involved in Nigeria's cassava value chain compared to only 36.7% of men (Gabriel and Babalola 2011). Women with comparatively higher levels of education compared to other women are more likely to participate in value-added processes, including 'gari'<sup>2</sup> or 'fufu'<sup>3</sup> production, and women are more likely to have a positive attitude to adopting new cassava varieties if they are shown to have better commercialization properties than other varieties (Gabriel and Babalola 2011). Even though women may have more positive attitudes to adopting new technologies revolving around cassava production they do not seem to adopt ICVs at the same rate that men do in Nigeria. Obisesan (2014) found that men adopt technologies that improve cassava production at a 26% higher rate than their female counterparts. Wossen et al. (2017), for their part found that women adopt improved cassava varieties for on farm production at a lower rate than men.

Participating in the cassava value chain increases both individual and household income, regardless of gender, however, there is still a significant gender gap in income and production surrounding the cassava value chain in Nigeria (Ahmadu and Idisi 2014). This difference may be influenced by the differences in specialization influenced by gender norms found in the cassava value chain in Nigeria. Nigerian men who produce cassava specialize in the production, harvesting, and sale of fresh cassava roots while the women specialize in traditional value added products derived from cassava (Forsythe et al. 2016). The allocation of cassava used for value-added processing may be dependent on the bargaining power of the individuals in the household. It may be that men, who traditionally have higher household decision making power in Nigeria,

<sup>2</sup> Creamy-white colored granular flour with a shelf life of six months or more with proper storage (FAO 2020b)

<sup>3</sup> A starchy food made by boiling, pounding, then forming balls using cassava, commonly dipped in sauce or soups (Dipeolu et al. 2001)

decide the majority of cassava production is to be sold as raw, unprocessed goods, thus limiting potential income generating activities for women in the household<sup>4</sup>.

## Assets and Bargaining Power

The decision making process within households is complex, and in multi-person dwellings, commonly relies on individuals coming to agreements on how the household will allocate resources, utilize time, etc. This section will give a general overview of how different assets, such as economic indicators or social assets like group membership, may impact the bargaining power of individuals within the household. The bargaining power one holds in the household is an important component to how much of their preferences they are able to realize when “negotiating” with others. The more bargaining power one has the more of their own preferences they may see in the household. This section will give a brief explanation of some of the variables used to measure bargaining power, as well as discuss previous research analyzing how bargaining power dynamics between spouses impact household decision making.

Economic indicators of individuals can be measured to define their bargaining power. Two commonly used economic indicators are income (Udry et al. 1995; Babatunde and Olorunsanya 2008; Meinzen-Dick et al. 2011) and asset ownership (Udry et al. 1995; Doss 1996; Smith and Chavas 1999; Naved 2000; Quisumbing and De La Brière 2000; Fafchamps and Quisumbing 2002). If an individual’s income and asset ownership within the household is considered their individual leverage, then it may be assumed that the individual who has a higher pooled income and ownership of assets has a higher bargaining power. In other words, the person in the household who controls less assets has a higher incentive to reach a mutual decision than the person who

<sup>4</sup> This is only theorized and needs further research to substantiate this potential claim



controls more assets. This allows for the “wealthier” individual to have higher bargaining power when making household decisions (Browning et al. 2014).

Thinking of bargaining power solely in terms of economic indicators would not give the full picture. It is important to note other forms of “assets” can be measured as well to determine an individual’s bargaining power. Access to education and credit, as well as social network influence such as cooperative membership, can play an important role in relation to bargaining power. For example educational achievement differences between the head of household and their spouse have shown to have a negative effect on women’s status within the household (Smith and Chavas 1999). Increased access to social networks, like cooperatives or religious groups, have also been shown to increase the status of the woman within the household via increased access to information through their social network (Maluccio et al. 2003).

When measuring wealth within agriculturally centered developing economies it is more common for individuals and families to view their wealth in terms of assets instead of solely income (Narayan 2000). Research conducted worldwide has found that, on average, men tend to own and/or control more assets than women. In South Africa, Ethiopia, Indonesia, and Bangladesh researchers found men brought, on average, greater wealth to marriage than their wives did (Quisumbing and Maluccio 2003). In Thailand, researchers showed that the worth of men’s total assets is higher than the assets owned by women (Antonopoulos and Floro 2004). Deere and Doss (2006) found men in Northern Nigeria (as well as Kenya, Ghana, Mexico, and parts of Guatemala) own more physical assets than women. With men commonly controlling more assets within the household than women, and if it is assumed those who control more assets have more bargaining

power, then it can postulated that men may have more bargaining power within the household than women (Iversen and Rosenbluth 2005) <sup>5</sup>.

Research has shown if a household reduces the gender gap related to asset allocation the preferences and choices of the household change for the better in terms of nutrition, education, health outcomes, etc. For example, Friedemann-Sánchez (2006) demonstrated that women in Colombia who had more access to land and higher individual incomes had significantly higher bargaining power within their households resulting in lower levels of domestic violence. Quisumbing and Maluccio (2003) demonstrated that when women held more assets at the time of marriage the household spent a larger share of income on children's education. Hallman (2000) found when a woman in the household has a higher share of the household's assets there was a positive correlation with girls health outcomes.

Increased bargaining power in terms of assets has been shown to have impacts on agricultural decision making within the household as well. Lim (2007) demonstrated the more livestock a woman in Ethiopia owns the less they contribute to on-farm labor for coffee production, and in contrast move more of their on-farm labor hours to the production of enset.. Women having more bargaining power in terms of livestock ownership was shown to have a positive correlation to women's on-farm labor dedicated to enset, a starch obtained from the stem of a banana-like tree, production. In Ethiopia coffee revenues commonly accrue to men while enset revenues are commonly collected by women (Bevan and Pankhurst 1996). The higher bargaining power the women held in relation to how much livestock they owned may contribute to increasing their negotiating leverage within the household. This may indicate those with higher bargaining power are able to spend their labor on crops that directly increase their individual income.

<sup>5</sup> Especially in agriculturally focused societies

In Nigeria the opportunity and decision to participate in the cassava markets is heavily influenced by the bargaining power of the individuals within a household (Forsythe et al. 2016). It is common for the women of the household to be heavily dependent on their husband's decisions on asset allocation in regards to the opportunities they have to participate in any commercial enterprise. Upon marriage, it is traditionally accepted that the husband provides the initial capital and production tools, equipment, and land for the household (Forsythe et al. 2016). This cultural norm of depending on the husband to provide goods for his wife for agricultural production heavily impacts the woman's bargaining power within the household. Furthermore, traditionally women have been the primary person responsible for purchasing goods and necessities like food, school supplies, cleaning goods, etc., for the household. In a qualitative study conducted by Forsythe et al. (2016, p. 12) a female cassava producer from the Ogun state in Nigeria stated:

*“A different type of man will pay for the school fees. More of the women take this cassava and pay for school fees.”*

The survey results indicated the woman's responsibility for providing goods and necessities for the household has been slowly increasing over time (Forsythe et al. 2016). This heavily influences the bargaining power within the household. If the women are expected to use their individual incomes to provide for the household then they will have less freedom over their own expenditures. This may result in the inability to invest more capital into their individual agricultural plots or start small businesses leading to potentially reduced gender inequality outcomes.

## Contribution to the Literature

The literature has shown there are many direct correlations between gender, development, and agriculture. In terms of agricultural technologies, it is important to analyze factors that impact an

individual's, and/or a household's, decision to adopt new technologies. This is true for the adoption of ICVs as well. Previous research (Lim et al. 2007; Gebre et al. 2019) has shown how gendered intrahousehold bargaining power dynamics impact household decision making in terms of what crops households and individuals choose to produce. However, the question of how the perceived bargaining power of the wife affects the adoption of ICVs still remains.

My research uses the Bargaining Power Model framework to construct variables based on economic and social indicators found in the household to measure the perceived bargaining power wives in Nigerian agricultural households have. I then utilize a Double-Hurdle Model to analyze how these perceived bargaining power variables are related to both adoption of ICVs (yes/no) and the intensity of ICV adoption (percent of cassava acres planted to ICVs) on farms in Nigeria. This method allows me to account for different power dynamics, measured by the bargaining power variables, and their relationship to the initial decision to adopt ICV and then the subsequent decision on how intensely to adopt ICVs.

I construct three variables measuring the perceived bargaining power the wife has within the household in Nigeria:

- 1) A ratio measuring the amount of physical assets the wife is perceived by their husband to control or have access to.
- 2) A ratio measuring the amount of land the wife is perceived to control in terms of total household agricultural land.
- 3) If the wife is a member of an agricultural cooperative, thus, allowing for more potential opportunities to be exposed to ICVs,

I postulate the more physical assets and land the wife is perceived to control by their husband will have a statistically significant negative impact on ICV adoption and/or the intensity

of ICV adoption. Previous research analyzing specific factors of ICV adoption in Nigeria suggests when women have more control over the decision making process of agricultural land plots the probability of adopting ICVs decreases (Wossen et al. 2017). There may be unobserved negative relationships between women's perceived bargaining power within the household the probability, as well as intensity of, adopting ICVs in Nigeria. Secondly, I hypothesize the wife's participation in a cooperative will have a statistically positive impact on ICV adoption. Cooperatives allow for the potential of more educational opportunities for members, especially in terms of agriculture. If more women are exposed to the potential benefits of ICVs they may be more likely to adopt ICVs.

## Methodology

In this section, I will introduce the economic theory of the Bargaining Model, and then discuss the empirical model used to measure adoption of ICVs, the Double-Hurdle Model. First, I will discuss the Collective Model and then the Bargaining Model. Second, I will discuss the Double Hurdle Model and why it is an important tool for measuring technological adoption, specifically ICV adoption. Thirdly, I will discuss the data and survey. Finally, I will give a description of the variables used in my analysis.

## Theoretical Model

Historically, economists have looked at households as a combination of individuals who jointly decide the optimal way to allocate time, resources, and assets in order to maximize a common welfare index (Quisumbing and Maluccio 2000). This model is commonly referred to as the Unitary Model as it consists of a singular preference function. The Unitary Model itself relies on the idea that households make decisions to maximize total household utility and thus treats the

household as a singular unit with homogeneous preferences among its members. While the Unitary Model is a powerful tool to help explain household behavior, it provides an incomplete explanation because it ignores household dynamics that affect the decision-making process and providing an incomplete picture in terms of women's preferences and behavior to formulate better gender equality outcomes. Household members have different preferences, and resources are not always equally distributed within the household. If it is assumed preferences are no longer homogeneous within the household than Pareto efficacy is lost within the household (Chiappori 1992; Browning and Chiappori 1998). To account for this fallacy within the Unitary Model, Collective Models, specifically the Bargaining Model, have been developed (Chiappori 1992; Browning and Chiappori 1998).

All Collective Models rely on two main assumptions:

1. There are two people within a household,  $a$  and  $b$ , who make decisions on resource allocation, both of whom may have different preferences for how resources should be allocated.
2. All resources within the household are optimally distributed following Pareto efficiency.

If Pareto efficiency is assumed, that is for any price( $p$ )-income( $x$ ) bundle  $(p, x)$ , the following consumption bundle  $(q_a, q_b, Q)$ <sup>6</sup> would be chosen such that no other consumption bundle  $(\bar{q}_a, \bar{q}_b, \bar{Q})$  could make both members better off (Browning and Chiappori 1998). In other words, the members of the household must be allocating their resources in a such a way that changing the allocation would make one of the members better off while simultaneously making the other member worse off. Using Chiappori's (1992) methodology one can obtain the following household

<sup>6</sup>  $q_a$  represents person  $a$ 's consumption,  $q_b$  represents person  $b$ 's consumption,  $Q$  represents combined public good consumption of members in the household

utility function under the assumptions that the two members of the household have different preferences but abide by Pareto efficiency, or the “collective setting”:

$$\max_{q_a, q_b, Q} \mu(p, x) \cdot u_a(q_a, q_b, Q) + [1 - \mu(p, x)] \cdot u_b(q_a, q_b, Q) \quad (1)$$

$\mu$  = measurement of the distribution of power within the household of individuals  $a, b$

$u_a$  = utility of person  $a$

$u_b$  = utility of person  $b$

*Subject to the following budget ( $x$ ) constraint*

$$p \cdot (q_a + q_b + Q) = x \quad (2)$$

If one takes the two utility functions,  $u_a$  and  $u_b$ , and constrain the consumption with price vector  $p$  and household income  $x$  then there should always be one outcome of the consumption of goods by each household member, supporting the assumption of the household operating on the Pareto frontier.

The crux of the Collective Model lies with the distribution of power measurements:

$$\mu(p, x) \text{ \& } (1 - \mu(p, x)) \quad (3)$$

where  $\mu$  represents the “distribution of power” within the household (Browning and Chiappori 1998). The higher parameter  $\mu$  is the more power household member  $a$  has. If one assumes  $\mu = 1$  then person  $a$  has complete control over the household consumption of goods. On the other hand, if  $\mu = 0$ , then person  $b$  in the household will have complete control over the household allocation of consumption. If  $\mu$  has a value such that  $0 < \mu < 1$  then each member of the household has some power, and thus decision making ability, within the household. While these assumptions take into account the different demands for asset allocations within a household, they do not necessarily show how these allocations affect choices made by the members of the household. The Bargaining

Model works to model potential inputs affecting intra-household decision making by attempting to measure the distribution of power within the household via variables.

Bargaining Models allow for intra-household power dynamics to be analyzed via variables, such as control over resources (Quisumbing and Maluccio 2000). Economists have used Bargaining Models to test how economic resources within the household affect bargaining power, specifically, asset allocation (Quisumbing 1994; Doss 1996). For example, Doss (1996) demonstrated that if assets are equally distributed in the household then women have higher bargaining power and input in household economic decisions.

The Bargaining Model assumes that the resulting outcome of the bargaining process is Pareto efficient. Using bargaining theory, the threat points of the individuals are defined such that if  $T = (T_a, T_b)$  lies behind the Pareto efficient set then no agreement will be made that will maximize both persons utility. Instead, a decision will be made that results in one of the participants “losing” (Browning et al. 2014). If  $T$  is located within the Pareto efficient frontier then both participants will be better off by acting together than separately.

Due to the importance of cassava production in agriculturally focused communities and households in Nigeria it may be advantageous for members of a household to act together in terms of adopting new ICVs for cultivation. Adopting improved cassava varieties (ICVs) may be an opportunity households utilize to increase their productivity or income, and in turn, may be an opportunity for the household members to maximize their utility. If potential adopters, such as household members, are treated as agents who make decisions in their own best interest, and it is assumed that adopting ICVs may increase utility, then a simple approach to measuring ICV adoption can be used. I examine these issues in the empirical model below.



## Empirical Model

The adoption of agricultural technology are the outcome of optimizing heterogeneous agents (Foster and Rosenzweig 2010). It is assumed that farm households will maximize their utility function subject to constraints such as budget, information, credit, technological availability, and asset allocation amongst other inputs (Foster and Rosenzweig 2010; Gebre et al. 2019). Using this one can model the decision to adopt ICVs using the utility framework (Gebre et al. 2019):

$$G_i^* = \beta X_i' + v_i \text{ with } G_i = \begin{cases} 1 & \text{if } G_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

where  $G_i^*$  is a latent variable representing the difference between the utility  $u_{i,A}$  of adopting an ICV and the utility  $u_{i,N}$  of not adopting an ICV, such that a utility maximizing farm ( $i$ ) will choose to adopt an ICV if  $u_{i,A} > u_{i,N}$ .  $\beta X_i'$  is an estimate of the difference in utility from adopting ICVs compared to not adopting ICVs where  $\beta$  is a vectors of independent parameters,  $X_i$  is a vector of explanatory variables such as perceived individual bargaining power, and  $v_i$  is the error term.

The probit/logit model is commonly used to identify adoption of new agricultural technologies while the Tobit model is used to model the extent of the new technological adoption in agricultural by modelling the land dedicated to the new technology. Unfortunately, both strategies are highly restrictive as they assume the decision to adopt and how intensely to adopt the new technology are made jointly (Gebre et al. 2019). This may be problematic as both the choice to adopt ICVs and how much land is be dedicated to ICVs may differ significantly, and be affected by different factors (Lin and Schmidt 1984). Tobit estimates may be biased due to its joint determinations resulting in potentially violating homoscedasticity and normality of errors (Gebre et al. 2019). To counter this potential issue the double-hurdle model may be more appropriate to measure ICV adoption (Eakins 2016; Gebre et al. 2019)

The double-hurdle model allows for modelling both the probability of ICV adoption as well as the intensity of ICV adoption on the farm. Both choices may be determined by separate factors so measuring them independently is imperative. The double-hurdle model allows for more flexibility in measuring the factors of both adoption and intensity of adoption of ICVs than a simple Tobit model. The double-hurdle model hypothesizes two separate choices (hurdles) must be done to properly measure adoption of ICVs:

- 1) What factors contribute to the probability of ICV adoption?
- 2) What factors contribute to the intensity of ICV adoption?

Following Gebre et al. (2019) and Eakins (2014) I specify the double-hurdle model as follows:

$$y_{i1}^* = \beta_1 a_i + \beta_2 b'_i + \beta_3 c'_i + \varepsilon_i, \quad \varepsilon \sim N[0,1] \quad \text{probability of ICV adoption decision} \quad (5)$$

$$y_{i2}^* = \alpha_1 a_i + \alpha_2 b'_i + \alpha_3 c'_i + \varepsilon_i, \quad v \sim N[0, \sigma^2] \quad \text{intensity of adoption} \quad (6)$$

$$y_i = \alpha x'_i + v_i \quad \text{if } y_{i1}^* > 0 \text{ and } y_{i2}^* > 0 \quad \text{observation mechanism} \quad (7)$$

$(\varepsilon, v) \sim$  bivariate normal distribution with correlation between errors

Where  $y_{i1}^*$  is a latent variable indicating if a farm has adopted ICVs;  $y_{i2}^*$  is a latent variable describing the intensity of ICV adoption as a proportion of cassava producing land the farm has access to;  $a$  represents the agricultural land control ratio indicating the land controlled by the woman of the household,  $b$  represents the physical asset control ratio measuring the percentage of physical goods owned by the woman of the household, and  $c$  represent vectors of control variables such as men and women cooperative membership, age, age-squared, education, total land ownership, geographic binary variables, household access to credit, women headed household, and having access to cassava processing variables; and  $\sigma^2$  is a standard deviation that incorporates heteroscedasticity across observations.

To measure the power distribution within the household variables will be developed showing the ratio of assets controlled and/or equally controlled by the spouse of the head of household in relation to total assets owned by the household. It is important to note that not all assets are created equally nor valued the same. To account for the differences in value the assets will be binned into two main categories; physical goods and land ownership. Each classification will be measured as a ratio of assets ( $X$ ) perceived to be owned or controlled by the spouse ( $x_{f,i}$ ) compared to the total household assets ( $\bar{x}_i$ ), where  $f$  denotes the spouse of the head of household and  $i$  denotes the asset classification.

$$X^{f,i} = \frac{x_{f,i}}{\bar{x}_i} \quad (8)$$

*Subject to the constraint*

$$0 \leq X^{f,i} \leq 1 \quad (9)$$

Where  $X^{f,i} = 0$  would represent 100% perceived control of assets in favor of the head of household within asset class  $i$  while  $X^{f,i} = 1$  represents 100% perceived control of the asset class  $i$  by the spouse.

The perceived allocation of resources within a household may play a part in the choice to adopt ICVs. It may be that in households where one member controls a disproportional amount of assets that their desires and preferences may be dominate due to a potential inequality of bargaining power, thus, the household's potential joint-decision to adopt ICVs may impacted as the person who has more bargaining power may have their utility impacted more or less by adopting ICVs than other members of the household. Households where women have more bargaining power may behave differently than households where men have the majority of the bargaining power. On one hand, if a woman in the household has more bargaining power due to perceived asset control the household may choose to produce other products that better reflect the desires of the woman. The

choice of adopting new cassava varieties may also be impacted by the household characteristics. For example, a household who has one or two members participating in a coop may be more willing to adopt an ICV than a household that has no members participating in a coop if said coop pushes for members to adopt ICVs.

## Data Description and Survey

The data used for this study were obtained in 2015 from the Cassava Monitoring Study (CMS) (Wossen et al. 2017). The CMS questionnaire was conducted using the Surveybe tool and conducted from June 2015 to September 2015. Survey enumerators were trained on the Surveybe software and tested a sample CMS themselves in May 2015. In order to improve the quality of data obtained through the Surveybe tool, and given the technical requirements of the CMS, enumerators were required to have completed at minimum a first university degree such as a BA/BSc.

Using the National Population Commission of Nigeria (NPCN) the list of enumeration areas (EAs) for the CMS was developed. 80% of the total cassava production in Nigeria is found within 16 states across four political regions. A visit was made to each EA and a list consisting of at minimum 50 cassava producing households was developed. Of these 50 households, five heads of household, as well as two spouses, were chosen at random to participate in the CMS.

The CMS uses a multistage clustering sampling design, stratified by four established geopolitical regions described above. Each region had a sample size of 125 EAs. 625 total households were interviewed in each region. Furthermore, in total, 2,500 randomly selected cassava growing households in the major cassava growing states in the regions were interviewed for the CMS.

A sub-sample of the overall CMS was developed specifically looking at how gender may impact ICV adoption. This data was collected using focus level groups and one-on-one interviews. 30% of spouses of the household heads were interviewed. In total, 730 interviews were conducted specifically with spouses of the head of the household resulting in 730 households having both the husband and wife being asked the same questions.

## Variable Description

In order to estimate the bounds of the model different dependent variables are considered for both the probit and truncated regressions. For the first hurdle, adoption or not, a simple dummy variable, *improved*, is used representing yes (1) or no (0) adoption of an ICV. For the truncated regression a ratio is used to measure intensity of the ICV adoption. This variable, *percent improved*, measures the amount of land dedicated to ICVs against total land used for cassava cultivation resulting in a percentage of total land dedicated to ICVs. The higher the percentage the more intensely a farm has adopted ICVs.

Evidence has shown there is a direct positive linkage between total assets and agricultural land (Mottaleb et al. 2016). While it may be true that more assets in total leads to a higher rate of adoption we are looking at how assets effect perceived bargaining power by individuals within a household and adoption of ICVs. To measure bargaining power via assets two ratios have been developed to measure the respondents' spouses perceived bargaining power within the household:

- *Goods ratio*
- *Land access ratio*

The variable *goods ratio* measures the ratio of physical goods the respondent perceives the spouse in the household controls compared to the total amount of physical goods in the household. This variable is a combination of four other ratios:

*Goods Ratio*

(10)

$$= \frac{\sum \text{Womens Ownership/Access}_i(\text{Household Assets, Production Assets, Livestock, Processing Access})}{\sum \text{Total}_i(\text{Household Assets, Production Assets, Livestock, Processing Assets})}$$

All four of these are calculated by comparing the assets the woman has been identified as having control over in relation to the total assets within the household. Both *household asset ratio* and *production asset ratio* were calculated using the total value of household and production asset in Naira. Household assets take into account common household goods like jewelry, radios, TVs, cell phones, chairs, etc. Production assets are assets specifically meant for on farm productivity such as hoes, axes, plows, etc. When measuring the livestock ratio all livestock reported were converted to standardized animal units. Processing assets include tools used to process cassava into a value-added agricultural products like garri or fufu, common Nigerian cassava products. No value in Naira, nor any other measurement of value, was given for the processing assets so each was given an equal value. These four ratios were combined to make a single ratio describing the spouse's bargaining power related to physical goods as these goods may be taken with them if no decision (divorce) were to occur in the household. Furthermore, the assets are more easily liquidated than non-physical assets like land.

Land as an asset is not as easily transferred when a decision between two actors on the household cannot be agreed upon. Unlike physical assets land cannot be "picked up" and moved. Due to its intrinsic nature of being a non-transportable asset land control may play a larger role in the bargaining power one has. The variable *Womens Land Access* is included to measure the reported input the woman of the household has on the decisions made regarding the total land the

household has access to. The CMS survey asks respondents to indicate which person makes the decisions for each plot of agricultural land the household owns. I develop a ratio describing how much decision making power the woman has in relation to total agricultural land:

$$Womens\ Land\ Access = \frac{\sum Womens\ Control_i (Land\ in\ Hectares)}{\sum Total_i (Land\ in\ Hectares)} \quad (12)$$

This variable is bounded by 0 and 1. The closer the value to 1 the more decision making power in relation to plot management decisions the woman of the household has. This may have the largest impact on the spouse's bargaining power in the household as land is an extremely valuable asset. Women's ability to make choices regarding crops and what is grown on the land has been shown to have a significant effect on new agricultural technology adoption (Gebre et al. 2019).

The variables *education* and *age* of the survey respondent are included. Both education and age may play a part in the adoption of ICVs. If one has a higher education than it may be they know more about the benefits of adopting ICVs, thus, the rate may be higher. On the other hand, age may play an important role as well as the respondent may be less willing to change which crops they decide to grow as they may have grown accustomed to them over time. That being, there may be a relationship between age and education as an older respondent may have a higher level of education and may know more than a younger person regarding the benefits of ICVs. Another educational variable is measured by the variables *female coop* and *male coop*, which measure the participation in a cooperative network by the husband and/or wife of the household. Coops commonly offer educational opportunities for members and easier access to certain crops or technologies. There may be a positive relationship between coop participation and ICV adoption (Wossen et al. 2017).

The variable *female head of household* measures the woman's relation with the head of household. If the value is given a 1 then the woman is the head of the household, if the value is given a 0 value then the woman is the spouse of the head of the household. This is commonly used in development studies as an attempt to reveal gendered effects (Kassa 2013; Diiro et al. 2015). However, it is not sufficient to solely measure if a woman is the head of the household to capture how gender affects household decisions.

*Total land* measures the total amount of agricultural land (measured in hectares). Land ownership has historically been used as a variable measuring wealth and has been shown to have a positive relationship with improved crop varietal adoption in Africa (Doss and Morris 2000; Gebre et al. 2019). Larger land owners, however, may be hesitant to adopt ICVs as they may require more labor, capital, or time than the traditional cassava varieties. On the other hand, it may be easier for smaller farms to adopt ICVs as they will have less land to change over to the new processes and varieties.

The variable *SFboth* represents a household having access to both a sieve and a fryer. These two pieces of cassava processing equipment indicate a household participates in value added cassava production, specifically garri production. There may be a relationship with a household participating in value added production techniques and ICV adoption.

Finally, dummy variables indicating the four geographic regions the CMS was conducted in are included. It has been shown by Wossen et al. (2017) that geography plays an important role in ICV adoption. These are included to help identify underlying trends based on geographic regions that cannot be identified directly in the CMS questionnaire.



## Results

In this section I discuss my results. First, I give a brief explanation of the descriptive statistics for each model. Second, I give a detailed overview of the results of each regression. I look at both the probability of a household adopting ICVs by utilizing the first hurdle in the double hurdle model via the probit model. To analyze intensity of adoption I use a truncated regression only utilizing data from respondents who indicated either they, or their spouse, had adopted ICV(s).

### Descriptive Statistics

Table 1 provides the summary statistics of the tested variables for both the probit and truncated models. 1,483 of the 2,118 households indicated adopting ICVs in some capacity. Of those who did adopt ICVs the average percentage of cassava production on their household farms dedicated specifically to ICVs is 59.6%. In total, 54 households reported that women were the head of the household, accounting for roughly 2.5% of respondents. This is a stark contrast from the 14.6% of households reporting a female head of household in Nigeria as of 2015 (The World Bank 2020a). Since the reported number of female-headed households account for less than 3% of the total data testing them as a stand-alone model may not appropriate. For that reason, the variable *female head of household* is kept in the models as a binary variable instead of running a new model of just female headed households.

**Table 1: Descriptive Statistics of Model 1 - Probit Model Measuring Adoption (yes/no)**

Variable Name	Mean/Frequency	Std. Deviation	Min	Max	Obs.	Unit
Improved	70.06%	0.458	0	1	2118	Binary
Womens land access ratio	59.02%	0.590	0	1	2118	Ratio
Goods Ratio	40.25%	0.171	0	1	2118	Ratio
Age	51.089	13.374	18	101	2118	Years
Education	9.289	4.89	0	22	2118	Years

Female Head of Household	0.025	0.025	0	1	2118	Binary
Credit	0.425	0.494	0	1	2118	Binary
Coop, female	0.184	0.387	0	1	2118	Binary
Coop, male	0.236	0.425	0	1	2118	Binary
Sfboth	0.515	0.499	0	1	2118	Binary
Landsize	1.052	2.018	0	43.506	2118	Hectares
Farm occupation	0.760	0.426	0	1	2118	Binary

**Table 2: Descriptive Statistics of Model 2 Truncated Regression Measuring Intensity of Adoption**

Variable Name	Mean/Frequency	Std. Deviation	Min	Max	Obs.	Unit
Percent Improved	60%	30.763	0.5%	100%	1484	Percent
Womens land access ratio	56.40%	0.436	0	1	1484	Ratio
Goods Ratio	40.48%	0.169	0	1	1484	Ratio
Age	50.890	13.253	18	100	1484	Years
Education	9.298	4.931	0	22	1484	Years
Female Head of Household	0.028	0.165	0	1	1484	Binary
Credit	0.446	0.497	0	1	1484	Binary
Coop, female	0.197	0.398	0	1	1484	Binary
Coop, male	0.264	0.441	0	1	1484	Binary
Sfboth	0.608	0.488	0	1	1484	Binary
Landsize	1.153	2.228	0	43.506	1484	Hectares
Farm occupation	0.770	0.420	0	1	1484	Binary

Respondents are shown to view their spouses to have access to roughly 59% the agricultural land the household owns (Women's land access ratio). This is an interesting finding as traditionally men own and control the majority of agricultural land in Nigeria. It may be that women have a say in how the choices are decided for how the land itself is used but the male of the household may actually own it. The survey tool does not indicate this difference in the questionnaire so it is difficult parse out exactly what is happening with land control without more details. Furthermore, men perceive themselves to control a higher proportion of physical assets within the household than their spouses do as indicated by the average *Goods Ratio* equaling roughly 40.2%. This show women within the household on average control just over 40% of the total physical goods in the household. Both control of land and control of physical goods play a role in bargaining power within the household. The contrast between the two ratios is interesting as land control within agricultural societies is one of, if not the, most important assets one can have. The data show see men perceive their spouses to have more control over land but less control over physical assets.

The average age of the male respondents is 51 years old and the average education level is just over 9 years of formal education. This may be important as higher education may lead to a higher adoption of ICVs due to an increased knowledge of the benefits of adopting improved crop varieties (Doss and Morris 2000). OF the respondents 42.5% indicate the household as having access to credit.

About 76% male respondents report their main source of income comes from their on-farm labor. This is a stark contrast to the 44% and 26% of male and females respectively who The World Bank estimates to obtain their main source of income from on-farm labor (The World Bank 2020b). However, as the CMS was implemented in communities where the majority of

inhabitants are agricultural laborer's this contrast is to be expected and is not an issue. The survey was designed to identify inputs affects ICV adoption and thus having a respondent pool of mainly agricultural laborers is appropriate.

The average amount land, measured in hectares, is just over one hectare for both male and female respondents (1.052 and 1.001 hectares respectively). This is in line with previous studies conducted by IFAD (2009) showing 44% of male farmers and 72% of female farmers cultivate less than one hectare of land. Also find just over 23% of men and just over 18% of women participate in cooperatives. Cooperatives are an important source of information and offer educational opportunities for their members. With men indicating they participate in cooperatives more than their spouses there may be a power imbalance revolving around agricultural education and opportunities favoring men. Over 51% of respondents indicated their household has access to both a sieve and fryer. This indicates the household may participate in processing practices in order to participate in the cassava value chain in Nigeria. Households who participate in this value chain by creating garri or fufu may adopt ICVs at a higher rate than those households who only sell their cassava as unprocessed roots.

### Adoption Estimation Results

To run the double hurdle model first a probit regression was run measuring the probability of adopting ICVs, this is seen in column two. The second hurdle, measuring the intensity of adoption, uses a truncated regression to remove any household who reported not adopting ICVs at any level.

**Table 3: Double Hurdle Model Estimation Results**

	<b>1</b>	<b>2</b>
Womens land access ratio	-0.105 (0.074)	-8.038*** (2.322)
Goods Ratio	0.255 (0.180)	-11.661** (5.731)
Age	0.008 (0.014)	0.1903 (0.441)
Age2	-0.000 (0.000)	-0.001 (0.004)
Education	-0.002 (0.006)	-0.082 (0.200)
Female Head of Household	0.100 (0.203)	3.327 (5.667)
Credit	0.119* (0.063)	-0.958 (1.903)
Coop, female	-0.301** (0.125)	-0.273 (3.344)
Coop, male	0.388*** (0.116)	4.103 (3.053)
Sfboth	0.202 (0.142)	16.175*** (4.264)
Landsize	0.335* (0.199)	-1.754 (4.074)
Farm occupation	0.1024 (0.0725)	-1.124 (2.285)
South-West	0.553*** (0.153)	3.623 (4.399)
South-East	-0.401*** (0.084)	-9.598*** (3.278)
South-South	0.266* (0.158)	-8.958* (4.653)
Constant	-0.085 (0.384)	53.273*** (12.014)
Sigma/		31.902*** (0.764)
LR chi2(15)	264.52	172.67
Prob > chi2	0.000	0.000
Observations	2,118	1,484

<sup>1</sup>Probit model indicating ICV adoption

<sup>2</sup>Truncated regression measuring intensity of ICV adoption

\*p<0.1, \*\*p<0.05, \*\*\*p<0.001

In terms of perceived bargaining power based on asset control within the household there is no statistically significant impact of this variable on the probability of adopting ICVs. However, there are statistically significant impacts on the intensity of adoption. When men perceive their spouse to have more control over the household's land, results indicate the household adopts ICVs at statistically lower rate. Furthermore, when women control more of the physical goods in the household there is again observe a statistically significant lower intensity of adoption. As both of these are variables for bargaining power it may be true that if a woman in the household has a higher level of bargaining power then the intensity of adoption of ICVs in the household is lower than that of household that are more controlled by men. A potential explanation for this result is women who control more of the land, as well as household goods, may have a higher bargaining power within the household in regards to what agricultural goods the household produces. These women may not want to adopt ICVs at higher rates as the ICVs may not contain the desired traits the women want, they may want to produce other crops, or they may be happy with normal cassava varieties' and simply do not want to change.

Land size is shown to have a positive statistically significant impact on the probability of adopting ICVs. This may suggest there are underlying economic conditions that favor households who have larger plots of land resulting in an increased probability of adopting ICVs. Gebre et al (2019) and Doss and Morris (2000) found similar findings in terms of improved crop varieties in Africa. Since land is commonly used a variable indicating household wealth this result may indicate wealthier households have a higher probability of adopting ICVs. While increased land holdings increase the probability of adopting ICVs there is no indicated significant impact on the intensity of adoption.

Male participation in cooperatives and household access to credit both significantly increase the probability of adopting ICVs. Coop membership may provide members more access to the benefits of adopting ICVs. Access to credit may allow for households to obtain the necessary capital to change their crops over from traditional cassava to ICVs, making the transition easier and increasing the probability of doing so. However, female participation in cooperatives is shown to statistically decrease the probability of a household adopting ICVs. Cooperatives are commonly used to educate their members on crops, agricultural practices, allow more access to different crops, and help increase their members agricultural education at large. It may be that when women participate in cooperatives that they are exposed to more opportunities for how to utilize the agricultural land they control, thus, they may choose to plant other crops than cassava. Cassava is a physically demanding crop. If the spouse is exposed to more information about other crops, something coops commonly educated their members about, they may want to switch from cassava to a crop that is less physically demanding. This may not indicate that women are against adopting ICVs but instead that women may want to plant other crops than cassava in general. While cooperative membership of both men and women are shown to impact the probability of adopting ICVs they are not shown to have any statistical impact on the intensity of adoption.

Having access to both a sieve and a fryer is shown to have no statistical impact on the probability of a household adopting ICVs. However, for households who do ICVs having access to both a sieve and a fryer significantly increases the intensity of ICVs adoption. This indicates participating in value-added processes does not increase nor decrease the probability of adopting ICVs, but instead significantly increases how intensely a household will adopt ICVs. This may indicate that the ICVs available to the households contain traits that make them easier to

transform into other products making them more desirable to households who participate in the cassava value-added chain in Nigeria.

Geographic factors play a significant role in the probability of adopting ICVs. When comparing the South-West, South-East, and South-South regions to the Northern region there are both positive and negative statistically significant results. Both the South-West and South-South regions show households are statistically more likely to adopt ICVs than households in the Northern region. The South-West region is shown to increase the probability of adopting ICVs the most out of the four tested regions. Households in the South-East region are statistically less-likely to adopt ICVs compared to households in the Northern region. These findings are consistent with the findings of Wossen et al. (2017) indicating households in the South-East region of Nigeria adopt at the lowest rate while households in the South-West reporting adopting ICVs at the highest rate of the four tested regions in Nigeria.

In terms of intensity of adoption geography is shown again to play a significant role. Compared to the Northern region the South-East region adopts ICVs at a statistically lower intensity. Curiously, when compared to the Northern the South-South region adopts at a statistically significant lower intensity. Remember, households in this region are shown to have a statistically significant higher probability of adopting ICVs than those in the North, but when adopting they adopt at a statistically lower intensity than their Northern counterparts.

Other variables like the age and education of the respondents, if the head of the household is female, as well as farm occupation being the main source of income have no statistically significant impact on the probability of adopting ICVs nor intensity of adoption.



## Conclusion and Discussion

In this section I will discuss my conclusions of how perceived bargaining power within the household may affect ICV adoption. I will then discuss descriptive findings of a subset of data from the CMS survey where both the husband and wife of the same household were asked to take the CMS survey. Households from the subset were used for my main research but only the men's responses were used. I discuss the reasons for exclusion of the women's responses in this section. Finally, I discuss potential for future research based on my findings as well as the limitations encountered during this research project.

### Conclusion

Gender plays a significant role in agriculture, especially in Nigeria. Whether it be women traditionally having less access to land, women being expected to produce food for both the household and market while men traditionally are expected to just produce for markets, as well as the disproportional amount of women participating in the Nigerian cassava value chain compared to men, it is clear gender impacts all aspects of the agricultural industry revolving around cassava in Nigeria. Many studies looking at agricultural technology adoption, whether it be worldwide or specifically in Nigeria, fail to adequately take into account gender dynamics within the household. The unitary model which treats household as one cohesive unit is commonly used to measure household utility. This model does not take into account differences in power dynamics within the household which play large roles in the decisions that households make. Instead, adopting the bargaining model and attempting to measure an individual's bargaining power within the household may be a better tool to identify how intra-household power dynamics affect household decisions.

I measured the perceived bargaining power of individuals within a household using variables. One such variable measures the agricultural education of household members by identifying if the man and/or woman of the household partake in cooperatives. A second such variable measures perceived bargaining power via control of land. If the husband perceives their spouse as having more control over land, then their spouse may have more bargaining power within the household. Thirdly, I use a variable measuring an individual's perceived bargaining power via control over physical assets. Again, if a husband perceives their spouse to have more control of physical household goods it may be that the spouse has more bargaining power, and thus, more of their preferences will be realized through household decisions.

In general, our variables measuring the perceived bargaining power of married women in Nigeria show the more bargaining power the woman has the less likely, and less intensely, that household is to adopt ICVs. Results suggests that if a woman participates in a cooperative that household is be less likely to adopt ICVs. When measuring for intensity of adoption we see the more bargaining power the woman has in terms of both land control and physical asset control the less intensely that household adopts ICVs when the household does choose to adopt. The results of our double-hurdle model indicate that when women in Nigeria have more say in household decisions, measured using the bargaining model, the less likely that household is to adopt ICVs.

These findings are consistent with previous literature looking at ICV adoption in Nigeria. Wossen et al. (2017) found a statistically negative relationship between agricultural land controlled by women the probability of adopting ICVs. It may also be that women do not wish to adopt the ICVs that are currently on the market, or that they have access to, in their communities as well as Nigeria at large. Women tend to prefer ICVs that are easier to process and manipulate

into other goods compared to ICVs that maximize yields or are disease resistant (Wossen et al. 2017). If the households where women have more bargaining power in terms of assets, land, and/or educational opportunities like cooperative membership have limited access to the ICVs that better mirror the preferences of the women then they may be less likely to adopt.

While our results are statistically significant and paint a consistent picture across both the choice to adopt ICVs and how intensely to adopt ICVs in relation to women's bargaining power in Nigeria, it is important to interpret these results cautiously. When measuring gendered impacts on agricultural projects, and development in general, it is important that data collection and survey design are both tilted towards gender. The CMS is one of the better implemented survey tools found when looking at gender differences in ICVs adoption in Nigeria as the survey asks both men and women questions about their households and choices. However, the survey design only provides responses for both the husband and wife of a household for roughly 30% of total households interviewed resulting in roughly 2,500 male respondents compared to just 596 female respondents. Due to this disproportionate survey design via gendered responses it is irresponsible to compare male and female responses directly. To properly measure gender power dynamics within a household it is important to start at the beginning when designing survey questions, structuring how surveys are given, and deciding the target population of the survey. Without relatively equal representation in surveys and data from both male and female respondents it is difficult to properly and adequately measure how gender affects agricultural and development projects.

### Subset Comparison

A significant limitation to my study is the lack of women respondents. 594 households had both the male and female (spouses) surveyed separately which are included in the data

described above. Due to some data irregularities nine of these households had to be dropped from the observations for a total of 585 household observations. Both the husband and wife were asked the same questions.

Table 2 provides information on a subset of the survey respondents. Theoretically, if a household had completely open communication one may expect to see none of the variables of interest regarding adoption, adoption rates, asset allocation, land ownership, or access to credit to have a statistically significant differences between the respondents as they are answering for the same assets. However, that is not the case.

The mean differences of both the decision to adopt ICVs and the intensity of adopting ICVs show differences that are statistically significant at a 1% level. Male respondents of the same household say the household adopts ICVs at a significantly higher rate than their spouse's claim the same household does. Furthermore, male respondents in the household claim, on average, the household's intensity of adoption is over 6% more than what their spouses claim. This shows a significant breakdown of communication between the head of household and their spouses in terms of on-farm decision making.

As with the full data set of male respondents, the men in the households where both the husband and wife were interviewed are roughly 10 years older than their wives, while also have on average over a half a year more of formal education. Women (7) also claim the head of household is a woman more than men (5). However, the difference is not statistically significant.

**Table 4: Husband & Wife Subset T-Test Comparison Results**

<b>Tested Variable</b>	<b>Husband Response</b>	<b>Wife Response</b>	<b>Difference</b>	<b>Unit</b>
Improved	0.703	0.5341	0.168***	Binary
Percent Improved	41.824	35.459	6.364***	Percent
Womens land access ratio	0.692	0.590	0.101***	Percent
Goods Ratio	0.406	0.467	-0.060	Percent
Age	51.597	41.485	10.112***	Years
Age2	2833.433	1854.491	978.942***	Years
Education	9.130	8.473	0.656***	Years
Female Head of Household	0.009	0.012	-0.003	Binary
Credit	0.427	0.383	0.044*	Binary
Coop, female	0.191	0.205	-0.014	Binary
Coop, male	0.234	0.234	0.000	Binary
Sfboth	0.596	0.539	0.056***	Binary
Landsize	1.097	1.001	0.096	Hectares
Farm occupation	0.783	0.648	0.134***	Binary
Observations	594	594		

\*p<0.10, \*\*p<0.05, \*\*\*p<0.01

Male respondents claim the household has access to credit more than women do. Again, this may be due to the way the question was interpreted by the respondents. If the woman respondent does not feel as though they personally have access to credit they may have answered “no” when asked if the household has access to credit in general. However, this is unknown. Men also claim, at a statistically significant higher level, that their spouses have access to both a sieve and fryer. This is an interesting observation as access to a fryer and sieve indicates with high likelihood that the household participates in garri production. Neither the fryer nor the sieve are small items, and instead take up considerable space making it highly unlikely that one would not, at minimum, see the items use.

Two of the most interesting takeaways are the statistically significant differences the men and women have regarding perceived asset allocation within the household. Men perceive their spouses to have statistically more control over land than their wives perceive themselves to have

access to. This is an interesting observation as it is both statistically significant and the exact opposite of our findings when comparing the full data set of male respondents against the subset of female respondents. There may be psychological inputs at play here where the men in this data set knew their wives would be asked the same question. The men may be over reporting the land control they perceive their spouses having in order to look different to the enumerator. On the other hand, the female respondents indicate having a larger share of the physical assets within the household than their husbands perceive them having. This is consistent with what I found in the full data set comparisons. Women may be accounting for different assets, or have a different view of whom owns what physical assets within the household, thus, viewing themselves as having a higher distribution of the total household assets.

## Future Research

More research should be conducted to analyze the impact of women's bargaining power on the probability and intensity of both individuals and households adopting ICVs. Gender plays a large role in agriculturally centered households and communities and its importance in the decision making process cannot be understated. If further research is carried out analyzing both the preferences of men and women in regards to ICV characteristics, as conducted in the Cassava Monitoring Final Report (Wossen et al. 2017), as well as geographical analysis of where certain varieties of ICVs are available, a more concrete relationship between gender, ICV traits, geography, and adoption may be able to be identified. This also may help explain some of the statistically significant differences found relating to geographical location and the probability/intensity of ICV adoption.

One of the key takeaways of this research is how important clear, concise, and concrete survey implementation is to development and agricultural research. As stated above the CMS is

one of the better implemented agricultural development surveys in terms of asking both men and women the same questions about their preferences, household, crops, etc. However, the disproportionate response rate of over four men to one woman in terms of response allows for significant gender bias to potentially enter the data. Agricultural societies rely heavily on both men and women so it should be at the forefront of survey design to attempt to obtain roughly the same number of responses from both men and women.

Furthermore, more research should be conducted using the subset of data where both the husband and wife of the same household were asked the same questions. As explained above the information obtained from this subset of data shows statistically significant differences in the responses of the husbands and wives, indicating there are significantly different perceptions on what is taking place within the household. This is an important distinction as it indicates that who is asked a survey question may be just as, if not more, important as what is asked. The CMS data indicates that the individual, whether it be the husband or the wife, plays a significant role in the survey responses which could lead to biased or potentially incorrect results. More research into the subset of the CMS data, as well as more research into survey design and implementation, should be considered.

Finally, further research utilizing tools specifically meant for measuring women's empowerment and its relationship to agricultural technology, and specifically ICV adoption, should be considered. The CMS data does not allow for measurements of women's empowerment to be constructed due to the survey design. Utilizing tools like Pro-WEAI, a survey tool specifically developed to measure women's empowerment through multiple measurements may be able to better accurately portray the impacts of gender on ICV adoption, and potentially the adoption of other agricultural technology as well in agricultural communities.

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