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Estimating the Effects of Small-Scale Broiler Poultry Farming on Increasing Rwandan Meat Protein Consumption

Sarah Berman
University of Tennessee, sberman3@vols.utk.edu

To the Graduate Council:

I am submitting herewith a thesis written by Sarah Berman entitled "Estimating the Effects of Small-Scale Broiler Poultry Farming on Increasing Rwandan Meat Protein Consumption." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural and Resource Economics.

Jada Thompson, Major Professor

We have read this thesis and recommend its acceptance:

Chris Clark, Tom Gill

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Estimating the Effects of Small-Scale Broiler Poultry Farming on Increasing Rwandan Meat Protein Consumption

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ABSTRACT

This research centers on the United States Agency for International Development (USAID)-funded Tworore Inkoko, Twunguke program (TI Program) in Rwanda aimed at increasing domestic meat consumption through training and enrolling smallholder farmers in broiler chicken enterprises. The majority of Rwandans do not have consistent access to animal-sourced protein, which can be ultimately detrimental to an individual's health. This thesis describes differences in levels of meat consumption across time and across the treatment (participated in the TI Program) and control (did not participate in the TI Program) groups. The first chapter summarizes annual survey results for both the treatment and control groups. Mean difference analysis is utilized to determine any selection bias and account for that bias in later analyses. The latter two chapters determine the statistical difference in meat consumption as a result of the TI program and changes in purchasing behavior. For the second chapter, difference-in-difference modeling and Poisson regressions are performed for the years 2017 and 2018 in this analysis to determine differences in meat consumption and what factors cause differences in meat consumption across those in and out of the program. The results indicate that the TI Program has significantly impacted meat consumption levels between 2017 and 2018 in program participants. The final chapter uses a probit analysis of asset purchases and income indicates that the program has also had an impact on the purchasing power of program participants. Results indicate this program has had an impact in improving Rwandan lives.

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INTRODUCTION

Food insecurity and lack of food diversity are global concerns. Increasing access to food and to a diverse diet is especially important for low income nations such as Rwanda. Today, the lack of well-balanced diets and access to nutrition affects 21% of the population of Africa (FAO, 2018). A lack of a nutritious diet or access to diverse foods can lead to malnutrition.

The Tworore Inkoko, Twunguke (TI) Program funded by the United States Agency for International Development (USAID), and implemented by the University of Tennessee, aims to alleviate malnutrition and increase incomes in the country of Rwanda by educating smallholder farmers on broiler chicken production, including coop construction and rearing practices. Rwanda was chosen for this program due to its increasing demand for animal protein attributable to rapid population growth and increasing incomes. The TI team aims to increase animal protein consumption in the form of chicken meat. This research evaluates the TI program in terms of its effects on the meat protein consumption and asset purchases of its participants.

The evaluation of the TI program begins with an overview of the program methodology. This overview includes, but is not limited to, a discussion of the selection process for participants, the provision of coops, monitoring throughout the broiler production cycle, and the implementation of a follow-up survey with enrolled participants. Given that participation in the program was not random, the evaluation includes a mean difference analysis comparing general population to participants over time to understand how these groups all differed at the start of the program. The

evaluation then examines any statistical changes in meat consumption associated with participation in the program. This examination utilizes difference-in-difference analysis and Poisson modeling to estimate the difference in meat consumption over time. Assets purchased as a result of increased income is beneficial to analyze. It aids in determining if another goal set by the TI program, to increase income, is being met. Probit modeling is used to identify differences in asset consumption associated with participation in the program.

CHAPTER I

The Rwanda Project, Survey, Motivations for Analysis, and Mean Differences Over Time

Introduction

Tworore Inkoko, Twunguke (TI) is an educational program aimed at alleviating food insecurity and providing additional income through small-scale broiler poultry farming operations in Musanze district, Rwanda. The Musanze district has a population of 368,563 (*Demographic and Health Survey RDHS*, 2016) and was chosen for the program because of its close proximity to a specific feed mill, Zamura Feeds, utilized for the project.

The TI program was proposed in 2016 and officially began in 2017 and operates by training 750 smallholder farms in broiler poultry production. By providing loans for capital and recurring expenses and chicken buyback at the end of every cycle, the goal of the program is to create a framework for small-scale broiler production, which can be later expanded. To define the project area, the Musanze district as a whole was initially narrowed down to three rural and five urban sectors based on logistics. Eligible farmers were selected from three of these sectors. Two rural and one urban sectors were chosen as a purposive sample because they had access to a main road (for broiler logistics coordination). The rural sectors were also deliberately targeted due to pre-existing differences in average income. Ultimately the Gataraga, Kinigi and Muhoza sectors were selected for the project. From these three sectors, three cells were chosen at random, from which farmers were recruited (see Figure 1.1).

The first step of recruitment was informational meetings in each cell (nine meetings – one in each selected cell in each chosen sector). Any resident of the cell was allowed to attend the informational meetings and sign up to participate in the program.

Following the session, contact information was collected from those who were interested in participating in the program. A random sample of those providing contact information was contacted for further screening, as the program did not have the capacity to train all farmers who had provided contact information. The random selection was then followed by rigorous screening and a phone call to all selectees to determine levels of interest. The test of interest continued with a home visit. This home visit also evaluated land on the respondent's property to determine if they were capable of housing a 10-foot by 10-foot chicken coop. If there was not sufficient space or if the person did not meet other requirements of the program, that person was not asked to participate in the next step of the selection process. The final portion of the selection process was a three-day training session followed by a largely hands-on exam. If an individual passed the training exam, they were invited to participate in the program. In the first year of the program (2017), the exam had an 82% pass rate. Upon passing the examination, participants are formally invited to undergo extensive training. Those participating in the training are also given the coop for the project.

Survey and Implementation

To assess annual change towards program goals of improving nutrition and income among participants, the TI team administers a household survey to all enrolled participants and a selection of 300 non-participating, general population households per sector in each of the three sectors (Gataraga, Kinigi and Muhoza). The survey is administered via tablet at the respondent's home during September and October of each year of the program for both those enrolled in the TI Program and the general population.

Figure 1.1 represents the survey area. Figure 1.1, along with all subsequent tables and figures, are located in the Tables and Figures Appendix.

The survey is designed to provide insight into the dietary and non-dietary effects of the program and to determine how participants feel the program has impacted their income and everyday lives. The survey has seven sections ranging from demographically based questions to specific questions about program participation and poultry ownership. While, the complete English version of the survey is presented in Appendix A, the following is a brief description of the household survey sections. The first section is dedicated to demographic and location information with questions on respondent gender, household role, sector, cell, and village. Respondents are then asked to answer questions about the demographics of all members of their households (i.e. spouse, child, parent, other). The next section focuses on household consumption of specific food groups including, but not limited to, grains, milk and dairy, sugar, meat, eggs, and vegetables. Respondents are asked whether items from each food group were recently purchased, how many times they were recently consumed, and how much money was spent on them. The final segment of questions focuses on program participation and is comprised of two questions asking if the individual is a member of the TI Program and for how long they have been a part of the program.

Implementation Methodology

In the fall of 2017, 975 general population surveys were administered before anyone officially enrolled in the program (Group A). The sample for these surveys was split roughly evenly between the three sectors, Muhoza, Gataraga, and Kinigi, with around

300 survey participants per sector. Figure 1.2 represents this distribution. A similar approach was used for the second year of survey data, 2018, where 922 general population surveys (Group C) were administered equally across the sectors for non-program households, but not necessarily to the same households as the 2017 survey in each sector as it is a randomized survey. Table 1.1 represents the full distribution of when participants were surveyed, as well as whether or not they were in the program and in what year they were surveyed. In addition, program participants are surveyed when first enrolling in the program to serve as a participant baseline (Group B) and there were 162 participants. In 2018, surveys were collected from the 155 farmers that were enrolled at that time in the program and had completed at least two broiler production cycles by the 2018 survey within the study area (Group B2). A broiler cycle, as defined here, is one sequence from chick to bird collection for slaughter or sale. To be included in the B2 group responses, a farmer must have completed that cycle twice.

Thus, the groups can be characterized as:

- Group A: 2017 general population (n=951);
- Group B: Initial TI participant baseline collected between September 2017 and April 2018 (n=162);
- Group B2: 2018 TI program participants who had completed at least two growth cycles (n=155); and
- Group C: 2018 general population (n=922).

Differences in Means Across TI Participants and General Population

Mean difference calculations between the survey groups provide information about differences between the groups, highlights potential selection bias between the participants and the general population. Mean difference calculations use several sample metrics to determine statistical difference between two survey samples. These metrics are the average of the variable in question for both samples and the hypothesized difference between the two samples.

T-testing can be a helpful tool in determining statistical difference in variables. The general formula for the operation is indicated below (equation 1.1). The resulting t-score can be compared to a t-table at various testing levels to determine level of significance. For the purpose of this analysis, paired t-test formulas are utilized as pairs of like variables are investigated.

(*1.1*) $$t = \frac{m}{(s/\sqrt{n})}$$

For equation 1.1 *m* corresponds to the mean of the sample, *s* corresponds to the standard deviation, and *n* represents sample size. Significance levels obtained from t-tests indicate the likelihood, given that the true difference is zero, of observing the given difference between the pair of values of interest. Table 1.2 presents the results of t-tests and subsequent significance levels.

Results

First, a general understanding of basic demographics across the two years, broken down by year and participation is calculated. Figures 1.3-1.6 encompass all survey participants broken down by year. Figure 1.3 represents the individuals home situation, where the individuals could indicate that they rent or own their home, live there free of charge, or other. From 2017 to 2018, home ownership differed with 3% more people indicating they own their home. Home renting also differed by 3%. Those living in their home for free and those in the "other" category both show changes of -3%. Figure 1.4 represents a different asset, land ownership. Between 2017 and 2018, the percentage of people who owned land changed from 49% to 39%. These differences may reflect changes in home situations or a difference in the population surveyed.

Figures 1.5 and 1.6 indicate differences in utilities, namely whether individuals have electricity and/or running water in their homes. With electricity access (Figure 1.5), there is a noticeable difference in those who had access to electricity and those who did not between 2017 and 2018. In 2018, the number of those who had access to electricity differed by 30%. Water, illustrated in Figure 1.6, stayed nearly identical with only a 1% difference.

2017 General Population vs. TI Participants Baseline Surveys

The first TI farmers were enrolled in the program in September 2017. T-testing is used to compare the average response to select 2017 survey questions for the TI participant baseline (Group B) and general population (Group A) surveys. These comparisons provide evidence of the extent to which program participants differ from or resemble the

general population in the study area. Mean comparisons are useful to calculate whether there is statistical difference between the general population and the program participants at point of enrollment. Table 1.2 presents these mean comparisons.

As shown in Table 1.2, the differences in the mean values for the two groups are statistically significant for all of the questions included in the analysis. What this indicates is that there is high confidence that the difference between the two groups for all variables is different than zero. This can be interpreted that the participants' baselines statistically differ from the general population in all of the dimensions considered including, but not limited to, meat consumption/purchasing, home ownership, and income. This is further illustrated by looking at the averages for specific variables such as meat consumption within the last day or week of being surveyed. There is a statistically significant difference between participants and the general population in both the percentage of respondents who indicated they consumed meat within a day of being surveyed or a week of being surveyed from 0.018 to 0.039 and from 0.037 to 0.163, respectively (Table 1.2). This shows is that those who elected and were selected to join the program were, on average, consuming less meat than that of a person in the general population. Another factor which differs between Groups A and B is income, which will be explored deeper in later chapters. Briefly, income is shown to have a difference from an average of 0.038 to 0.134 between program participants and the general population. This is indicative that the participants are different from the general population. This difference is important for the TI program as lower income individuals were the target demographic of the study.

Conclusions

Overall, what can be concluded from this analysis is that there are statistical differences between the general population and the program participant baseline surveys that would indicate that the program selection did select low income farmers who on average consumed less meat. These underlying differences in levels of income, education, and meat consumption likely had influence on who chose to participate in the program, which is important to understand when modeling changes across time.

Moving forward, this information can be used in later analyses to compare levels of meat consumption and purchasing power based on income. The results of this chapter and these subsequent analyses will offer insights into the numerical and statistical effects of the program on participants.

CHAPTER II

Difference-in-Difference Estimation of Meat Consumption as a Result of the Tworore Inkoko Program

Introduction

One of the primary goals of Tworore Inkoko, Twunguke is to improve access to animal-sourced protein for both program participants and second-order beneficiaries (non-enrolled households within the study area). Animal-sourced protein is one of the areas in which dietary diversity for households in the region is currently lacking. The majority of Rwandans eat roots and tubers as their staple food ("Customs and Cuisine of Rwanda," 2019). While that is important, roots and tubers alone do not constitute a balanced diet based on international food group recommendations. Recommendations are to have balanced servings every day of grains, fruits, vegetables, protein, and fats (*INDDEX Project*, 2018).

A difference-in-difference estimation and Poisson models will provide an analysis to understand how TI Program participants meat consumption changed in the first year of the program. This can help show how much protein consumption changed within the study area for the program participants, with the hypothesis being that significant statistical change will be observed between the program participants and the greater community. The end goal of this proposed research is to establish an effectiveness measure of how well TI has achieved its goal of improving access to animal protein to program participants. Specifically, this analysis will estimate the quantified effects of the program participation on improving respondents' access to animal protein.

Background

Food diversity is eating from at least 5 food groups (protein, grains, fruits, vegetables, and fats) within 24 hours. Mirmiran et al. (2004) further defines a diverse diet as one who

eats at least half a serving of multiple food groups over a span of two days. Results of that study found positive relationships between dietary diversity scores and nutrient adequacy scores, indicating that dietary diversity is an effective way of determining what a human's level of nutrient density and adequacy is, and by extension their overall nutritional health.

Another approach to examining the concept of dietary diversity in Malawi was used by Jones, Shrinivas, and Kerr (2014) which includes a metric called the Household Dietary Diversity Score (HDDS). The score utilized by these researchers is a measure of food items consumed from a list of 113. The results of this study indicated that urban areas have higher HDDS metrics than rural areas throughout Malawi, and also that northern rural areas showed higher HDDS levels than the remaining rural areas analyzed. Relevant to the TI Rwanda program, the research by Jones, Shrinivas, and Kerr found that urban areas showed significantly higher meat consumption levels, which is to be expected and is an underlying assumption of the TI Rwanda framework.

Dietary diversity levels can also be impacted by food security. A study by Hoodinott and Yohannes (2002) concerning several regions of Africa, in addition to other areas, uses a variety of linear regression techniques to attempt to determine if addressing dietary diversity may be a more effective indicator of well-being. The reasoning is that simply addressing food security does not necessarily equate to a balanced or complete nutritional diet. Increasing dietary diversity could provide healthier options and increased caloric intake to reduce malnutrition. They found that a one percent increase in dietary diversity leads to 0.5 to 1.4 percent increases in factors such as per capita consumption

and per capita caloric availability for both dietary staples and non-staples (Hoddinott & Yohannes, 2002). These results indicate dietary diversity has a correlation with caloric intake and availability, such that increasing diversity could be a valuable step toward reducing malnutrition.

Animal Protein Impacts on Dietary Diversity

Results contained in the prior literature associate the type of food groups consumed with an individual's nutrient density. One area not discussed, however, is animal protein and its effect on dietary diversity scores. Research suggests that 1.2 to 1.6 grams per day per kilogram of a person's weight is the ideal protein amount to achieve good health (Phillips et al., 2016). Potts et al. (2019) attempted to determine factors that affect animal protein consumption and subsequent health impacts and found that religion, location, and participation in safety net programs increased animal sourced protein consumption, specifically in young children.

Research by Schönfeldt and Hall (2012) highlights that animal source and cereal based proteins are considered important staple proteins. However, they also found that in developing nations the majority of protein consumption comes from cereal, the lower quality option, and results in high levels of malnutrition. This would suggest that a metric to determine only the amount of protein consumed is not sufficient to determine dietary adequacy.

With the presented literature surrounding animal source protein and its effect on dietary diversity known, not much is known about whether raising broiler chickens in northern Rwanda would lead to increase meat consumption and improved dietary

diversity. Does this agricultural initiative in Rwanda translate into realized changes in direct and indirect beneficiary consumption of meat? One of the purposes of this endeavor is to determine linkages between protein access and improved diets for this specific population.

Poultry Farming and Its Effect on Dietary Diversity

One important, often low-cost source of dietary diversity is poultry. State, Birungi, and de Haan (2009) studied the role of poultry in the livelihoods of Ugandans and indicated that while poultry farming has had a statistically strong impact on their lives in terms of income generation, the practice itself does not receive the attention it requires to be successful and make dietary changes. Their conclusion was reached through a survey of rural households to determine the role of poultry in the lives of small-scale farmers and how easily their operations could be threatened by things such as diseases in their poultry. The results determined that these particular small operations represented a very large portion of household income (State et al., 2009). Additionally, respondents showed a very high perception of their well-being when compared with their other community members and peers. The authors recommended more research should be done to determine how beneficial poultry farming is on a long-term basis in terms of changing individual diets.

A related study by Mahoro et al. (2017) in Rwanda was concerned with indigenous chicken production. This study indicated that a disease outbreak was a major challenge to poultry production and income generation, meat production, and egg production were the primary reasons for the farming of poultry (Mahoro et al., 2017).

The results showed that low production possibilities for rural poultry farmers pose a significant constraint to production systems such as these in Rwanda (Mahoro et al., 2017).

The previous literature shows that there is continued work to determine the prevailing factors which challenge Rwandan poultry farming and find innovative solutions in consumer demand, production, and marketing. Little can be known about the long-term efficiency gains of previous projects, as well as long term dietary impacts, but results show that they increased poultry consumption. Additionally, lacking in the previous studies is the added benefits expected when programming is centered on educating farmers on how to better expand and reach their individual goals.

Effects of Programs on Poultry Access

Tworore Inkoko's main focus is increasing poultry consumption and subsequently increasing animal sourced protein consumption. For a low-income country, there are numerous factors any program designed to increase market access will need to address. A study by Aklilu et al. (2007) concerning gender and market access to poultry in Ethiopia indicated that female headed homes had higher percentages of poultry consumption per household member, but that male headed households have higher overall levels of consumption and poultry sales. This study also indicated that the producers/sellers side of the poultry market was primarily female (Aklilu et al., 2007). A solution offered through their research is increasing information access about poultry production to lower income communities.

In a different study by Aklilu et al. (2008) in Ethiopia, it is suggested that poultry consumption has previously not been analyzed by research endeavors such as this. It is also a common belief among researchers that farming can be a stepping stone out of poverty (Aklilu et al., 2008). The end results of this research echo that of previous studies in pointing out the primary reason for participant's decision to engage in poultry farming is increased income. Also, Aklilu et al., (2008) noted that small flocks are indicative of poor market access and that those farms located strategically close to a feed source or large capital were more successful.

Conceptual Framework

A central concept surrounding the economic understanding of consumers is that they will operate under conditions that maximize their utility:

(*2.1*) $Max\ U=U(x,y)$

$S.T.: Income=P_xQ_x+P_yQ_y$

From this, it can be derived that the marginal utility gained from good X divided by the price of good X, is equal to the marginal utility gained from good Y divided by the price of good Y.

Program Concepts

A framework for how program participation affects diet and food security are laid out as follows:

(*2.2*) *Program Participation= f(interest level, exam score, land size, training proficiency)*

(*2.3*) *Diet = f(income, age, household size, program participation, education, number of children)*

(*2.4*) *Food Security= f(diet, access to resources, number of children)*

where diets are a function of individual demographics. An individual's participation in the TI program, is a function of a person's interest level, their available land, their proficiency during training, and their final TI program exam score (which is used as a program participant selection tool). There is overlap between what may make a person participate in the program and what factors have the potential to improve a person's dietary intake.

Demographics and socio-economic status contribute to dietary and food security. A lack in dietary diversity and food insecurity may be linked to a lack of income, dietary education, or access to a diverse set of food. If a person in Rwanda is unemployed, underemployed, or uneducated nutritionally, it could affect their family's ability to secure a healthy, nutritionally abundant and diverse diet. Any examination of the malnutrition problem would need to also include an analysis of the economic factors to determine their connection to their dietary decisions.

Hypothesis

A central hypothesis to be tested in this analysis is whether TI program participation improves access and consumption of meat protein. This hypothesis will determine if there

are any changes in meat consumption evidenced by estimations of changes in meat consumption for participants, while also accounting for changes in protein consumption in general population. This is investigated by comparing the diets, specifically meat consumption, of the survey respondents before program implementation in 2017 to after the program is established in 2018.

(*2.5*) $H_o: \delta^{2018} - \delta^{2017} = 0$

(*2.6*) $H_a: \delta^{2018} - \delta^{2017} \neq 0$

The null hypothesis in this case is that the treatment effects of the program are not statistically significant. The alternative hypothesis is that the difference between the treatment effects for the two periods are statistically significant.

Data

Through the process of the TI program, pre-program enrollment surveys (2017-2018) and annual surveys (2018) were collected from participants. Additionally, annual surveys of the general population (2017 and 2018) were collected to understand the overall community (See Chapter 1 for more details). A limitation of the participant's enrollment surveys is that they were collected at time of enrollment, thus at various times (predominantly between the months of June and October) compared to annual surveys which are collected within the same timeframe (survey collection times are discussed later). For the analysis these enrollment surveys will act as proxy for the first general population survey (2017 Groups A and B) as enrollment began in 2017 and going through early 2018. Using participant's enrollment surveys as a proxy for the 2017

general population surveys allows for understanding any heterogeneity and selection bias between participants and the general population at the onset of the program. While not ideal, using these baseline enrollment surveys allows for an analysis of changes in meat consumption for program participants while accounting for inherent differences between program participants and the general population. In order to take part in the participant's annual survey in 2018 (Group B2), participants had to have completed at least two bird cycles (a minimum of 45 days per cycle from placement through grow out).

The annual surveys include questions pertaining to the respondent's gender, education level, number of children, meat consumption/purchasing, household agricultural work and program participation. These questions are used to create demographic and categorical variables which will account for the structure of households and their impact on participation choices. The survey also provides measurements for how often households consume various food groups, including meat consumption. These levels of meat consumption will be the dependent variable for the economic modeling.

The times of year during which participants were surveyed were also considered for this analysis, but ultimately were excluded due to limited heterogeneity in observations. Rwanda has two rainy seasons and two dry seasons (*About Rwanda*, 2020) that may affect food access and consumption. Table 1.1 (See Chapter 1) represents the distribution of when respondents were surveyed corresponding to Rwanda's seasons. In both 2017 and 2018 the largest number of surveys were conducted during Rwanda's second dry season with 1,016 and 1,077 surveys collected, respectively. In 2017 and 2018, 63 and 0 surveys were conducted during the first dry season, whereas 24 and 0

surveys were conducted during the first rainy season, respectively. Only 9 surveys took place during the second rainy season. This low number of observations in the distribution of surveys administered across seasons limits its use in econometric modeling and as such seasonality will not be included in the following analyses.

Methods

Difference-in-Difference Estimation

Difference-in-difference estimation relies on panel form data (at least time periods). For these purposes, the format is 2017, a pre-program baseline year, and 2018, a mid-program investigation. The use of software expedites this process and determines the difference between the control group in each period, the difference between the treatment group in each period, the difference across each period as a whole, and the overall difference between the two periods known as the "difference-in-difference" critical value.

Difference-in-difference estimation is used to determine statistical difference between the control group (general population) and the treatment group (program participants.) The order of this process begins by estimating the treatment effect on protein consumption for the pre-program period (2017) and the mid-program period (2018) in the following:

(*2.7*) *Pre-Program (2017):* $Y_i^{Pre}=\beta_0+\beta_k X+\delta T_i+\varepsilon_i$

(*2.8*) *Mid-Program (2018):* $Y_i^{Mid}=\beta_0+\beta_k X+\delta T_i+\varepsilon_i$

(*2.9*) *Pre-Program (2017) – Mid-Program (2018) = Difference-in-Difference*

Because Y_i in this case is a non-continuous count variable measuring how many times per week a survey respondent consumed protein, a Poisson estimator is used. Comparing the statistical differences in the pre-program time period, mid-program time period, and then the difference-in-difference between the two time periods overall, it can be determined if the program has produced statistically significant outcomes in animal protein consumption in the treatment group.

Poisson Regressions

Poisson distributions were originally conceived by Siméon Denis Poisson and are useful when the dependent variable in a regression is a count variable, or non-continuous. Poisson models are log linear models that assume a distribution that the logarithm of the expected value of Y and as a function of various independent explanatory variables (equation 10). The log-likelihood aspects of Poisson modeling are represented below,

(*2.10*) $$\Pr(Y = y) = (e^{-x\beta} x\beta^{y})/y!$$

(*2.11*) $$\int (y_j) = e^{x\beta} x\beta^{y}/y!$$

(*2.12*) $$lnL = \sum_{j=1}^{n} w_j \{-e_j^{x\beta} + x\beta_j y_j - ln(y_j!)\}$$

where Pr(Y=y) is a count data distribution of the independent, explanatory variables including, but not limited to, age, income, agricultural work and their respective coefficients, and the effect they have to produce the outcome y. Equation 11 represents that y is a function of those same explanatory variables and their coefficients. In order to estimate this model a linearized form is derived (equation 12) by taking the log likelihood of equation 11. In model estimation a search process finds the best fitting beta values that

likely generated the dependent variable. The above processes are all used in an effort to determine what demographics and consumption variables produce outcome y. For example, the above estimations could determine that only those survey participants who are young, female, and low income consumed more meat protein. That information can then be utilized to take to study why these sub groups are most effective or to better target those who aren't consuming as much meat relatively.

The dependent variable is the count of how many times a household consumed meat within the week prior to being surveyed. Poisson modeling is utilized for this analysis in providing factors significant to individuals consuming more meat protein. The general form for these is represented below.

(*2.13*) $$Y_i=\beta_0+\beta_k X+\delta T_i+\varepsilon_i$$

where Y_i is the number of times meat is consumed in the last week for the pre-program period (2017) and the mid-program period (2018) survey; β_i represents estimated coefficients; X represents a matrix of categorical demographic explanatory variables to be included; the term δ represents the marginal value or effect of the treatment (are participants consuming more protein compared to non-participants); T_i is a binary variable (1 if a program participant, 0 if not); and ε_i represents the error term.

In order to correctly specify the model, additional tests were estimated because data can have problems with the number of zeros in the observations, also called zero inflation. Over inflation breaks one of the assumptions of the Poisson model. In this data, 87% of the responses of the dependent variable, meat consumed within the last week, are zero, making a normal Poisson model inappropriate to use. The zero-inflation testing

process determines if there are an overabundance of zeros in the data. If so, a Zero Inflated Poisson (ZIP) model would correct for this by making the distinction between those groups of zeros and determining which of these zeros are legitimate or illegitimate. For example, the ZIP determines if people are not eating meat during the time period or whether they never eat meat for legitimate reasons such as religion or preference.

Additionally, Poisson models have an underlying equidispersion assumption, which assumes that the mean and variance are equal across the data. This assumption should be tested before final estimation. To correct for overdispersion, if present, a Zero Inflated Negative Binomial (ZINB) model would be used. To test for overdispersion, a ZIP test is performed to determine the necessity of transitioning to a ZIP model or a ZINB model. Both of these models create a linking function between the Poisson count model which estimates the zero inflation, or legitimacy of the zeros, and links this to the Poisson estimation. The equations below represent this testing process,

(*2.14*) $$E\{d_{ij}(y_i)-p_{ij}(w_i,\theta)\}=0$$

(*2.15*) $$E\{d_i(y_i)-p_i(w_i,\theta)\}\neq 0$$

where these determine whether a ZIP model is needed to loosen this assumption and correct for the number of zeros in the data or if one must take additional steps and estimate a ZINB model. The ZINB model is most reasonable if the Chi Square test is statistically significant. After testing these models, we fail to reject the hypothesis that the models are statistically equivalent but in the ZIP test we reject the hypothesis for no zero inflation, so a ZIP model will be modeled to correct for the zeros, given no presence of overdispersion.

Results and Discussion

Mean Comparisons

In order to understand the effects of program participation, first there should be an understanding of any changes or trends in meat consumption in the general population to understand how possible selection bias in these general populations may affect the results. A comparison of the 2017 general population (Group A) means to the 2018 general population (Group C) means are calculated to determine how the general populations differ in their levels of meat consumption, income levels, and other factors. Summary information for select questions are presented in Table 2.1 (more survey summaries in Chapter 1). In these comparisons, the only variable that does not show a statistically difference in mean is the number of times meat was consumed last week. However, for all other variables there is at least 90% confidence that there is a statistical difference between all explanatory variables from 2017 to 2018, or that the difference is statistically different from zero. While the number of times meat was eaten in the week before being surveyed was not statically significant, an increase in the average (0.039 to 0.068) is observed for meat consumed within a day of being surveyed. This difference indicates that there could be changes in meat consumption throughout the study area, not just among program participants due to Rwandan nutrition programming. Alternately, this could reflect sampling differences between the 2017 and 2018 general population surveyed which would imply that the sampling biases should be considered when reviewing estimated models for all factors. Because there are no significant differences in

means from 2017 to 2018 the variable of interest, meat consumed last week, shows no sampling bias.

Difference-in-Difference Modeling

Table 2.2 represents the results of the difference-in-difference model where p-values for difference-in-difference estimates are provided to determine statistical significance. For the 2017, the overall difference for the period is -0.015 between the general population and program participants. This would imply that participants ate less meat than the general population, but this difference is not statically significant. The reason for this could be that before the program was truly operational, the general population and program participants were roughly equal in the area of protein consumption. For 2018, the the overall period difference is 0.118. This means that participants were more likely to consume meat in the previous week than the general population. This was significant at the 0.01 or 99% confidence level, which would indicate high statistical difference in meat consumption between the general population and program participants in 2018. The difference-in-difference is estimated to be 0.133 and is significant at the 0.05 or 95% confidence level, indicating the difference from 2017 to 2018 in meat consumption among participants (groups B and B2) is greater than the difference in consumption among the general population (groups A and C) for the same two years. The difference-in-difference results show that the program had a statistical effect on the amount of meat consumed for program participants.

Zero Inflated Poisson Model

The purpose of the Zero Inflated Poisson (ZIP) models are to determine significant factors contributing to the likelihood of a person to consume meat. Table 2.3 represents the results for 2017 and 2018 ZIP models. Parameter estimates indicate how explanatory variables relate to the number of times a person consumed meat last week. While the direction of the log differences provides some insights, the Incidence Rate Ratio (IRR) allows for a better understanding of the rate at which the factors change the likelihood of meat consumption. The IRR is calculated by exponentiating the ZIP regression parameter estimates. These IRRs are interpreted as the rate at which an event will occur, in this case a person consuming meat, given a unit change in the explanatory variable.

For the 2017 model all but chicken ownership (not including program broilers) was significant. Conversely, in the 2018 model only education level, household agricultural workforce and average monthly income significantly affected meat consumption. The log difference of a female's meat consumption is 0.33 less or a factor of 0.72 of a male's meat consumption in 2017 and the is not significant in 2018. This difference might indicate change in food preference or access across Rwanda or a difference in sample selection in the general population surveys.

Education level's parameter estimate indicates that a person whose education level is at or above completion of secondary school, the log difference of their meat consumption is higher by a factor of 3.38 in 2017 and 1.45 in 2018 compared to those that did not complete secondary school both statistically significant $p < 0.01$ and $p < 0.05$ respectively. The positive effect is lower in 2018, but the effect of increasing education on meat consumption remains positive. This could be a result of increased nutritional

knowledge or a result of increased disposable income which could provide access to meat.

Related to education, if a member of a household is employed in agriculture, that respondent's log difference in meat consumption compared to non-agricultural employees is 0.42 lower in 2017 and 0.28 lower in 2018 than households not working in agriculture. Considering the IRR, agricultural workers consume 35% less meat than those not employed in agriculture in 2017 and 24% less in 2018. The survey does not allow for further inquisition as to whether this is access, profit, or nutritional education driven. Average monthly income is another variable shown to have significant ($p<0.01$) but small effect on meat consumption directly in both years. These small factors may reflect the scale of income in the model. When scaling average monthly income to 10,000 RWF, the IRR for 2017 is still 1 but for 2018 it becomes 1.03 which means that as income changes by 10,000 RWF per month, meat consumption increases by a factor of 1.03. This could reflect the relative expense and access of meat protein or may reflect the preferences of participants. School aged child increase meat consumption 0.12 in 2017 but is insignificant in 2018, which are most likely to reflect sampling differences rather than a change in meat consumption in households with school aged children.

Lastly, program participation in 2017, which represents the baseline values for participants, show the logged count of meat consumed by participants was 1.65 less in 2017 and significant at the 0.01 level. This indicates participants have a statistically significant lower rate by a factor of 0.19 in 2017. This result isn't surprising considering the selection of participants was aimed at low income household which may or may not have been consuming meat protein. The effects of program participation in in 2018 was

insignificant in 2018, meaning participants consumed statistically similar counts of meat as the general population. The reduction in the disparity between participants and the general population is a positive result as it indicates the effect of the program has reduced meat consumption disparity. These results are consistent with program selection aimed at low income household, not necessarily consuming meat due to income and/or access prior to enrolling.

Conclusions

Through survey implements and statistical analysis, it is possible to determine whether the TI Rwanda Program has accomplished its aims of increasing protein access by seeing if the program participants' meat consumption has been impacted. Background information surrounding projects such as TI Rwanda in other nations determines ever-growing importance placed on animal sourced protein. Results from a difference-in-difference analysis and Zero Inflated Poisson regressions indicate that while the effects on the levels of meat consumption of program participants are still negative, they are becoming less negative with time as the program grows and develops after accounting for general population trends. This reduction in difference between participants and general population indicates the program has increased meat consumption for program participation. This would indicate that the program is aiding its participants in catching up across time with the general population in terms of meat consumption. Results indicate that across both years completing secondary school and increased income contribute to increased meat consumption. While some of the factor's differences could also be contributed to sampling differences across the two survey years, there is evidence that the program has been effective in its mission to impact low income, rural producers.

CHAPTER III

Asset Acquisition Analysis During the Tworore Inkoko Rwanda Program

Introduction

One of the aims of the Tworore Inkoko, Twunguke (TI) program is to increase income for participants. Increased income can be used to improve participant livelihoods. This income provides access to purchase foods and can also be used to purchase a variety of goods including agricultural inputs, household necessities, and entertainment. Access to food and improving dietary outcomes are important, but little is understood about what types of goods participants purchase as a result of increased income. The TI program annual survey of participants includes questions regarding purchases of goods as a result of program participation. Using these recorded purchases, an analysis of the types of goods being purchased and the factors contributing to these purchases can be estimated

This research focuses on six groups of goods purchased. These groups are farming tools, household tools, transportation, entertainment/lifestyle, animals and livestock, and property. A purchase from any of these groups would likely require an increase in income, indicating potential improvement in lifestyle resulting from program participation, assuming no other income generation has occurred.

Background

In order to understand household purchases resulting from increased income, it is important to understand changes in household income streams. There are multiple ways a smallholder farm can increase their income or improve their livelihood. One could consider learning new trades. The household could also increase their education level. While all of these avenues remain valid, much is still unknown about the effects increased income can have on the farmer's overall lifestyle or assets purchased.

One factor that has been observed to cause increases in farmer well-being is working off or outside of the farm. El-Ostra, Mishra, and Morehart (2007) determined how various factors such as farmer education level, spouse education level, age/demographics, program participation, and off-farm work choices affected a farm's level of prosperity. Results for off-farm income or work determined that when a farmer worked off farm, there was a positive impact on overall farm welfare (El-Osta et al., 2007).

Similarly, Oyinbo and Olaleye (2016) used tobit regressions and poverty models to determine if livelihood diversification has positive impacts on farm welfare in Nigeria. Their analysis found a positive relationship between livelihood diversification and poverty reduction. That is, if a farmer works other jobs in addition to their duties at the farm, their welfare rises, and their household is less likely to be below or at the poverty line (Oyinbo & Olaleye, 2016). This study also emphasizes the importance of training programs in terms of income diversification and improvements. The TI program aims to do both, though creating an additional income stream through small-scale broiler production with supplemental training and support.

Manyumwa et al. (2018) suggests access to programs such as community cash, savings programs, or training can affect purchasing power or access to various levels of assets. One benefit of these types of programs is that they provide access to or increases in multiple types of capital (e.g., human or natural) as opposed to only one or limited amounts of capital. This can aid farmers becoming more productive and more profitable than they would otherwise be.

Lastly, empowering women to engage in agribusiness may also lead to increased income and potentially household welfare in Rwanda. A study of rural households in Guatemala by Katz (1995) determined that including women in farming and other male dominated activities involves a shift in duties among household members. Shifting some agricultural duties allows more household members to be involved in the decision making process and income generation, thus increasing overall welfare (Katz, 1995). While there are cultural differences to consider in terms of household dynamics that may differ by region, this might indicate a positive relationship between women participants and improved overall household welfare.

Effects of Increased Income on Livelihoods

There are several effects that increased income can have on overall livelihoods. Smallholder farmers can be uniquely impacted by using increased income to improve nutrition or access to goods. Nutritional intake and profiles overall can be impacted by increased income. A study concerning rural smallholder farmers by Ogutu, Godecke, and Qaim (2019) estimated the effects of commercialization of small-scale agriculture and increased income on food and nutritional intake using various methods to examine nutrient levels and compared own-grown food to purchased foods. They found that commercialization of smallholder farms increased income and had a significant impact on nutritional intake from purchased foods, while it did not decrease the nutritional intake from home-grown food (Ogutu et al., 2019). The results from these papers imply that there are differences in the types and access to food that are important when considering how changes in income may affect nutrition and spending.

In terms of spending increased income beyond food, Lambert et al. (2009) determined that farm spending, including smallholder farm spending, creates significant economic activity and can be encouraged by increased income and support payments (Lambert et al. 2009). These results suggest through multiplier effects the TI program could potentially achieve ancillary benefits for people not in the program. For example, if a TI producer's income increases which leads to increased spending and participation in their local economies this may provide multiplicative effects on the greater economy.

While it is known that increased income improves every day life, the literature is limited on what specific foods or products are purchased in order to induce these changes. Much of the literature on increased income is concerned with changes in purchasing behavior related to food and farm investments. Leki et al. (2016) examined rural corn farms in Indonesia, and the effect of development policies on increasing income and subsequent consumption changes locally. The various analyses pointed toward an increase in food consumption and income, but not to increased asset ownership or household goods purchased outside of food (Leki et al., 2016). These researchers suggest that a policy that increases the scale of farming may be a more effective strategy (Leki et al., 2016).

As previously stated, most of the literature highlights the impact of increased income in smallholder households upon food purchasing. While nutrition is considered important and a primary goal of the TI program, positive externalities outside of diet should not be discounted. If purchases of home goods and farm tools can improve farm productivity and livelihoods, this may also work toward achieving ancillary benefits from the program.

Conceptual Framework

Utility maximization stipulates that consumers will purchase those goods that maximize their level of utility based on their budget constraint. In this case, Rwandans will purchase goods from product groups that fall within their budget and meet their needs in some capacity. This concept is represented below.

(*3.1)* $$Total\ Utility = \sum_{i=1}^{K} \left(\frac{MUi}{Pi}\right)$$

$$S.T.: Income = \sum PiQi$$

where MU_i represents the marginal utility gained from product groups one through K, P_i represents the relative prices in product groups (*i*), and Q_i represents the quantity of good is purchased from *i*-th product groups. It is important to address the factors influencing an individual's marginal utility. These factors are represented below,

(*3.2*) $$MU_{Products\ Purchased} = f(Y, \lambda, P_i)$$

where Y represents an individual's income, λ represents an individual's matrix of preferences, and P_i represents the prices in group *i*. In other words, whether an individual will purchase from the given group is a function of their income, preferences, and the goods' prices. Equation 17 represents maximizing the sum of marginal utilities gained from purchasing from groups *i* given relative prices, where factors from equation 3.2 are considered as part of the maximization process.

Hypotheses

The purpose of this analysis is to determine the household factors that contribute to purchases made by TI program participants in several purchase groups. In this instance,

the null hypothesis (H_o) is that there is no statistically significant heterogeneity between participants who purchase from the studied product groups. The alternative hypothesis (H_a) is that there are heterogeneous factors contributing to purchase decisions.

Data

The annual survey for the TI program (see Chapter 1 for more details) provides a list of 34 items in order to understand Rwandans' asset purchasing behavior. These acquisitions range from farming implements like a shovel all the way to purchasing a home or more land. TI program participants were specifically asked if they purchased items as a result of their participation in the program. The purchase of items such as farming tools may provide opportunities for increased production efficiencies. For the purposes of this analysis, only Group B2 (see description of groups in Chapter 1) were considered, which are the 2018 program participants who had completed at least two broiler production cycles.

The 2018 annual self-reported effects of program participation are the focus of this study with a total of 155 responses indicating program participation. In order to better understand purchasing behavior, the 34 individual goods are aggregated into groups of like items. The *Farm Goods* group consists of goods and implements that would be used on farm: hoe, shovel, rake, spade, hatchet/axe, saw, pick, wheelbarrow, and plough. The *Home Goods* group accounts for goods used in the home for food or fiber: a grinding mill, oil press, sewing machine, or clothing iron. The *Transportation* group deals with purchases of modes of transportation: bicycle, motorbike, car, van, or fishing boat/canoe. The *Lifestyle* group includes goods that are used for connection,

entertainment, or comfort: television, tape/CD player, mobile phone, radio, living room suite, fancy living room suite, and bed. The *Livestock* group pertains to the purchase of: cattle, goats, poultry, rabbits, sheep, pigs, and other livestock. Purchases of land or a house would fall into the category of *Essentials*. The final catch-all group *Other* accounts for the sizeable number of purchases labeled as other.

Methods

To determine the changes in income and subsequent purchases, econometric models will be used. Probit models offer marginal effect measurements that determine the effect various factors have on the likelihood of the dependent variable having a favorable or unfavorable outcome. In this case, the favorable outcome would be the purchase of any of a series of goods. The outcomes can be determined by first categorizing items into the mentioned groups and determining from which product groups program participants purchased. By understanding the changes in purchase behavior as a result of income changes, insight is provided into the livelihoods of Rwandans and how program participation has contributed to household assets.

As stated, Probit modeling is used to estimate the effects of independent variables on a dichotomous choice dependent variable, i.e. the dependent variable will have a value of 0 or 1. For this analysis probit modeling will estimate the factors that impact the likelihood for a survey participant purchased from one of the specified groups. A value of 1 would indicate that a purchase was made from the group and 0 otherwise. The general format for Probit model applied to this analysis is represented as:

(*3.3*) $$Pr(Y=1)=\phi(x\beta)$$

Where Y represents the dichotomous choice dependent variables with potential responses of zero (no purchase from group) or one (purchase from group), the x correspond to variables such as age, income, education level, or diet and their corresponding influence on the likelihood of purchase from the product group in question, and β are the estimated parameters. Using this methodology, the effects of survey respondent's sex, education level, work in agriculture, income, and number of children these factors on purchases from the *Farm Goods*, *Lifestyle*, *Livestock*, *Essentials*, and *Other* groups can be determined.

Results

Figure 3.1 represents an overview of how many purchases occurred within each group that were reported as a direct result of participation in the TI program. These were recorded with a value of 1 if a purchase was made from the group and a value of 0 otherwise. As shown, out of all responses from 155 usable responses, 22 responses were recorded for the *Farm Goods* group, which is 15% of the total responses. *Lifestyle* items received a total of 50 responses, or 34% of total purchase responses. *Livestock* received 21% of total responses with 32 purchase decisions. *Essential* items received 1.29% of the total purchases with 2 purchases. The remaining 25% of purchases fell under the *Other* category with 40 purchases. *Home Goods* and *Transportation* both received no responses and will be excluded from the analysis. This is not to say that no purchases were made from these groups, merely that those purchases were not reported to be result of program participation.

All results are presented in Table 3.1 for the five purchase group models. Parameter estimates in the case of Probit models provide information about the direction

(positive or negative) of the relationships between explanatory and dependent variables, but do not represent the marginal values. Marginal effects provide the numerical change in the value of the dependent variable given a change in an independent variable. Both are presented and discussed.

For the *Farm Goods*, *Livestock,* and *Essentials* models, there were no significant effects from any of the explanatory variables. The homogeneity of effects implies that these product groups were purchased similarly across male and female participants, for all education levels, across income levels, and for all household sizes. There are parameter estimates for each variable but because they are insignificant at the 0.1 level we cannot reject the null hypothesis that these are not zero.

For *Lifestyle* goods, all variables but education level are insignificant. Based on parameter estimates, an individual who completed secondary school or higher negatively impacted their lifestyle purchases. The marginal effects show that higher education is shown to decrease one's likelihood of purchasing lifestyle items by a factor of 0.14 and was statistically impactful at the $p < 0.1$ level. This could potentially indicate that a more educated individual may seek other forms of employment which may reduce the importance of farm implements. Conversely, this would mean that those with less than a secondary education are more likely to purchase a lifestyle good. These goods are used for connection, entertainment, or comfort such as television, mobile phone, or fancy living room suite. These purchases reflect the program participants purchases as a result of the program. The participants with less than a secondary education level may have not had access to disposable income in order to purchase lifestyle items for their households.

Similar to *Lifestyles*, *Essentials* purchase factors were predominantly insignificant. The only significant ($p < 0.01$) factor contributing to heterogeneity of purchase behavior in program participants in 2018 was the number of school aged children living in the home. A participant having children in a home is shown to be negatively related to the purchase of essential items. While this may initially sound counterintuitive, it could be due to the fact that other items were needed more the time of purchase. The marginal effects for essential purchases directly echo the parameter estimates. School aged children are shown to reduce the likelihood of purchasing an essential good by a factor of 0.02. This could be due to the need to pay school fees or buy food items not in the *Essential* category as children can shift the needs of a household. Very few, 1.29%, of participants purchased essential item (land or a house). These large purchases would require a household capital investment. School age children who may need tuition, clothes, or supplies may put more demand on the household budget that would preclude them from purchasing these large items.

Other goods continues the pattern and very few variables explain the purchasing behavior of TI Rwanda participants. In this case sex and income significantly impact asset purchases at the 0.1 and 0.05 level respectively. The parameter estimate indicates that female TI program participants have a positive relationship with purchases from this category, making them more likely to purchase more from it. Marginal effects show that female program participants are more likely to purchase from the *Other* group by factors of 0.13. These significant results mean that spending decisions by female participants differ than spending decisions by male participants. The *Other* group is comprised of goods the survey did not ask about such as food, tuition, and seeds. Even though it is

unknown what these goods are, it is shown that female participants are more likely to purchase something not on the list surveyed than their male counterparts. Average monthly income also has a significant effect on purchases, and it had a marginal effect of 0.00. This implies that as average monthly household income increased, participants were purchasing items not listed. Inversely, this would mean that those with lower incomes were more likely to purchase from one of the other groups if they purchased as a result of program participation.

Conclusions

Purchasing power and behavior, while not the explicit target of the TI program, are important externalities to consider in the examination of the project. Purchases for existing farm work to expand the business, items to improve daily life, new livestock to increase income or food prospects, and essential items are all possible uses of increased purchasing power brought about by the program. Background information related to this subject indicates that diversifying one's employment, working multiple jobs, is also a key way to increase income. Another method to increase one's purchasing power is involving more household members or a spouse in the farming business.

One limitation in the research surrounding the TI program is what citizens may do with their increased income. Background information on this would suggest farm investments could be an investment opportunity for this income. Econometric analysis of program participant outcomes indicate that the TI program has had an effect on purchases of all of the product groups, with the exception of home goods and transportation. The models also indicate that there is no single variable deemed to be statistically significant to all purchase groups.

CONCLUSION

The TI program has two primary goals for its participants, improving nutrition through the consumption of meat protein and increasing income. Annual surveys offer respondents to tell how they make their livelihood, what that livelihood has afforded them, and how they have or have not participated in the program. It also allows for essential follow-through maintenance on the program. General survey summaries indicate that basic human comforts such as running water and electricity are seeing increases across the program's duration, as well as meat consumption among TI Program participants.

Factors proven to be significant over time that could lead to higher meat consumption levels include average monthly income, education levels, and household agricultural work. In other words, the promotion of activities that increase income or promote agricultural work could show to increase meat consumption. Promoting higher education could conceivably have the same results.

Assets obtained as a result of or during the program's current life are also important to note as it points to any success external to the original goal. Items that saw the largest ownership increases include beds, hatchets/axes, living room suites, and radios. Factors that show to statistically impact asset purchasing include gender and average monthly income.

Overall, there are lessons learned about the program's potential to impact meat consumption and asset acquisition by participants. These lessons aid in future expansion of this TI Rwanda program, as well as implementation of other similar programs throughout Rwanda and Africa.

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APPENDICES

APPENDIX A: TABLES AND FIGURES

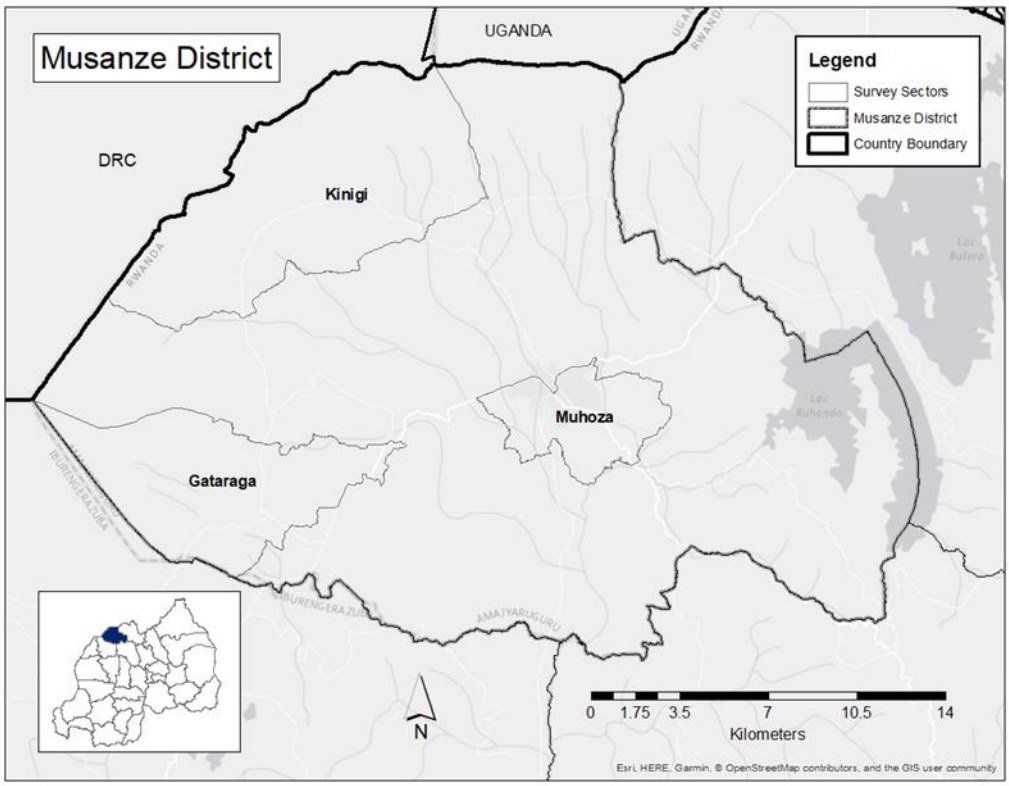
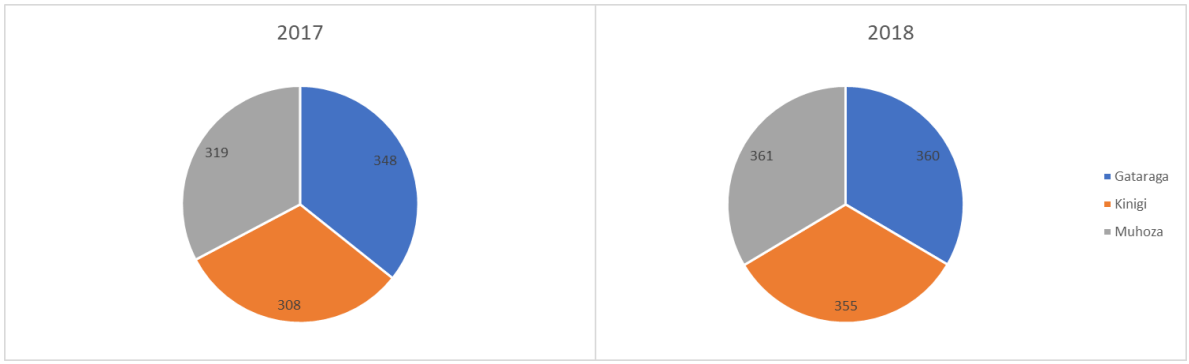
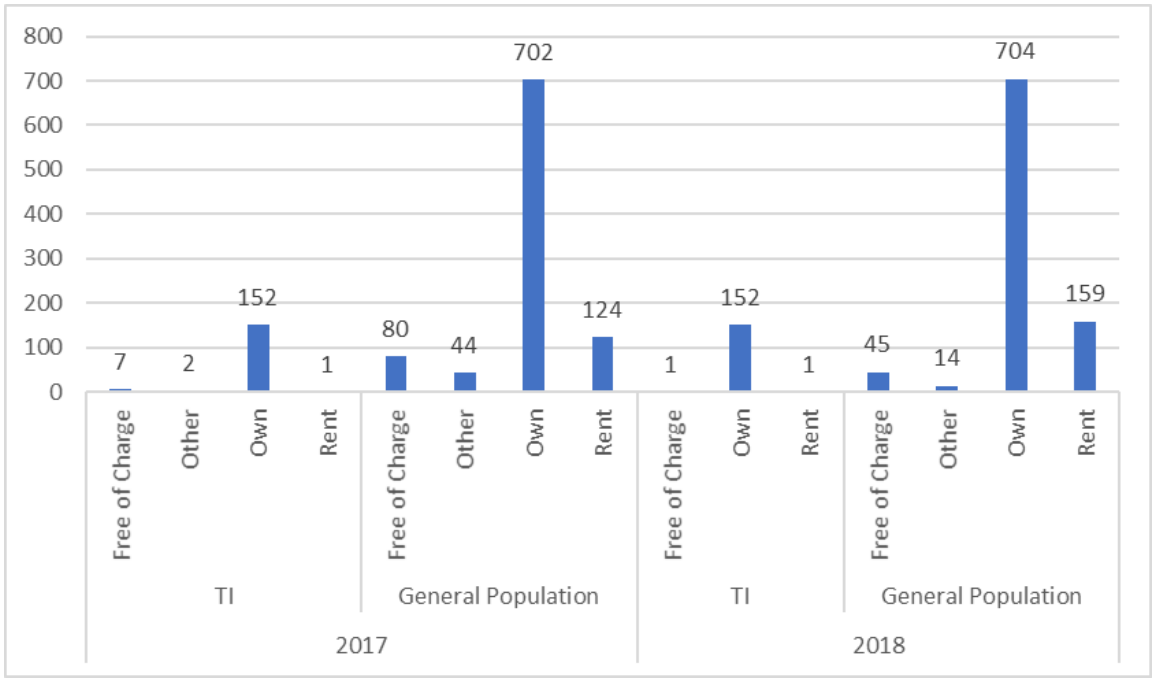


Figure 1.1: Rwanda Sector Map



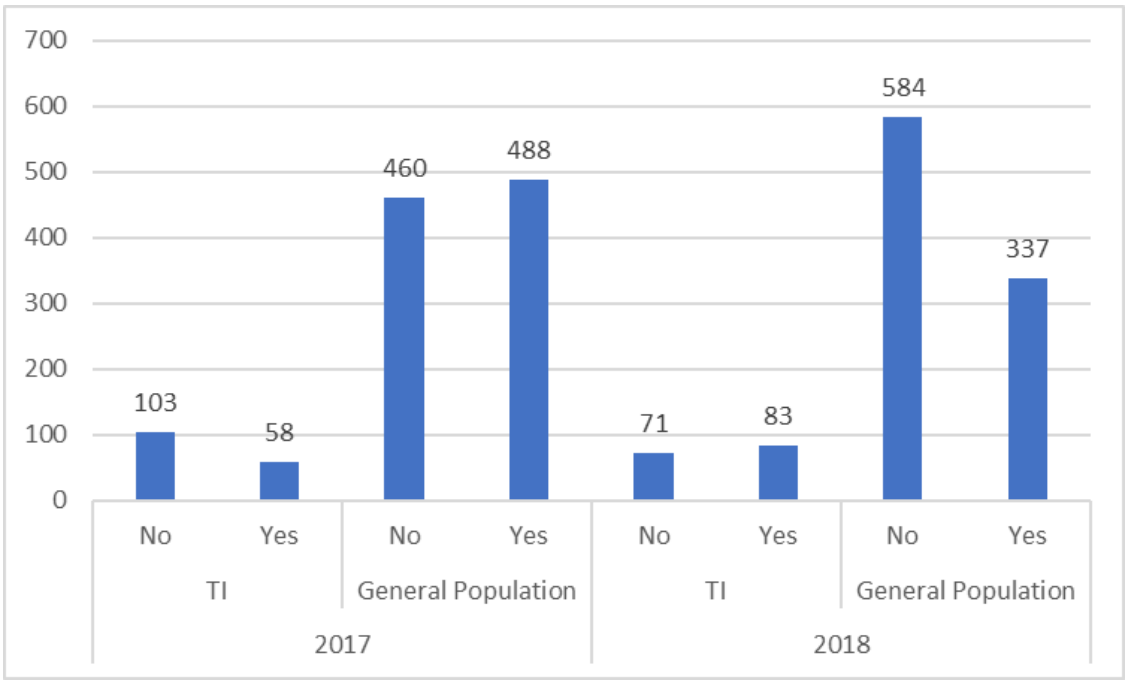
Note: n_{2017}=951 and n_{2018}=1,077
TI farmers dropped from 2017

Figure 1.2: Survey Distribution Across Sectors 2017 and 2018



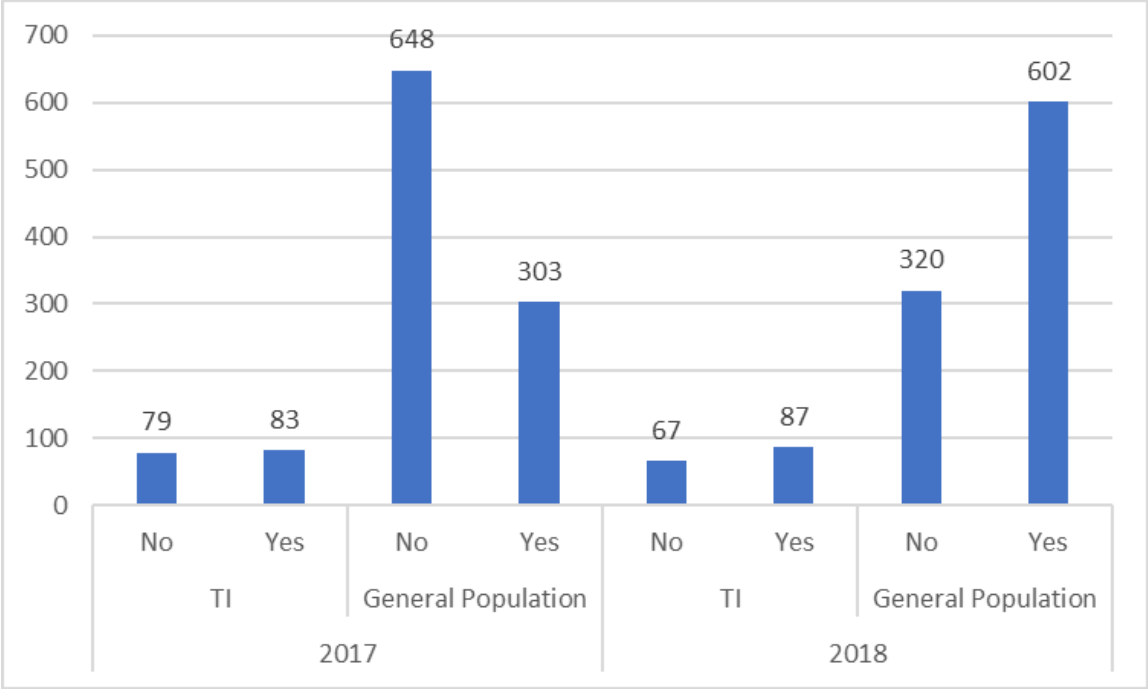
Note: n_{2017}=1,113 and n_{2018}=1,077
N includes blank observations

Figure 1.3: Home Interest 2017 and 2018



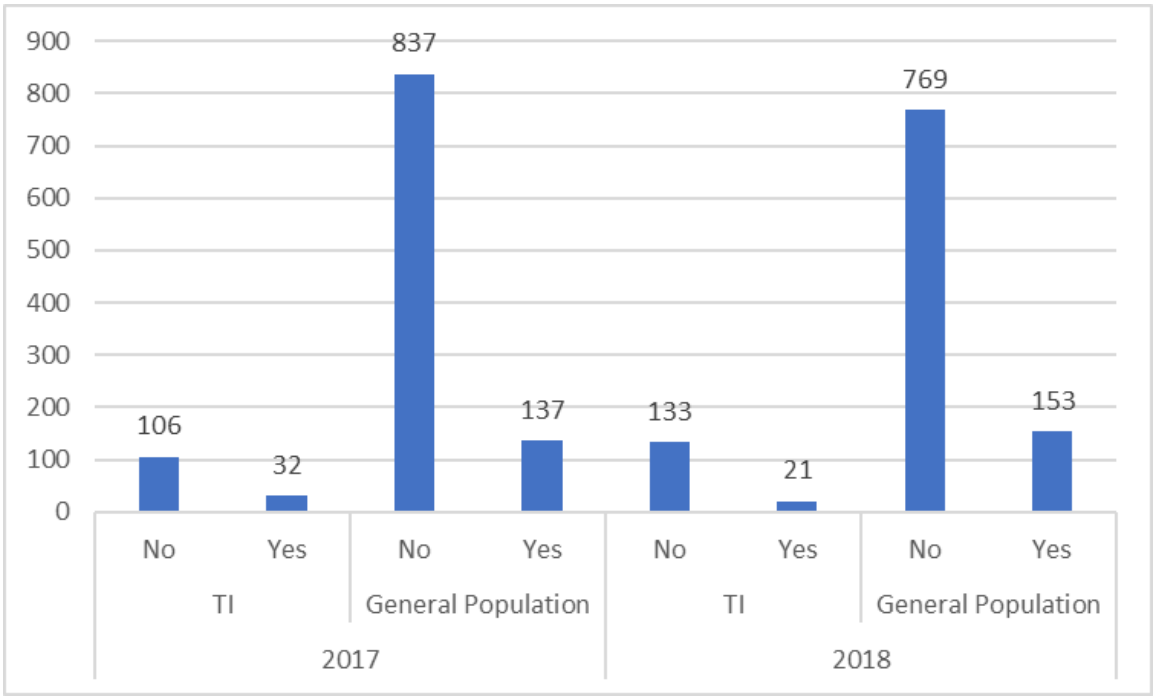
Note: n_{2017}=1,113 and n_{2018}=1,077
N includes blank observations

Figure 1.4: Land Ownership 2017 and 2018



Note: n_{2017}=1,113 and n_{2018}=1,077
N includes blank observations

Figure 1.5: In-Home Electricity Access 2017 and 2018



Note: n_{2017}=1,113 and n_{2018}=1,077
N includes blank observations

Figure 1.6: In-Home Running Water Access 2017 and 2018

Table 1.1: Season Distribution 2017 and 2018

		2017(n=1,113)		*2018(n=1,077)*	
		TI	*Non-TI*	*TI*	*Non-TI*
Season	*Months*	*Count*		*Count*	
First Dry Season	*December-March*	63	0	0	0
First Rainy Season	*April-May*	24	1	0	0
Second Dry Season	*June-October*	66	950	155	922
Second Rainy Season	*November*	9	0	0	0
Totals		162	951	155	922

Table 1.2: Select Summary Statistics and Mean Comparison for the 2017 General Population Rwandan Household Survey and the 2017 Baseline TI Participant Surveys

		2017				
		TI Participants		General Population		Mean Difference
Variable	Units	Obs.	Mean	Obs.	Mean	
Average Monthly Income	Rwandan Francs	154	23,442	793	36,616	***
Sex	0, Male or 1, Female	162	0.463	951	0.566	***
Education Level: Completed Secondary School	1 if completed secondary school, 0 otherwise	162	0.311	951	0.2	***
School Aged Children	Count of school aged children	162	1.94	899	1.186	***
Household Work in Agriculture	1 if yes, 0 otherwise	124	1	951	0.598	***
Meat Consumption: Yesterday	1 if yes, 0 otherwise	162	0.018	906	0.039	***
Meat Consumption: Last Week	Count of times meat consumed	162	0.037	906	0.167	***
Meat Consumption: Last Month	1 if yes, 0 otherwise	161	0.13	951	0.146	***
Purchased Meat: Last Week	1 if yes, 0 otherwise	162	0.024	903	0.093	***
Increased Income	1 if yes, 0 otherwise	154	0.038	897	0.134	***

Note: ***, **, * indicates significance at 0.01, 0.05, and 0.1 level respectively.

Table 2.1: Select Summary Statistics from Rwandan General Population Household Survey for 2017 and 2018

		2017		2018		
		General Population		General Population		Mean Difference
Variable	Units	Obs.	Mean	Obs.	Mean	
Average Monthly Income	Rwandan Francs	793	36,616	908	28,034	*
Sex	0, Male or 1, Female	951	0.566	922	0.518	**
Education Level: Completed Secondary School	1 if completed secondary school, 0 otherwise	951	0.200	922	0.210	***
School Aged Children	Count of school aged children	899	1.186	850	1.315	*
Household Work in Agriculture	1 if yes, 0 otherwise	951	0.598	922	0.689	***
Meat Consumption: Yesterday	1 if yes, 0 otherwise	906	0.039	922	0.068	***
Meat Consumption: Last Week	Count of times meat consumed	906	0.167	914	0.199	
Meat Consumption: Last Month	1 if yes, 0 otherwise	951	0.146	922	0.121	**
Purchased Meat: Last Week	1 if yes, 0 otherwise	903	0.093	922	0.113	*
Increased Income	1 if yes, 0 otherwise	897	0.134	835	0.107	***

Note: ***, **, * indicates significance at 0.01, 0.05, and 0.1 level respectively.

Table 2.2: Difference-in-Difference Estimation Results for Tworore Inkoko Meat Consumed Lat Week Estimations for 2017 and 2018

	2017 (n=868)	2018 (n=1054)	Difference-in-Difference (Total n=1922)
General Population	-0.001	0.021	
Program Participants	-0.016	0.138	
Difference	-0.015	0.118***	0.133**
P-Value	0.745	0.010	0.030

Note: ***, **, * indicates significance at 0.01, 0.05, and 0.1 level respectively.

Table 2.3: Zero Inflated Poisson Model Results for Meat Consumed Last Week for Years 2017 and 2018

	2017 (n=1,114)			2018 (n=1,077)		
Variable	Parameter Estimate	IRR	Std Error	Parameter Estimate	IRR	Std Error
Sex	-0.33*	0.72	0.19	0.12	1.13	0.18
Chicken Ownership	0.00	0.995	0.00	0.01	1.01	0.01
Education Level: Completed Secondary School	1.22***	3.38	0.29	0.37**	1.45	0.19
HH Work in Ag	-0.42**	0.65	0.22	-0.28*	0.76	0.17
Average Monthly Income	0.00***	1.00	0.00	0.00***	1.00	0.00
School Aged Children	0.12**	1.12	0.06	-0.02	0.98	0.04
TI Farmer	-1.65**	0.19	0.73	-0.26	0.77	0.63

Note: ***, **, * indicates significance at 0.01, 0.05, and 0.1 level respectively.

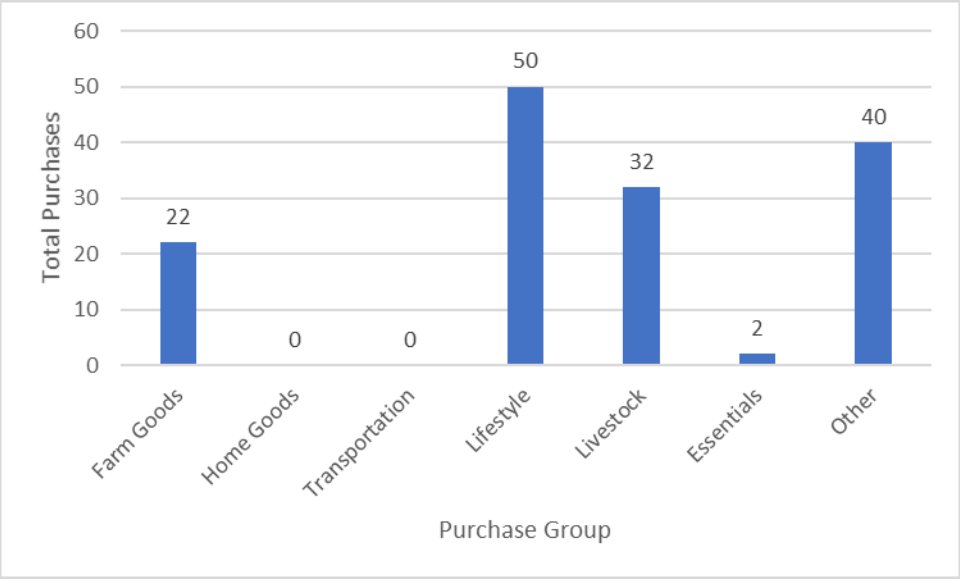


Figure 3.1. Breakdown of Total Purchases

(n=155)

Table 3.1: Probit Analysis of Asset Purchasing as a Result of the TI Rwanda Program

	Farm Goods		Lifestyle Items		Livestock		Essentials		Other Goods	
Variable	Parameter Estimate	Marginal Effect	Parameter Estimate	Marginal Effect	Parameter Estimate	Marginal Effect	Parameter Estimate	Marginal Effect	Parameter Estimate	Marginal Effect
Female	0.19	0.04	0.16	0.05	0.10	0.03	0.20	0.01	0.42	0.13*
	(0.28)	(0.06)	(0.24)	(0.07)	(0.25)	(0.07)	(0.55)	(0.02)	(0.24)	(0.07)
Education Level	-0.38	-0.07	-0.46	-0.14*	0.21	0.06	0.01	0.00	0.02	0.01
	(0.36)	(0.07)	(0.29)	(0.08)	(0.32)	(0.09)	(0.66)	(0.02)	(0.29)	(0.09)
Average Monthly Income	0.00	0.00	0.00	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
School Aged Children	0.00	0.00	-0.01	-0.00	-0.01	-0.00	-0.69	-0.02***	0.03	0.01
	(0.09)	(0.02)	(0.09)	(0.03)	(0.28)	(0.02)	(0.16)	(0.02)	(0.08)	(0.03)
Constant	-1.17		-0.89		-0.89		-1.58		-1.19	
	(0.29)		(0.29)		(0.28)		(0.44)		(0.27)	

Note: ***, **, * indicates significance at 0.01, 0.05, and 0.1 level respectively.; n=155

APPENDIX B: SURVEY

Rwanda TI Program Survey

Section 1-Inforational

Q1. Type of Respondent

1. Survey Test
2. Pilot Farmer
3. Farmer
4. General Public

Q2. Sector

1. Kinigi
2. Gataraga
3. Muhoza

Q3. Cell-Kinigi

1. Kaguba
2. Nyabigoma
3. Bisoke

Q4. Cell-Gataraga

1. Mudakama
2. Rungu
3. Rubindi

Q5. Cell-Muhoza

1. Mpenge
2. Kigome
3. Ruhengeri

Q6. Village Name

Q7. House Number

Q8. Are you the person responsible for making important decisions for your HH?

1. Yes

0. No

Q9. Roll of Respondent

1. Head of Household
2. Spouse of Head of Household

Q10. First Name

Q11. Sex

1. Female
0. Male

Q12. Year Born

Q13. Marital Status

1. Never Married
2. Married
3. Civil Marriage/Companionship
4. Seperated
5. Widowed
6. Divorced

Section 2- ANSWER THE FOLLOWING FOR EACH HOUSEHOLD MEMBER

Person 1

Q14. Sex

1. Female
0. Male

Q15. Age

Q16. Relationship to Head of Household

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Extended Family

6. Domestic Employee

Person 2

Q17. Sex

1. Female
0. Male

Q18. Age

Q19. Relationship to Head of Household

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Extended Family
6. Domestic Employee

Person 3

Q20. Sex

1. Female
0. Male

Q21. Age

Q22. Relationship to Head of Household

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Extended Family
6. Domestic Employee

Person 4

Q23. Sex

1. Female

0. Male

Q24. Age

Q25. Relationship to Head of Household

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Extended Family
6. Domestic Employee

Person 5

Q26. Sex

1. Female
0. Male

Q27. Age

Q28. Relationship to Head of Household

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Extended Family
6. Domestic Employee

Person 6

Q29. Sex

1. Female
0. Male

Q30. Age

Q31. Relationship to Head of Household

1. Head of Household

2. Spouse of Head of Household

3. Child

4. Parent

5. Extended Family

6. Domestic Employee

Person 7

Q32. Sex

1. Female

0. Male

Q33. Age

Q34. Relationship to Head of Household

1. Head of Household

2. Spouse of Head of Household

3. Child

4. Parent

5. Extended Family

6. Domestic Employee

Section 3-Household Information

Q35. Highest Level of School Completed by Anyone in the House

1. None

2. Some Primary

3. Completed Primary (Grades 1-6)

4. Vocational School

5. Some Secondary

6. Completed Secondary (Grades 7-12)

7. Some University

8. Completed University

9.Graduate School

Q36. Does anyone in your household work in the agriculture sector?

1. Yes
0. No

Q37. Who works in Ag?

1. Head of Household
2. Spouse of Head of Household
3. Child
4. Parent
5. Other

Q38. What type of Ag?

1. Plants
2. Animals
3. Both

Q39. What is their employment status in Ag?

1. Employer
2. Employee
3. Self-employed
4. Producers co-op Member
5. Domestic Use Only
6. Other

Q40. Who is the main food preparer in your home?

1. Respondent
2. Other

Q41. Did the main food preparer join the survey?

1. Yes
0. No

Q42. Was yesterday a normal eating day?

1. Yes

0. No

Section 4-Food Group Questions

Cereals, Grains, Roots and Tubers Food Group

Q43. Did your family each anything from this group yesterday?

1. Yes

0. No

Q44. How many times did your household eat from this group last week?

Q45. Were any items from this group purchased last week?

1. Yes

0. No

Q46. How many francs were spent on this group last week?

Q47. Notes on group

Legumes Food Group

Q48. Did your family each anything from this group yesterday?

1. Yes

0. No

Q49. How many times did your household eat from this group last week?

Q50. Were any items from this group purchased last week?

1. Yes

0. No

Q51. How many francs were spent on this group last week?

Q52. Notes on group

Nuts and Seeds Food Group

Q53. Did your family each anything from this group yesterday?

1. Yes

0. No

Q54. How many times did your household eat from this group last week?

Q55. Were any items from this group purchased last week?

1. Yes

0. No

Q56. How many francs were spent on this group last week?

Q57. Notes on group

Orange Vegetables and Fruits Food Group

Q58. Did your family each anything from this group yesterday?

1. Yes

0. No

Q59. How many times did your household eat from this group last week?

Q60. Were any items from this group purchased last week?

1. Yes

0. No

Q61. How many francs were spent on this group last week?

Q62. Notes on group

Green Leafy Vegetables Food Group

Q63. Did your family each anything from this group yesterday?

1. Yes

0. No

Q64. How many times did your household eat from this group last week?

Q65. Were any items from this group purchased last week?

1. Yes

0. No

Q66. How many francs were spent on this group last week?

Q67. Notes on group

Other Vegetables Food Group

Q68. Did your family each anything from this group yesterday?

1. Yes

0. No

Q69. How many times did your household eat from this group last week?

Q70. Were any items from this group purchased last week?

1. Yes

0. No

Q71. How many francs were spent on this group last week?

Q72. Notes on group

Other Fruits Food Group

Q73. Did your family each anything from this group yesterday?

1. Yes

0. No

Q74. How many times did your household eat from this group last week?

Q75. Were any items from this group purchased last week?

1. Yes

0. No

Q76. How many francs were spent on this group last week?

Q77. Notes on group

Meat Food Group

Q78. Did your family each anything from this group yesterday?

1. Yes

0. No

Q79. How many times did your household eat from this group last week?

Q80. Were any items from this group purchased last week?

1. Yes

0. No

Q81. How many francs were spent on this group last week?

Q82. Notes on group

Eggs Food Group

Q83. Did your family each anything from this group yesterday?

1. Yes

0. No

Q84. How many times did your household eat from this group last week?

Q85. Were any items from this group purchased last week?

1. Yes

0. No

Q86. How many francs were spent on this group last week?

Q87. Notes on group

Milk and Other Dairy Food Group

Q88. Did your family each anything from this group yesterday?

1. Yes

0. No

Q89. How many times did your household eat from this group last week?

Q90. Were any items from this group purchased last week?

1. Yes

0. No

Q91. How many francs were spent on this group last week?

Q92. Notes on group

Sugar Food Group

Q93. Did your family each anything from this group yesterday?

1. Yes

0. No

Q94. How many times did your household eat from this group last week?

Q95. Were any items from this group purchased last week?

1. Yes

0. No

Q96. How many francs were spent on this group last week?

Q97. Notes on group

Section 5-Other Eating Information

Q98. What are the top three ways your household obtains the food it eats? (Label 1 as most common, 2 as middle, 3 as least common)

-Own Production

-Gathering/Hunting/Fishing

-Exchange Labor

-Purchase from Market on Credit

-Purchase from Market with Cash

-Supermarket

-Purchase from a Vendor

-Gift

-Trade/Share/Barter

-Food Aid

-Don't Know/Unsure

Q99. On an average day what meals does your family typically eat?

1. Breakfast

2. Lunch

3. Supper

4.Other

Q100. In the last 30 days, did your household eat meat in your home?

1. Yes

0. No

Q101a. What kind of meat was eaten?

-Cow

-Pig

-Goat

-Poultry

-Rabbit

-Fish

-Sheep

-Game Meat

-Other

Q101b. How was it prepared?

-Boiled/Fried/Grilled

-Cooked with Cassava Leaves

-Sambousa/Samossa

-Mixture

-In a Soup

-Other

Q102. In the last 30 days, did anyone in your household purchase meat for your household?

1. Yes

0. No

9. We do not eat meat for religious/other reasons

Q103. What types of meat were purchased?

1. Cow

2. Pig

3. Goat

4. Poultry

5. Rabbit

6. Fish

7. Sheep

8. Game Meat

9. Other

Q104. When was the last time your household ate chicken in your home?

1. Within the last 7 days

2. Within the last 30 days

3. Within the last 6 months

4. Within the last year

5. Longer than a year ago

6. Never

9. Family does not like or want to eat chicken

Q105. How many times did your family eat chicken in your home in the last month?

Section 6-Monetary and Purchase/Asset Information

Q106. In the last 12 months because of a lack of money or other resources, was there a time when:

(Answer 1 if yes, 0 otherwise)

-You or others in your household were worried about not having enough food to eat?

-You or others in your household were unable to eat healthy and nutritious food?

-You or others in your household ate only a few kinds of foods?

-You or others in your household had to skip a meal?

-You or others in your household ate less than you thought you should?

-Your household did not have food?

-You or others in your household were hungry but did not eat?

-You or others in your household went without eating for a whole day?

Q107. In an average month, how much money does your household make?

Q108. Which family member makes decisions about the use of the money for food purchases in your home?

1. Male Head of Household

2. Female Head of Household

3. Spouse of Head of Household

4. Mutually

5. Eldest Son

6. Eldest Daughter

7. Other

Q109. Which family member makes decisions about the type of food to purchase for your home?

1. Male Head of Household

2. Female Head of Household

3. Spouse of Head of Household

4. Mutually

5. Eldest Son

6. Eldest Daughter

7. Other

Q110. Over the past year, has your income increased?

1. Yes

0. No

2. Not Sure

Q111. How many people in your household have income outside the home?

Q112. What class of Ubedehe are you?

1. 1

2. 2

3. 3

4.4

Q113. Were you able to pay for the school fees of all the children in your home of school age this year? (for the last 2 terms Jan-Mar, and May-Jun)

1. Yes

0. No

99. N/A

Q114. What was the total amount you spent on school fees?

Q115. How many kids attended school that live in your home?

Q116. Which of the following describes your interest in your home?

1. Own (99 year lease)

2. Renter

3. Free of Charge (not owner)

4. Other

Q117. Do you own land?

1. Yes

0. No

Q118. Do you have electricity in your home?

1. Yes

0. No

Q119. Do you have running water in your home?

1. Yes

0. No

Q120. I am going to read you a list of things, tell me if you own any of them.

1. Hoe

2. Shovel

3. Rake

4. Spade

5. Hatchet/Axe

6. Saw

7. Pick

8. Wheelbarrow

9. Plough

10. Grinding Mill

11. Oil Press

12. Sewing Machine

13. Clothing Iron

14. Bicycle

15. Motorbike

16. Car

17. Van

18. Fishing Boat/Canoe

19. TV

20. Tape/CD Player

21. Mobile Phone

22. Radio

23. Living Room Suite

24. Fancy Living Room Suite

25. Bed

26. Cattle

27. Goats

28. Poultry

29. Rabbits

30. Sheep

31. Pigs

32. Other Livestock

33. Other

Q121. How many chickens do you own currently?

Q122. Is the main purpose of your chicken for meat or eggs?

1. Meat

2. Eggs

99. N/A

Q123. Are you a farmer in the TI program?

1. Yes

0. No

Section 7-TI Farmers ONLY

Q124. How long have you been in the program?

Q125. Have you made money through raising chickens in the TI Program?

Q126. Have you at least harvested twice?

1. Yes

0. No

Q127. Which of the following assets would you say your household was able to acquire as a result of raising chickens over the past year?

1. Hoe
2. Shovel
3. Rake
4. Spade
5. Hatchet/Axe
6. Saw
7. Pick
8. Wheel Barrow
9. Plough
10. Grinding Mill
11. Oil Press
12. Sewing Machine
13. Ironing Machine
14. Bicycle
15. Motorbike
16. Car
17. Van
18. Fishing Boat/Canoe
19. TV
20. Tape/CD Player
21. Mobile Phone
22. Radio
23. Living Room Suite
24. Fancy Living Room Suite
25. Bed
26. Cattle
27. Goats

28. Poultry
29. Rabbits
30. Sheep
31. Pigs
32. Other Livestock
33. Land
34. House
35. Other

VITA

The author was born on August 26, 1996 in New Orleans, Louisiana. She and her family moved to Johnson City, Tennessee on Christmas Eve, 2008. She graduated from Science Hill High School in Johnson City on May 24, 2014 and began her studies at the University of Tennessee, Knoxville College of Agricultural Sciences and Natural Resources (now Herbert College of Agriculture) in August 2014 to major in Natural Resource and Environmental Economics.

While attending the University of Tennessee she pursued a minor in Sustainability and held a position as a student aid in family and consumer science and had an active role in the University of Tennessee Extension programs, including accounting and outreach responsibilities. She also held positions as an intern for a United States congressman and a local, family owned zoo. She also received the Outstanding Undergraduate Award for the Natural Resource and Environmental Economics Major twice. She graduated with her Bachelors of Science degree on May 11, 2018 cum laude and began graduate school at the same university to pursue a degree in Agricultural and Resource Economics with an Agricultural Economics concentration.

While a graduate student she became very active in her work with USAID both in relation to this thesis and in a separate role with the organization's efforts in Liberia. She is also a member of the Southern Agricultural Economics Association and has presented her work at their annual meeting. She currently resides in Knoxville, Tennessee with her fiancé of the past four years.