DETERMINANTS OF SUSTAINABILITY OF COMMUNITY SEED BANKS IN NICARAGUA: A DURATION ANALYSIS APPROACH

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ABSTRACT

DETERMINANTS OF SUSTAINABILITY OF COMMUNITY SEED BANKS IN NICARAGUA: A DURATION ANALYSIS APPROACH

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Access by small holder producers to seeds of improved bean varieties remains a constraint in many parts of the world. In response to this development challenge, this study examines the salient features of the Community Seed Bank (CSB) models implemented in Nicaragua from 2010 to 2014, through support from the Bean Technology Dissemination (BTD) project and analyzes the determinant factors contributing to their sustainability. CSB level data were collected from 154 CSBs through a survey and from project reports. Using the duration analysis technique, several determinants of sustainability mentioned in the available body of literature are confirmed. Namely, the CSBs that produce quality seed, recover seed production costs, have experienced leadership, operate formally as a group by documenting decisions, and have access to productive assets operate longer than CSBs that lack these characteristics. This study also confirms the importance of not only building seed production capacities of the CSBs but also seed marketing and administrative capacities. Seed marketing training was found to reduce the failure rate of CSBs that reported low seed yield in their first year of operation. Intensity of CSB operation was positively associated with increased risk of failure. Of the three types of CSBs implemented, individual seed banks failed 30% faster than CSBs administered collectively by community members. While the size of CSB membership did not impact time to failure, the CSBs that were more representative of the community did have lower failure rates. The study identifies important characteristics that should be considered in future promotions of community based or decentralized models of seed production of staple food crops such as beans.

Dedicated to Jackie, Lydia, David, Ron and Fran

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KEY TO ABBREVIATIONS

AIC	Akaike Information Criterion
AFT	Accelerated Failure Time Model
BIC	Bayesian Information Criterion
BTD	Bean Technology Dissemination Project
CIAT	International Center for Tropical Agriculture
CSB	Community Seed Bank
FAO	Food and Agriculture Organization of the United Nations
INIDE	*Instituto Nacional de Información de Desarrollo*
INTA	*Instituto Nicaragüense de Tecnología Agropecuaria*
KMS	Kaplan-Meier Survival Curves
KM	Kilometers
LB	Pounds
MAGFOR	*Ministerio Agropecuario y Forestal*
MCC	Millennium Challenge Corporation
MZ	*Manzanas*
NARS	National Agricultural Research Systems
NGO	Non-Governmental Organization
PCA	Principal Component Analysis
PESA	Program of the Framework for Food Security and Nutrition
PH	Proportional Hazards Model
QDS	Quality Declared Seed

QQ	*Quintales* (equal to 100 pounds)
RAAS	South Atlantic Autonomous Region
UNISEM	*Unidad de Semilla*
USAID	United States Agency for International Development

CHAPTER 1: INTRODUCTION

Common bean *(Phaseolus vulgaris)* is widely produced and consumed in Nicaragua and is strategically important for food and nutritional security of both the rural and urban poor. Long-term investment in research by the national program in collaboration with international researchers has resulted in the development and release of many disease resistant bean varieties with a potential to increase bean grain yield in the country. However, access by small holder bean producers to these improved bean varieties developed through the research system remains a major constraint due to the lack of a private sector led seed multiplication and dissemination system. Consequently, bean yields remain low, contributing to food insecurity and limiting the potential of beans to be a profitable cash crop.

1.1 Bean Production in Nicaragua

Nicaragua is the largest bean producing country in Central America. The increase in bean production seen by this country over the past two decades is due to an increase in area cultivated rather than an increase in yield, which was estimated to be 643 kg per hectare for the country in 2011 (Quiroz Cortez el al. 2009, MAGFOR 2009, Schmidt et al. 2012). Large shares of bean producers in Nicaragua are smallholder farmers.[1] In 2011, 64% of producers cultivated beans on

[1] Compared to many developing countries in Asia and Africa, the definition of smallholder farmer in Nicaragua based on the size of land holding may seem out of range. However, there are limitations to focusing only on land size as a definition of smallholder. Even a land size plus family labor index fails to capture investment capabilities, market integration and regional socioeconomic environmental factors (Berdegué et al. 2011 and Hallensleben 2012). Furthermore, the decision to exclude subsistence farmers (focused on non-farm income) and commercial family farms (less than 3 permanent non-family workers) from the smallholder category will impact policy decisions (Berdegué et al. 2011). Definitions with an upper threshold of 2 hectares are common outside of Central America, but Berdegué and Fuentealba (2011) and Carmagnini (2008) point out that given the conditions of rural Nicaragua, a family cannot maintain its sustenance on less than 5.6 hectares (8 manzanas). MAGFOR considers farmers to be small scale if they cultivate less than 50 manzanas for all crops (Hallensleben 2012). In Guatemala, families with less than 10 manzanas (7 hectares) are considered subsistence ((Berdegué and Fuentealba 2011). In Honduras, the 2007-2008 Agricultural Census' smallest category was farmers were those with less than 5 hectares (7 manzanas) (INE 2008).

less than 20 manzanas (equivalent to 34 acres or 14 hectares)[2], 50% on less than 10 manzanas and 34% of farmers cultivated beans on less than 5 manzanas (INIDE 2012). One way to increase bean yields by smallholder farmers is to use certified seeds of improved varieties. (Remington 2002). However, according to the *Instituto Nicaragüense de Tecnología Agropecuaria* (INTA), due to the lack of availability and access to certified seeds, the use of this type of quality seed has remained low even among farmers who receive training on implementing practices to increase yield (MAGFOR 2009,Sain 2011, Carter el al. 2012). The Nicaraguan Ministry of Agriculture estimates that in 2008-09 agricultural season only 6.2% of bean production area was planted with certified seeds, and in the past seven years, even though the use of certified seeds has increased, it has never surpassed 15% of area planted to beans in Nicaragua (MAGFOR 2009, UNISEM personal communication).

Due to low profitability, private seed companies have had little interest in marketing certified bean seed directly to farmers. Instead, this private sector led formal system has focused on selling the certified seed to government agencies and NGOs to feed into their free or highly subsidized seed distribution programs. This model of seed production by for-profit private sector and its purchase and distribution to the farmers by government and NGOs at less than the economic price is not sustainable over the long run. Moreover, this approach only reaches a limited subset of bean producers in the country (MAGFOR 2009).

In general, the lack of a sustainable seed multiplication and dissemination system has resulted in negative rates of return on National Agricultural Research Institutions' investment in developing new varieties (Tripp and Rohrback 2001). As a result of the seed system constraint, most farmers end up using grain (either saved on-farm or purchased from the market) as planting

[2] One manzana is equal to 0.7 hectares and equal to 1.7 acres

material. The low quality of 'seed' used by the farmers results in low yields realized at the harvest (in combination with other constraining factors, including, lack of fertilizer and pesticides, poor growing conditions, etc.).

1.2 Efforts to Increase Yield in Nicaragua

Recognizing that 'access to good quality seed' is one of the limitations in increasing bean productivity, the government of Nicaragua has started several initiatives to improve access to quality seed by farmers in rural areas. One of these initiatives is to promote the community seed bank (CSB) model to produce '*apta* seeds,' or Quality Declared Seeds (QDS) of basic grains, including beans. The community seed banks (called *Bancos Comunitarios de Semilla*, in Spanish) is a formalized, but not a legally registered, organization that operates on the principles of self-help, whereby community members come together to produce seeds to meet their own current needs, save seeds for future seed security, and sell excess seeds to generate revenues to cover production costs. The CSB oversees community-level production, marketing, distribution, and storage of quality seeds (i.e., *apta* seeds). These *apta* seeds (i.e., QDS) are produced from registered seeds using the agronomic practices of 'seed' production, but are not certified as 'seed'. In other words, the seeds are produced **by the farmers** under the aegis of a community organization with **technical guidance from INTA** and **distributed to other farmers** within or outside the community.

This model of Community Seed Banks provides an opportunity to reach large numbers of smallholder bean farmers with quality seed of improved varieties. Thus, when the 'Bean Technology Dissemination' (BTD) project[3] was initiated in 2010 by the Dry Grain Pulses CRSP

[3] The official title of this project is "*Strategic Investment in Rapid Technology Dissemination: Commercialization of Disease Resistant Bean Varieties in Guatemala, Nicaragua, Honduras and Haiti*." The project was funded by the U.S. Agency for International Development under the Feed the Future initiative through an Associate Award grant

through funding from USAID with the aim of introducing technologies (i.e., improved varieties) that increase bean productivity to **a large number of rural households**, the CSB model was the most logical choice of the BTD project for seed dissemination in Nicaragua. The national bean research program of Nicaragua (INTA) was the in-country partner of the BTD project, and through its network of regional offices, it played an important role in supplying the registered seed stocks of improved bean varieties to community seed banks and provided technical assistance to ensure that the seeds produced by the seed bank meet some minimum quality standards as planting materials. Within the broad class of community seed banks, there were three types of CSB models implemented across the country—two communal CSBs were managed by community members but seed production took place either on community managed land (the classic CSB model) or individually managed land (parceled CSB), and one completely managed by individuals (individual CSBs).

From 2011 to 2013, more than 234 communities[4] received support to establish a CSB in Nicaragua from the BTD project, and the project was able to reach 16,065 beneficiaries (23% of farmers cultivating bean on 10 MZ or less) through this community based approach of seed production and distribution. In 2011, an estimated 5,365 farmers received seed produced by the CSBs representing 8% of small holder bean farmers cultivating bean on 10 MZ or less in Nicaragua. In 2014, when the BTD project ended, several of these CSBs that were established by INTA had ceased to exist (i.e., failed) and some had survived and continued to receive

funding to Michigan State University from October 2010 to March 2014. One of the objectives of this project was to implement sustainable bean seed systems with local farmer involvement/ownership so as to ensure long-term availability of quality seed of improved bean varieties to resource-poor farmers in the four project countries.

[4] In these 234 communities 501 CSBs were established according to BTD project reports. To be counted as a different CSB a unique promotor had to appear for a CSB that had not previously been included in previous years reports. Some communities had multiple CSBs because of the parceled CSB structure (in Pacifico Norte, one community had 16 CSBs) while other communities are listed as having multiple CSBs after year 1 because a second or third CSB was established with a different promoter.

support from INTA beyond year 3 of the BTD project. This mixed result on the survival status of the CSBs at the end of the BTD project offers an interesting opportunity to study the factors influencing the sustainability of the community based seed production model. Studies that have looked at similar experiences in Africa indicate that community based seed production is unsustainable due to low demand for the seed and an inability of the community based organization to cover production costs (Tripp and Rohrbach 2001). Yet, there are few alternate models that address the constraint of lack of availability of seeds of improved varieties for staple food crops, such as legumes, to smallholder farmers in developing countries. Understanding the factors that influence the success or failure of different models of seed multiplication and dissemination (including community based seed systems) that can meet the seed needs of a large number of smallholder farmers thus remains an important research question.

1.3 Objectives of the study

The objective of this study is to use duration analysis methodology to understand the factors that determine the sustainability (or failure) of the community based model of CSBs used in Nicaragua under the BTD project. Specifically, the study:

(1) Gives an overview of different CSB models used in the BTD project in Nicaragua;

(2) Characterizes the differences and similarities between the CSB models;

(3) Analyzes the determinant factors of sustainability (or failure) of the CSBs as a collective group and by CSB model; and

(4) Provides recommendations for improving future implementation of CSBs in Nicaragua and elsewhere.

1.4 Research Questions

This study achieves these objectives by addressing the following research questions:

(1) What are the characteristics of the Nicaraguan CSBs that participated in the BTD project in terms of their:

   a. membership and leadership profile;
   b. community characteristics, asset ownership and prior experience in collective action;
   c. seed production quality, quantity, distribution and repayment rates; and
   d. duration of participation in the BTD project?

(2) What are the factors that determine the success or failure of the CSBs in the BTD project?

   a. Do the factors vary across different Duration Analysis models?
   b. What variations in determinants of sustainability are attributed to the different CSB models observed in the BTD project?
   c. Which of the three CSB models in the BTD project is more sustainable, if they are different?

(3) What improvements can be made for future implementation of CSBs to make them more effective and sustainable?

1.5 Organization of the study

The study is divided into seven chapters. **Chapter 2** describes the concepts and principles of a sustainable seed system and seed security. Previous examples of CSBs and lessons learned from these experiences are presented along with theoretical determinants of CSB sustainability.

Chapter 3 describes the BTD project and the bean seed sector in Nicaragua. The three variations of CSB models implemented under the BTD project are described and their differences and similarities are explained. This chapter also brings out the regional differences in the history of seed production activities and their effect on the design and operationalization of the CSB models across the country under the BTD project.

Chapter 4 provides the analytical framework and methodological models for studying the determinants of sustainability. A model of adoption and withdrawal from participation in non-traditional markets is considered and its application for the current study is explained. Finally, the methodology of duration analysis is explored.

Chapter 5 presents the descriptive statistics of the data after describing the data collection process. The variables of interest are described and differences in descriptive statistics between the three CSB models are explored.

Chapter 6 presents the results. Several possible duration analysis models are considered initially. After finding the best model and exploring interactions terms, a separate model is considered excluding individual CSBs due to their structural difference from the other two communal models. CSB and regional heterogeneity, possibly from unobserved variables, are tested and removed as needed from the final model.

Chapter 7 concludes the thesis with the policy implications. Limitation of the study and recommendations for future research are also provided.

CHAPTER 2: CONCEPTS, CONSTRAINTS AND CHALLENGES OF A SUSTAINBLE SEED SYSTEM: A REVIEW OF THE LITERATURE

The model of CSBs, which is the focus of this study, assumes that their presence in the communities will meet needs of the farmers in terms of quantity, quality and diversity of seeds, while generating the resources to be economically sustainable and continue to meet those needs in the future. Before we analyze the factors contributing to the sustainability of this CSB model, it is important to clarify several concepts and terminologies associated with sustainability, seed system and community seed banks.

2.1 Sustainable Seed System

Seed systems refer to, “the entire complex of organizations, individuals and institutions associated with the development, multiplication, processing, storage, distribution and marketing of seeds in any given country” (Maredia et al. 1999). It encompasses the entire spectrum of the seed value chain that can exist at the community (village), municipality (district), department (province), country or regional levels.

A sustainable seed system is characterized by a set of players, infrastructure, policies and guiding principles that provide framers with quality seed in the right quantity at the right time, place, and price (van den Burg 2004). In the context of CSBs, it is the ability to meet a community’s need for seeds and doing so while recovering all production costs. Additionally, sustainability implies that a seed production and distribution system is profitable beyond the end of a project (Sperling et al. 2013).

Often, these principles of sustainability are reduced to the three components of seed security: availability, access and utilization (quality) (Sperling et al. 2011). As Remington et al.

(2002) indicate, these same parameters have been used to assess food security although recent publications have added stability as a fourth component.

Availability of seed is determined by two conditions, sufficient quantity and service. Service is defined as both providing the seed prior to the planting period (timing) and within a realistic distance to the farmer's home (location) (Longley et al. 2002).

Access is mainly focused on the price that farmers pay to purchase seed. If farmers' income and assets can be used to obtain seed through sale, barter, or loan, then the farmer can access available seed. A loan or lending mechanism that allows farmers to obtain the seed and repay from their harvest is one way to increase access, which is more amenable to a community-based seed production and distribution model than a private sector led seed system (Longley et al. 2002).

Finally, utilization is divided into two conditions, quality of seed and diversity of varieties. Quality can be measured in terms of genetic value, purity and seed viability (Sentimela et al. 2004). A germination test is an indicator of seed quality. The diversity of varieties refers to providing the varieties appropriate for the region that the farmers prefer either for yield potential, resistance to stresses, grain characteristics (size, weight, taste, and cooking time) or a combination of these factors (Longley et al. 2002).

In order to meet the needs of a community and continue in the following year, a CSB must be able to cover its expenses. Length of operation is a good measure of economic sustainability as it indicates that revenues generated are sufficient to cover the costs needed for its continued operation (Wiggins and Cromwell 1995) (Witcombe et al. 2010). According to Sperling et al. (2013) continued operation without any project or external support is the true measure of economic sustainability.

2.2 Formal and Informal Seed Systems

Within a seed system a distinction is made between formal and informal system. A formal seed system is a, "deliberately constructed and bounded system, which involves a chain of activities leading to clear products: certified seed of verified varieties" (Sperling et al. 2013). Variety breeding and seed development is most often coordinated by National Agricultural Research Systems (NARs) in collaboration with universities, international research centers and possibly NGOs. In the case of highly profitable crops or seed types (i.e., hybrid seeds), the private sector develops new varieties that are registered with government authorities prior to release for sale. For such crops, even if the varieties are developed by the public sector, often private enterprises purchase the registered seed (which are also called basic or foundation seed in some countries) to then be used to grow seed for commercial sale. Government programs with a goal of disseminating new varieties or to provide seed aid after natural disasters are also part of the formal seed system. In general, the distinctive feature of a formal system is, "the clear distinction between seed and grain" (Sperling et al. 2013).

An informal seed system, also called a traditional or farmer system, lacks government certification and involves the "seed production activities of farmers, mostly small-scale" (Almekinders 2000). Seed is obtained by farmers from his or her own harvest or exchanged through barter, sale or gift with other farmers (Bentley et al. 2011). Although no certification process takes place, quality is ensured by trusting their production methods or those of known seed producers in their area. In the worst case scenario, farmers purchase grain for sale at a local market and must judge the physical attributes to determine the quality of using the grain as seed (Maredia et al. 1999).

Informal seed system remains the main source of seeds for farmers around the world contributing between 90-100% of seed depending on the crop (Rubyogo 2007). Other studies have found similar evidence across countries and crops and place the percent of seed coming from informal sources at 60 to 85% for most staple crops and nearly 99% for neglected and underutilized crops (Shrestha et al. 2013). Under certain conditions, seeds sourced from the informal system can effectively meet the seed needs of the farmers. There is no need to have a formal seed system to meet 100% of seed need for all the farmers in all the seasons. For example, for most self-pollinated crops the use of saved seed from previous harvest is a common practice. This is because the genetic quality of the seed of self-pollinated crops such as beans, rice, and wheat does not deteriorate from one generation to the next. For such crops if there are no widespread seed borne diseases, the informal seed system co-exists with the formal seed system even in more matured agricultural systems. For example, Almekinders (2000) reports that in Europe informal seed systems make up the majority of seed supplied for all crops. Greece, Germany and the Netherlands had area sown with seeds supplied from the informal sector at 90, 50 and 25% respectively (Almekinders 2000).

In the traditional maize and bean farming systems of Central America, use of seed from the formal system is low. Wierema et al. (1993) found that only 6% of the interviewed farmers reported obtaining maize seed from the formal system in Nicaragua while in Costa Rica and Honduras the use of the formal system was at 2 and 13% respectfully. For beans, 13% of Nicaraguan farmers used the formal system compared to 21% in Costa Rica and 6% in Honduras. A representative survey of the seed recipients of the BTD project in Nicaragua in 2012 revealed that only 32% had easy access to certified seeds of bean and 54% of farmers had never used them (Maredia et al. 2014). The same study interviewed seed recipients of the BTD project in Honduras and Guatemala in 2013 where respectively, 44 and 19% of farmers reported easy access to certified bean seed while 21 and 57% respectively stated that they had never used certified bean seed (Maredia et al. 2014).

The main source of seed within the informal system is saved seed from the previous year's harvest. Wierema et al. (1993) found that 58% of bean farmers in Costa Rica used their own seed. Similarly, 79% of farmers in Honduras and 72% of farmers in Nicaragua used their own seed. For maize, 79% of farmers in Costa Rica, 75% of farmers in Honduras and 81% of farmers in Nicaragua reported using their own seed. When a farmer does not have enough saved seed the complementary portion is obtained through other informal system sources such as family, friends, the grain market or local seed producer (Tripp 1997) (Bentley et al. 2011). Data from Maredia et al. (2014), reveal that 54% of bean plots planted in May 2012, by the Nicaraguan farmers who received seed from the BTD project in 2011, used saved seed from the previous year's harvest, 15% used seed or grain from another farmer and 4% used grain purchased at a local market (*Author's calculation from BTD Project Beneficiary Survey 2012*).

2.3 Community Based Seed Production Schemes as a Type of Informal Seed System

To address the constraint of lack of availability of quality seed, NGOs, community leaders and government agencies have looked for ways to ensure seed security through community based seed production schemes (Shrestha et al. 2004). These schemes are known by different names in different countries, such as Village Seed Banks, Farmer Seed Enterprises, Seed Savers Networks, Smallholder Seed Enterprises and Community Seed Banks (the term used in the current study), but the basic element common across these schemes is the organization of community members within a geographical boundary that are focused on producing seed of desired crops and specific varieties. The organization of seed production can vary from a communal approach to having one or few community members specializing in seed production. Post-harvest activities of seed treatment and marketing, however, are community orientated in each model.

In their typology of CSBs, Lewis and Mulvany (1997) noted five types of CSBs. *De facto* seed banks occur regularly within communities to spread the risk of an individual farmer losing seed among all farmers in the community. The *de facto* bank also allows farmers to obtain additional quantities of seed if they wish to expand area planted to a certain crop. Community seed exchange is a second type of seed bank with a formalized sale, lending or trade system. Additionally, regional seed fairs, most notably those in the Andean region, allow exchange of seed and ideas among different regions. A third type of CSB is the organized CSB that multiplies both traditional and improved varieties. While the link to the formal seed system is stronger in this type of CSB, the dependence on outside funding and lower equity of access to the poor farmers are noted as downsides by Lewis and Mulvany (1997). Fourth, seed savers' networks focus on conservation of seed varieties existing in the community. Proponents of biodiversity fall under this category of CSB and may create an organized CSB (the third type of CSB) in order to multiply seeds of local landraces. Finally, ceremonial seed banks are controlled by community leaders and focus on traditional varieties and institutions. There is little or no overlap between the informal and formal seed systems in this final CSB type.

Lewis and Mulvany (1997) divide the third CSB category (organized banks) into four subcategories distinguished by the type of seed multiplied and reason for multiplication. Improved varieties are multiplied either for seed relief purpose or with the goal of dissemination of new varieties. Traditional varieties are multiplied either for conservation and biodiversity motives or to increase access to these varieties. Within the context of the current study, the

CSBs are multiplying improved varieties as part of a dissemination effort. Lewis and Mulvany (1997) conclude that such banks increase seed security but may not be equitable to all as the main benefits are realized by participating farmers. The authors did not reach a conclusion about the economic sustainability of this form of CSB.

Sentimela et al. (2004) do address the contribution to seed security and economic sustainability of organized CSBs multiplying three types of seed: certified seed, quality declared (or *Apta*) seed, and farmer varieties. Also included in the comparison by Sentimela et al. (2004) are contracted community level certified seed producers that offer a mutually beneficial agreement for both the seed producer and organization purchasing the seed, most likely the government or NGO. Sentimela et al. (2004) doubt CSBs multiplying farmer varieties will be sustainable because there is no clear incentive, beside the farmer's reputation, to maintain quality standards that incur additional costs and the selling price of such seed is often the same as grain prices. Finally, Sentimela et al. (2004) consider the multiplication of certified and *Apta* seeds (i.e., QDS) to be project based and unsustainable in the absence of an actor assuming the financial and technical support role of the organization that launched the CSB. Without the project, sourcing registered seed must be addressed and producing *Apta* seed (i.e., QDS) faces low selling prices compared to certified seed.

2.4 Sustainability of Community Based Seed System: Contributing factors

Community based seed production occurred through the 80s and 90s, but began receiving criticism for being unsustainable at the turn of the century. While Tripp and Rohrbach (2001) made the early claim that there were no examples of a successful CSB and that it is untenable, David (2004), Sentimela et al. (2004), Van Mele et al. (2011), and Witcombe et al. (2010) continue to present examples of community based seed production that they consider sustainable.

Currently, the literature is focused on combining the strengths of the formal and informal seed systems to form an integrated seed system (Sperling et al. 2013 and Louwaars et al. 2012). The focus is on cost effective, decentralized seed production of quality seed by producers who are strategically partnering with actors from the formal seed systems while using innovative marketing strategies (Sperling et al. 2013). Although not explicitly stated, the scale of production of these decentralized seed producers is significantly larger than most CSBs.

Despite differing opinions on CSBs and the new focus on integrated systems, there is broad agreement on many important factors that need to be in place for a community based seed production system to be economically sustainable. For simplicity these factors are grouped into the following categories--profitability, marketing, quality production, links to formal sector, and training.

2.4.a. Profitability

As stated earlier, for a CSB to be sustainable, it must charge a price for its seed that covers production costs. Van den Burg (2004) suggests a simple formula for setting the price of seed compared to the price of grain. When seed is grown in the same field as grain, a 5 to 10% increase is warranted but if different inputs are used in a different plot, at least a 20% markup is required. Seed treatment and packaging should add 50-100% to the price of grain. Charging a price that is more than double the price of grain is complicated when farmers do not distinguish between grain and seed (Rubyogo 2007). From the CSB opponents' viewpoint, the price obtained by most CSBs often do not cover the full cost of production, seed inspection and technical support, and thus require a project's financial support to sustain their existence (Tripp and Rohrbach 2001).

However, as shown in Kenya by Katungi et al. (2011), profitability is achievable in a community based model. A study of 30 bean seed producers across three districts found net revenue of 36% of total income. At the same time, a comparison seed company that incurred costs from irrigation, processing, storage and field inspection to obtain certification had net revenue of 61% due to the higher price charged for certified seed.

For CSBs, price alone does not ensure profitability as repayment rates determine total revenue. Lemessa (1994) found repayment rates to be around 50% in Ethiopia, and Wiggins and Cromwell (1995) reported similar rates among 84 CSBs in Mali but much lower (between 20 and 40%) among 16 CSBs in Sudan. Additional costs of enforcement to ensure repayment must be considered if the CSB is lending seed.

CSBs may experience profitability similar to early adopters in the technology adoption lifecycle model (Carletto et al. 1999). For example, CSBs formed in the early stages of its introduction in an area are more likely to experience favorable conditions such as external support, limited market competition and demand for new varieties that may not exist for CSBs that start at later stages or for the same CSB in subsequent years. Integration with formal seed system actors can be one mechanism to continue to innovate and identify growth opportunities and ways to remain profitable (Sperling et al. 2013).

2.4.b. Market demand

Demand for seed, and the reasons for seed demand, must be identified prior to the start of seed production, preferably using a market potential survey (van den Burg 2004). Demand is often limited within a small community (due to limited number of farmers and low frequency of seed replacement, which both translates into low quantity of seed demand), so CSBs must extend beyond their local clientele if they are to be successful (Tripp and Rohrbach 2001). As David

(2004) found in Uganda, many community members were one time buyers of seed from the community seed producers. By extending beyond the community, a seed producer will have a larger population of potential clients and thus more demand for their ‘seed’.

Marketing and market development are important elements of CSB sustainability as it generates demand for ‘seed’ and facilitates the sale of seeds produced by the community based seed organization beyond its community. Tripp and Rohrbach (2001) attribute community based seed production failures to, “mistaking seed multiplication (which all farmers are capable of) for the more complex process of market development.”

Documented experiences highlight several creative market development strategies used by organized seed production schemes. Participation in fairs, schools, door to door advertising, farmers meetings, and agricultural shows are some obvious examples but one group of seed producers in Uganda even authored a song to promote a new variety (David 2004). Partnerships are also formed within established organizations with broad local, district or even national coverage such as churches, NGOs and other social groups (Monyo et al. 2004). Van den Burg (2004) suggests negotiating with owners of fields located in high traffic areas, such as bus stops, to use for seed production. The CSB can then use the fields as demonstration sites to show the benefits of quality seed of improved varieties in the form of increased resistance to disease and higher yield.

Community based seed producers should not, however, be responsible for all aspects of marketing new varieties. Strong relationships with research stations, described below, should provide the communication and marketing opportunities for new varieties developed by the NARS and approved by the seed authorities (Rubyogo 2004, Sperling 2013).

Part of market research should identify the different seed package sizes and varieties demanded (David 2004, David et al. 1997). Providing seeds in varying package sizes to meet the varying needs of both small and large scale farmers as well as farmer groups making collective purchases, has been shown to be an effective tool for improved variety dissemination in Rwanda and elsewhere (Rubyogo 2004, Sperling et al. 2013).

In general David (2004) found that when demand is high and regular, and the CSB has technical supervision, the producers can be successful. Also, where diseases are common, seed producers are able to show the benefits of clean seed and secure a market for their product. However, lack of access to resources or credit to cover the cost of inputs needed for seed production can become a potential constraint in such an environment (David 2004, Van den burg 2004).

Several characteristics of beans affect the market demand for its seed and serve as a disadvantage for the success of a CSB. Ideally, the crop of choice for a CSB would have a high varietal deterioration rate (to maintain demand), high multiplication rate (to produce large volumes of seed) and low carryover of seed based diseases (to minimize seed quality concerns of clients) (Rubyogo 2007, David 2004). As proof that beans are not the first choice of the private sector (and thus also a concern for CSBs investigating market demand), case studies of seed enterprises across nine African nations noted that small seed enterprises focused on hybrid maize seed or vegetable seed because it could not make a profit competing with farmer-saved seed of a crop such as beans. The only exceptions were enterprises with government support or linked to larger grain producers (Bentley et al. 2011).

2.4.c. Seed quality

Seed quality involves genetic value, purity and seed viability (Sentimela et al. 2004). The assurance or guarantee of seed quality provided to farmers varies by type of seed system. In the formal system, a government agency provides monitoring and a government issued label certifies quality, but in the informal system, the reputation of the seed producer guarantees quality (Sperling et al. 2013).

When CSBs are formed as part of a project, seed quality concerns can arise after the NGO or the technical experts end their monitoring services for the seed production activities (Sentimela et al. 2004). Quality incentives must be established for the individuals responsible for seed production to maintain seed quality after the project support formally ends (Bänziger et al. 2004).

Additionally, there are several issues that affect production, but not necessarily seed quality. Group production schemes run the risk of neglected care of the group production plot as individuals tend to their personal plots prior to working on the communal plot (David 2004). While the conflict of prioritizing the household plots over the CSB or business plots was true of all groups, David (2004) noted it was most present in female groups. Female participation in community organizations is also affected by traditional attitudes of gender roles held by 49% of men in Nicaragua (Ortega et al. 2005).

Trust formed by previous work in groups should be considered prior to forming CSBs. In some cases, individual seed production may be favored to communal production but care must be taken in collective post-harvest decision making to ensure fair compensation among group members (David 2004).

Seed production is labor intensive and requires additional labor compared to bean grain production (Katungi et al. 2011). Farmers with resources should be targeted for new CSBs as they are more likely to avoid bottlenecks in seed production, practice crop rotation, use fertilizers and have land suitable for seed production (David 2004). A source of transportation (animal or truck), drying space, storage silos, packaging facilities and financial management are additional assets needed to ensure seed quality (Van Mele et al. 2011).

2.4.d. Links to formal system

Tripp and Rohrbach (2001) have criticized the CSB movement because it is often completely disconnected from the formal seed sector. Improvement has been made since the first NGO supported CSBs and the most successful seed producers in the informal sector have strong contact with the formal sector (Sentimela et al. 2004, Van Mele et al 2011, Witcombe et al. 2010, Katungi et al. 2011).

It is important for CSBs to identify where they will obtain registered (or foundation) seed of new improved varieties (Bänziger et al. 2004). For most developing countries and crops without a thriving private seed enterprise, the only option is the public seed authorities of the NARSs. For CSBs, this presents an opportunity to build ties with breeders and begin participatory plant breeding practices if they have not already begun in a given country (Rubyogo 2004, Sperling et al. 2013). Thus the business model of a CSB should go beyond seed production and sale to include a strategic partnership with the closest research station (Sentimela et al. 2004)

2.4.e. Training

Training is needed for new seed producers to produce quality seeds and be able to sell those seeds. As pointed out by Tripp and Rohrbach (2001), CSBs need to develop markets, not just multiply seed. Thus, CSBs need to be trained not only in agronomy and science of seed production, but also in business management, marketing, and accounting to gain skills in managing the seed production as an enterprise (Bänziger et al. 2004). For farmers and farmer groups unaccustomed to such practices, these new requirements can be especially challenging. Having prior business experience can thus be an important asset for the success of a community based seed enterprise (David 2004).

The success of three rice seed producer groups in Nepal was attributed to its focus on marketing and good management, and these groups were trained in this aspect by experts. Witcombe et al. (2010) found that nearly a decade after these groups were formed, two of the groups had expanded their market, and the third group had ended seed production activities but had continued their business operations by diversifying to specialization in rice milling.

2.5 Scope of Sustainability

In conclusion, there is an important issue related to sustainability of community based seed system discussed in the literature that needs to be highlighted. This is the issue of the scope of sustainability. Economic sustainability is a noble goal, but occasional investments from donors and public sector support may be needed to ensure CSBs continuing to provide community services. Some definitions of economic sustainability, such as that used by Van Mele et al. (2011), allow for external support, while Sperling et al. (2013) require seed producers to be profitable without subsidies or external project funding. In cases of chronic, but not annual seed crisis, community based seed production has offered an important contribution to a sustainable system than annual free seed distribution. Wiggins and Cromwell (1995) have documented NGO work with Village Seed Banks and point out that in the Sahel, the system worked for several years until rain failure depleted the seeds in the seed banks. After ten years, the banks again needed external support to replenish their seed stocks but they were not donor dependent every year.

CHAPTER 3: STUDY SETTINGS: THE BEAN TECHNOLOGY DISSEMINATION PROJECT AND THE COMMUNITY SEED BANK MODEL IN NICARAGUA

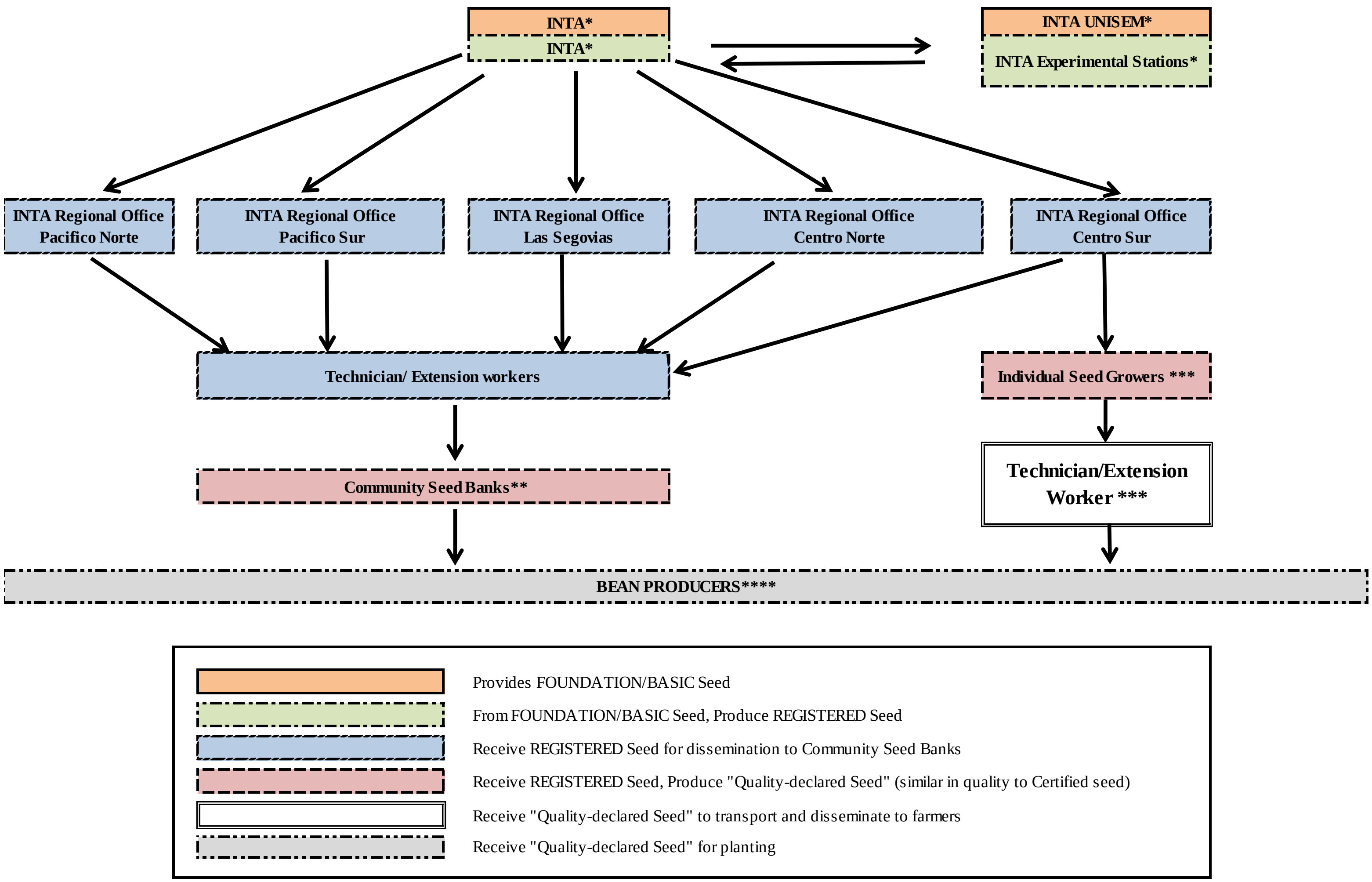
The Bean Technology Dissemination project (BTD), funded by USAID and implemented by the Feed the Future Innovation Lab for Collaborative Research on Grain Legumes (formerly called the Dry Grains Pulses Collaborative Research Support Program) focused on improving bean productivity in four countries: Haiti, Guatemala, Honduras and Nicaragua. The BTD project promoted yield improving technologies such as improved bean varieties and the inoculant *rhizobium* through the National Agricultural Research Systems in each country. Over the three years (2011-2013) of the project, 543 metric tons of improved varieties of seed were disseminated to 102,047 farmers in the four countries (Maredia et al. 2014). The partner organizations in each country chose different production and distribution strategies to disseminate seeds of improved bean varieties to the target numbers of farmer beneficiaries.

3.1 The BTD Project in Nicaragua

In Nicaragua, the partner organization was the *Instituto Nicaragüense de Tecnología Agropecuaria* (INTA). INTA staff members chose to build on the Community Seed Bank (CSB) models previously implemented in Nicaragua for local seed production by the Food and Agriculture Organization (FAO) in the Pacific South region and the Millennium Challenge Corporation (MCC) in the Pacific North region.

Figure 3.1 provides a diagram of the seed production and distribution system used in the BTD project in Nicaragua. INTA, through its seed unit UNISEM, produced or contracted the production of registered seed and provided it to the five INTA regional offices. Each regional office was responsible for establishing 40 CSBs using the criteria discussed below. INTA technicians, or extension workers, supplied 80 pounds of registered seed, inputs and technical support to each CSB to establish a 1 manzana (0.7 hectares) seed production plot. After post-harvest seed treatment, each CSB was responsible for selecting 50 farmers to receive a seed loan. Farmers were to receive 20 pounds of seed and repaid the loan with 40 pounds of grain or its cash equivalent at harvest. As discussed below, the Centro Sur region decided to select individual seed producers instead of establishing communal CSBs in year 1. Under this scheme, the extension workers received delivery of the *Apta* seed (i.e., QDS) produced by the CSBs (individual seed producers), transported the seed to selected farmers in other communities and facilitated the repayment of the cash equivalent of 40 pounds of grain after harvest.

Figure 3.1: Diagram of Seed Production and Distribution in BTD Project Nicaragua



* Aurelio Llano has noted that Genetic Seed is produced by UNISEM of INTA, Basic Seed produced at Experimental Stations of INTA and Foundation Seed comes from Zamorano or International Seed Centers like CIAT

** Community Seed Banks are formed of several community members

***Individual Seed Growers also are counted as Community Seed Banks. INTA extension workers transported seed to other communities and returned payment to the CSBs.

****Bean producers also include members of the Community Seed Banks

Source: Updated from Reyes et al. (2014)

The CSB model fits well within INTA's extension strategy while teaching seed production to and organizing bean farmers in bean producing communities. Extension workers are assigned to several communities to promote the field work of INTA. In each community, the extension worker identifies a member of the community to serve as a promoter, who receives training from INTA technical staff to promote improved technologies, including new variety seeds, through the establishment of demonstration plots. Under the BTD project, the extension worker was responsible for providing the inputs, specific technical knowledge on seed production and educational materials to the promoter and members of the community seed bank. Each CSB was given a target to reach a certain number of beneficiaries with its bean seed dissemination efforts. Thus, the BTD project added a community organizational element in addition to the normal production focus of the INTA/extensionist/promoter strategy.

3.2 Criteria for Establishing a CSB

A manual describing the establishment of a CSB in Nicaragua has been developed through collaboration between the Nicaraguan Ministry of Forestry and Agriculture (MAGFOR) and the Program of the Framework for Food Security and Nutrition (PESA) of the FAO. The guide was published after the beginning of the BTD project but provides the structure anticipated by INTA. It is part of a technical assistance series and intended for extension workers (FAO-PESA 2011).

According to this guidelines document, the following conditions must be met for a community to be considered for INTA to establish a community seed bank: a) favorable seed producing conditions, b) limited financial services including support from other organizations, c) limited access to quality seed, d) interest among farmers to organize a CSB, and e) farmers with limited resources.

To establish a CSB, INTA identifies community leaders as well as potential CSB members. Together with INTA staff, the economic conditions and seed supply needs are identified in the community. In the first meeting the community members are given an understanding of the advantages and disadvantages of working together or individually.

According to the CSB guidelines/manual, the CSB establishment criteria are to have at least 12 members who meet the following conditions: a) reside in the community, b) have experience growing beans (or the crop for which the seed will be grown), c) have a reputation of being honest and responsible, d) willing to participate in group work, e) be receptive to the line of work, f) willing to take the initiative and g) willing to try new technologies. Each potential member should formally apply to join the CSB as a member at a meeting, and a forming charter should be written and signed by all the members. A board of directors is to be formed that includes a president (coordinator), a vice president, secretary, treasurer, leader of production, attorney (*fiscal*) and additional members (*vocales*).

Although the CSB is not a legally registered organization, there are several policy and operational procedures recommended to be in place that gives a CSB a formal organizational structure. For example, the CSB is to be operated under the established rules of the internal by-laws. A written loan policy needs to be developed after forming the charter. Production and training plans are also developed to guide the actions of the CSB. Finally, an evaluation and follow up plan is needed to monitor progress and also to ensure repayment of seed.

3.3 Variation of CSBs in BTD Project

Despite the well-defined CSB criteria given in the PESA document, there were two important differences among the CSBs established in the BTD project and included in this study.

Figure 3.2 provides a map of the five administrative regions of INTA comprised of two or more continuous departments and Table 3.1 compares the three differing type of CSBs.

Figure 3.2: Map of INTA Administrative Regions

Source: Aurelio Llano. Additional detailed information available at: http://www.inta.gob.ni/index.php/cobertura/mapa

3.3.a. Regional Differences in CSBs

The mountainous regions of Centro Norte and Las Segovias are located near the border with Honduras. Thirty seven CSBs from the Centro Norte region are included in this study and all are classified as classic CSBs. The Las Segovias region is unique in that it contains CSBs of all three types: fifteen classic, eleven parceled and three individual seed banks (definition of each type is provided below).

The coverage of the Centro Sur region included parts of the South Atlantic Autonomous Region (RAAS) in the BTD project (see Figure 3.2). Forty CSBs from the Centro Sur region are included in the study. Communities such as Santa Lucia in the department of Boaco have historically produced bean seed for sale to other parts of the region. Due to the seed production experience and conducive seed growing environment in the northwestern part of the region and given the adverse conditions for seed production due to humidity (at least during the *primera* agricultural season) in the southern and western part of the region, INTA staff in Centro Sur chose to work with individual seed producers in the BTD project. Instead of organizing CSBs according to the guidelines or criteria above, *apta* seed (i.e., QDS) was produced with individual seed growers and transported by INTA to farmers in other parts of the region. The decision met a need for quality improved varieties of seed in the southwestern part of the region.

The Pacifico Norte region was the targeted area of the Millennium Challenge Corporation's Nicaragua Compact. With the goal of increasing incomes of rural farmers, bean farmers organized in cooperatives to collectively process and market the grain produced. The cooperatives participated in evaluation studies of different bean varieties to identify the best varieties for their region. When the BTD project began, INTA regional staff formed the CSBs for seed production from among the members of the cooperatives. As a result, the CSBs choose to grow *apta* seed (i.e., QDS) in multiple plots instead of a larger communal plot. Although production was distributed among many individuals, the seed was collected, processed and distributed as an organized group.

The Pacifico Sur region was included in the FAO's Program of the Framework for Food Security and Nutrition (PESA) that included CSBs in its pilot project. The INTA staff in the region chose to only establish (or continue ongoing support of) 20 CSBs within the BTD project. The production plots were double the size (2 manzanas) compared to the majority of CSBs in other regions and INTA provided double the inputs to each CSBs to ensure seed production and distribution to the regional goal of reaching 2,000 farmers each year.

3.3.b. Organizational Differences of CSBs

The second important difference among CSBs is the type of CSB. For the current study, CSBs were self-identified as one of the three types defined below. Classic CSBs resemble closely to the structure described in the manual above and was defined for this study as follows:

> The CSB is made up of several members of the community (partners or members) and bean seed is grown in an area of approximately one manzana (possibly only one field) with one promoter. The members of the CSB make decisions about which seed variety to use (beginning in 2012), what input to use, who should receive seed (loan), and how to secure repayment of grain (loan repayment).

David (2004) pointed to trust and previous work experience in groups as reasons to use the classic model and in their absence, to choose an individual option. In this study, the individual seed banks were defined as follows:

> The CSB is made up of one individual who grows the seed and makes decisions, sometimes with the help of INTA, as to who should receive the seed (loan).

Additionally, parceled CSBs were formed and resemble the structure David (2004) mentioned allowing a farmer, or farmers here, to focus on production and incorporate a collective process to post-harvest activities. The definition of parceled CSB used in this study is as follows:

> The CSB is made up of several members of the community (partners or members) and bean seed is grown on several lots with several promoters. The members of the CSB make decisions about which seed variety to use (beginning in 2012), what input to use, who should receive seed (loan), and how to secure repayment of grain (loan repayment).

Table 3.1 provides a comparison of the salient features across the three types of CSBs. Although, there are differences in several aspects across the three types of CSBs, it is important to note the similarities they share (Table 3.1). All the CSBs are producing *apta* seed (i.e., QDS) from fresh registered seed of improved varieties obtained from INTA[5]. Additionally, they are all operating within the BTD project management structure and received similar input packages and technical assistance from INTA technicians.

Within these three broad categories of CSBs, there are differences in the characteristics of CSBs in terms of membership and leadership profiles, operating procedures, seed production and distribution outcomes, and number of years different CSBs survived in the BTD project. In other words, all the CSBs were not implemented as per the manual/guidelines established by the FAO and not all the CSBs received support from the BTD project (i.e., survived) for all three years. In this study we exploit these differences across and within the three types of CSB models to understand the association of heterogeneity in characteristics with the survival outcome.

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[5] Other CSBs operated in Nicaragua during the project but used saved "seed" (grain) from previous harvests to produce "seed." CSBs in the BTD project, by contrast, ensure the quality of the seed they produce by growing it from registered seed.

Table 3.1: Comparison of Community Seed Bank Types implemented in the BTD Project

	Type of Community Seed Bank		
	Classic	**Parceled**	**Individual**
Organization	Several members with one seed plot	Several members with several seed plots	One member with one seed plot
Seed Production			
Seed used	Registered Seed provided by INTA	Registered Seed provided by INTA	Registered Seed provided by INTA
Size of Seed Plots	1 mz except for Pacifico Sur Region (2 mz)	Size varies, but most common sizes are 0.5 mz and 1 mz	Usually 1 mz
Inputs (Fertilizer, pesticides, seed packing bags / supplies)	Provided by INTA	Provided by INTA	Provided by INTA
Seed Distribution			
Who makes the decision on how to use the seed produced	Usually members of CSB	Usually members of CSB (seed producers might have more voice)	INTA
Who receives the seed produced	Community Members	Community Members	Unknown recipients outside the community
Who is responsible to collect repayment	Usually members of CSB	Usually members of CSB (seed producers might need to take initiative)	INTA
Form of repayment	Usually grain, but barter and cash equivalent accepted	Usually grain, but barter and cash equivalent accepted	Usually cash

CHAPTER 4: METHODOLOGY

4.1 Theoretical Framework

The methodology of duration analysis, also known as survival analysis, aims at understanding the factors that explain the time that passes (i.e., duration) before a certain event occurs (Greene, 2012). In the current study, the event of interest is the end of the CSBs' participation in the BTD project. Thus, during the project phase (2011-2014), the CSB can be in one of two states, (1) participating in the BTD project or (2) having withdrawn from the BTD project. The only way to leave the initial participation state, often called a spell in duration analysis literature, is to leave the BTD project.

The decision to withdraw from the BTD project can be modeled using a utility model. Drawing from Mangan and Trendle's (2008) duration analysis of students withdrawing from apprenticeship assignments in Australia, the members of each of the i^{th} CSB evaluate their collective utility after each year t of the BTD project from two alternatives j=1, 2. They could continue in the BTD project, j=1 or withdraw from the BTD project, j=2. The CSB also makes this decision with the *tecnicos* or extension workers from INTA. If an alternative project, say soil conservation, better met the needs of the farmers or community, the extension worker could suggest changing the CSB to a group of farmers implementing soil conservation practices.

The decision is made as a group, although an individual may choose to leave the CSB in any given year. The individual's decision to leave the CSB would impact the size of the CSB as well as human capital assets associated with that individual's age, experience and education.

The joint utility function of the CSB decision to withdraw from the BTD project is composed of two sub utilities, the first from the expected utility of the decision made for that time period and the second from the expected utility of future benefits, both economic and noneconomic, from participating in the BTD project conditional on recognition of the future benefits. This is expressed in equation 1,

$$U_{ijt} = U(u_1(W_{ijt}, X_{ijt}), u_2(W_{ijt}|Z_{it}^*)) \quad (1)$$

Where W_{ijt} is the expected economic and noneconomic benefits for CSB *i* from choosing option *j* at time period *t*. X_{ijt} is the composition of CSB *i* from choosing option *j* at time period *t*. Although it is easy to see how the benefits would differ under W_{ijt} when choosing between j=1 and j=2, note that a specific attribute, such as number of group members, might be different in option X_{i1t} than in X_{i2t} because a group member might continue only if the group decides to take up a different activity, say for example, conservation of local or land race varieties instead of producing improved varieties. Since CSBs are expected to maximize their utility, the CSB chooses j=2, to discontinue the BTD project, when the expected utility of the alternative option is higher than the net expected utility of continuing. The second sub utility u_2 captures an additional component of the CSB decision for awareness or recognition that low short-term economic utility in the BTD project could be part of a learning process and that the knowledge gained from continued participation could lead to higher future economic utility. Likewise, social capital within the community could prove valuable in the future as well as the trust gained with government employees. This is seen in the case of Nicaragua, where a few selected CSBs continued with other sources of financial and technical support when the three year BTD project ended.

While the above model is helpful conceptually, it does not lead directly to econometric specification, in part because enumerating future economic utility of Z_{it}^* is difficult in a pilot project. Additionally, given the uncertainty of future profit, the model is difficult to operationalize to explain the determinants of CSB sustainability.

The model developed by Carletto et al. (1999) to explain the technology adoption decision and entrance into non-traditional markets is more useful in modeling the determinants of CSB sustainability. This model includes two analytical components-- the analysis of time to adopt a new technology or market, and the duration of participation in the nontraditional market before withdrawal. In the setting of this study, 'technology' is defined as 'the production of *Apta* (i.e., QDS) bean seed using the community seed bank model.' The analysis of time to adopt a new technology as done by Carletto et al. (1999) is not applicable in the current study because the decision to adopt the technology (i.e., production of *Apta* (i.e., QDS) bean seed using the CSB model) and the new market (seed sales to neighbors/local community) had already been made before the start of the BTD project. The second/complementary part of Carletto's adoption analysis, i.e., the duration of participation in the nontraditional market before withdrawal, is however, applicable and used as a basis to model the determinants of CSB sustainability in this study.

Like the farmers in Carletto's farm-household choice model, the risk-averse decision makers of a CSB, will maximize their utility and thus choose to withdraw from the BTD project if the change in utility, ΔU, from leaving the project is positive. This utility function is expressed as a function of several factors (explained below) that positively or negatively influences the change in utility:

$$\Delta U = \Delta U(-A, -L/A, -p_x, -FK, -HK, -SK, -T_{CSB}, \pm t_s, \pm D_v) \qquad (2)$$

The factors included in equation 2 build on the model from Carletto et al. (1999) and the review of the literature discussed in Section 2. *A* represents land assets, which are associated with access to credit, adoption of technology and slower withdrawal from adopted technology through the risk factor. CSBs that produce seed on land owned by members are expected to be able to obtain financing should it be needed to cover emergency inputs to prevent crop loss. Bean seed harvest is particularly vulnerable to post harvest losses in the event of a rainy harvest season. Likewise, the more than proportional decline in absolute risk aversion associated with increased land assets indicates that land assets are expected to be associated with longer participation in the BTD project.

The size of the CSB is an indication of available labor *L* (per unit of land asset) that its members can supply. Hired labor is assumed to be less efficient and thus increase production costs. The expected price p_x of seed sales is negatively associated with withdrawal from the BTD project. The price comes from repayment of seed loans to community members and thus is not dependent on grain prices. The expected price would have a one year lag in our model.

Three sources of capital are negatively related to withdrawal from the CSB. Farm productive assets *FK* include sources of transportation (pick-up trucks, mules, oxen, horses) and tools (backpack sprayers, grain/seed drying areas, silos for seed storage). Human capital assets *HK* include leadership age and experience as well as gender and education. Social capital assets, *SK* are measured by the type of CSB (individual vs community based), share of CSB members that are related of other members and operational formality (i.e., number of meetings, written by-laws, recording minutes of the meeting, having a seed production and marketing plan). Training received by the CSB leadership and members could fall either under human capital (representing knowledge or education) or social capital (i.e., operational formality and connectivity to INTA).

Two time measurements are included in the model. The years of previous collective organization of CSB members prior to CSB formation T_{CSB} and the survival time t_s between entering BTD project and withdrawing from the project.

Finally, the village or community effects D_v include measures of remoteness such as distance to city (market), infrastructure, and public services. Regional effects are also included in the model to include regional level heterogeneity in the approaches used by the INTA regional offices to operationalize the CSB model.

Since we are interested in the survival time in years, equation 2 is manipulated to express t_s as a function of the independent variables.

$$t_s = t_s(+A, + L/A\,, +p_x, +FK, +HK, +SK, +T_{CSB}, \pm D_v) \qquad (3)$$

While the body of literature on small-scale community-based seed production does not provide empirical research on the determinants of survival of the specific model of CSBs, evidence in the literature does highlight several factors that may constrain or encourage the sustainability of such a community based seed production model. Based on the theory and information collected through interviews and literature review, the possible determinants of CSB survival, and thus sustainability, is expressed in the following equation of t_s:

> t_s=f(years of operational experience prior to the BTD project, number of CSB members, community members (including CSB) at least partially decided use of seeds (dummy), number of monthly meetings, percent of member attendance, meetings minutes are recorded (dummy), written bylaws (dummy), percent of CSB member with immediate family member in CSB, percent of CSB member with extended family member in CSB, distance to paved road, travel time in private vehicle to municipal city, predicted Principal Component Analysis (PCA) index score, CSB president older than 30 (dummy), CSB president's gender (dummy), promoter's gender (dummy), president and promoter are the same person (dummy), president's years of education, seed produced on CSB member land (dummy), seed produced on rented land (dummy), labor from CSB member (dummy), hired labor (dummy), number of silos, received silo from BTD project (dummy), access to: backpack sprayer (dummy), drying area (dummy), animal or vehicle for transportation (dummy), trained in CSB formation and organization (dummy), trained in seed marketing (dummy), yield, percent of seed

production distributed, , number of beneficiaries (per mz of seed production), percent of beneficiaries repaying, recovery rate, CSB supplied variety demanded (dummy), region of INTA (dummy for each region), type of CSB).

The dependent variable t_s is measured in years and calculated by the duration or survival of a CSB in the BTD project.

4.2 Empirical Estimation Strategy

Duration analysis has different names in different disciplines including survival analysis, event history analysis, transition analysis, lifetime analysis and failure-time analysis (Guo 2010). Regardless of the name, duration analysis focuses on a specified distribution of the population conditional on independent variables, called covariates, collected at the beginning of the study (Wooldridge 2011). In the current study, the duration of CSB operations in the BTD project is analyzed as a sequence of conditional probabilities that the CSB continues after time period *t* given that it has already survived until time period *t.*

T is a non-negative random variable that denotes the time to failure of the CSB. Following Cleves *et al.* (2010), the cumulative distribution function is expressed as,

$$F(t) = \Pr(T \leq t) \tag{4}$$

By reversing the cumulative distribution function, the survival function *S* is:

$$S(t) = 1 - F(t) = \Pr(T > t) \tag{5}$$

At *t* =0, or prior to the end of the first year of the BTD project, all of the CSBs are operating and thus the function is equal to one. Therefore, the survivor function reports the probability that no CSB has failed prior to *t.* As *t* increases, and as CSBs fail, the function approaches zero. In this study, as in most studies using duration analysis, *T* is treated as a continuous random variable. As such, its density function, *f(t)* is obtained from *S(t)* or *F(t)*:

$$f(t) = \frac{dF(t)}{dt} = \frac{d}{dt}\{1 - S(t)\} = -S'(t) \tag{6}$$

This density function forms the basis for estimating the hazard function, *h(t),* which has many names, but an appropriate name for this study is the age-specific failure rate. Also known as the instantaneous rate of failure, *h(t)* gives the probability of CSB failure during a given interval, here measured in years, conditional on the CSB having survived until the beginning of the interval, divided by the width of the interval:

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t+\Delta t > T > t | T > t)}{\Delta t} = \frac{f(t)}{S(t)} \tag{7}$$

By defining the accumulated risk up to time *t* as the cumulative hazard function *H(t),*

$$H(t) = \int_0^t h(u)du = \int_0^t \frac{f(u)}{S(u)} du = -\int_0^t \frac{1}{S(u)} \left\{\frac{d}{du} S(u)\right\} du = -\ln\{S(t)\} \tag{8}$$

it is possible to define any of the four functions (cumulative distribution function, survivor function, hazard function and density function) of probability distribution of failure time if one is already given.

$$S(t) = \exp\{-H(t)\} \tag{9}$$

$$F(t) = 1 - \exp\{-H(t)\} \tag{10}$$

$$f(t) = h(t) \exp\{-H(t)\} \tag{11}$$

As mentioned earlier, duration analysis is interested in estimating hazard functions conditional on covariates. Two important classes of models are used to analyze the effects of covariates on survival time.

The first is the proportional hazards (PH) model. The main assumption that cannot be violated in a PH model is that every CSB's baseline hazard function is the same and each CSB's hazard function is proportional to the baseline. The hazard function of PH models take on the form,

$$h(t; \boldsymbol{X}) = h_0(t)K(\boldsymbol{X}) \tag{12}$$

with time invariant and positive function $K(\boldsymbol{X})$ proportionally and multiplicatively shifting individual hazard functions away from the time dependent positive baseline hazard $h_0(t)$ (Wooldridge 2011). Following the notation of Cleves et al. (2010), $K(\boldsymbol{X})$ is parameterization as $K(\boldsymbol{X}) = \exp(\boldsymbol{X\beta})$ and the hazard function conditional on covariates for the PH models is

$$h(t|\boldsymbol{x}_j) = h_0(t)\exp(\boldsymbol{x}_j\boldsymbol{\beta}_j) \tag{13}$$

The semiparametric Cox Model and the parametric Weibull distribution and Gompertz models are PH models considered in this study. In each of these models, a well-defined baseline hazard $h_0(t)$ can be added to equation (13) above to obtain the hazard function conditional on the covariates.

The Cox model is a semiparametric model because its baseline hazard does not assume a parametric specification or distributional assumption. That said, the effects of the covariates are parameterized to establish a baseline survivor function. Said differently, it is assumed that the covariates shift the baseline survivor function. The hazard rate for the *jth* CSB at time *t* conditional on covariates $\boldsymbol{X}_j$ is given by

$$h(t|\boldsymbol{x}_j) = h_0(t)\exp(\boldsymbol{x}_j\boldsymbol{\beta}_j) \tag{14}$$

where β_j are the regression coefficients to be estimated. The equation is identical to equation (13) because the Cox model does not specify a baseline hazard function. Therefore, in estimations of Cox models no constant or intercept is computed. In statistical programs such as STATA, however, Cox-adjusted survival estimates can be computed.

One of the benefits of the semiparametric model is apparent when the distribution function is depicted graphically. While an assumed distribution will have a smoothed curve beginning at 1 when time is zero and approaching 0 as time increases, the Cox allows for a step function (as it is not bound to a specific distribution) that resembles plots such as Figure 6.1 below.

A second PH model is the Gompertz model. Like all of the models considered below, the Gompertz model is a parametric model. Parametric models use maximum likelihood estimators as they allow time, the dependent variable, to assume non-normal parametric distributions (Guo 2010). The parametric distributions are defined by parameters that can be calculated and once specified, used to obtain the survival and hazard functions. The baseline hazard for the Gompertz model is

$$h_0(t) = \exp(\gamma t)\exp(\beta_0) \tag{15}$$

After combining the above with equation (13) the conditional hazard function is given by

$$h(t|\boldsymbol{x}_j) = \exp(\gamma \, \mathrm{t})\exp(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_j) \tag{16}$$

and the conditional survivor function is

$$S(t|\boldsymbol{x}_j) = \exp[-\gamma^{-1}\exp(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_j)\{\exp(\gamma t) - 1\}] \tag{17}$$

For the Weibull model, the baseline hazard function is

$$h_0(t) = \mathrm{p}t^{p-1}\exp(\beta_0) \tag{18}$$

Thus using equation (13) above, the conditional hazard function is

$$h(t|\boldsymbol{x}_j) = \mathrm{p}t^{p-1}\exp(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_j) \tag{19}$$

and the conditional survivor function is

$$S(t|\boldsymbol{x}_j) = \exp\{-\exp(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_j)t^p\} \tag{20}$$

When the parameter p is greater than one, $p>1$, the hazard rate is increasing and when $p<1$, the hazard rate is decreasing as time passes. An interesting feature of the Weibull distribution is its relationship with the exponential distribution. When the p parameter is one, the Weibull distribution reduces to the exponential distribution. Thus the exponential distribution assumes constant hazard rate over time. The Weibull distribution not only can be a (PH) model, but it can also take the form of an accelerated failure time (AFT) model, the second class of models considered in this paper.

While PH models provided results allowing for the comparison of hazards between CSBs of differing covariates, AFT models provide results allowing for a comparison of survival times. Specifically, how covariates accelerate the time that passes between the beginning of the study and the time of failure or CSB withdrawal from the BTD project.

Following Cleves et al. (2010) AFT models or ln (time) models follow the parameterization:

$$\ln\left(t_j\right) = \mathrm{x}_j\beta_{x,} + \epsilon_j \tag{21}$$

but instead of assuming a distribution of t_j, a distribution is assumed for

$$\tau_j = \exp(-\mathrm{x}_j\beta_x)t_j \tag{22}$$

and since $t_j = \exp(-\mathrm{x}_j\beta_x)\tau_j$

$$\ln\left(t_j\right) = \mathrm{x}_j\beta_{x,} + \ln(\tau_j) \tag{23}$$

When $\exp\left(-\mathrm{x}_j\beta_x\right) = 1$, then $\tau_j = t_j$ and time is “normal” but when $\exp\left(-\mathrm{x}_j\beta_x\right) > 1$ time passes faster so the event occurs sooner and thus time is accelerated. Likewise, when $\exp\left(-\mathrm{x}_j\beta_x\right) < 1$ time passes slower so the event occurs later and time is decelerated.

For the lognormal regression, $\tau_j \sim lognormal(\beta_0, \sigma)$

$$S\left(t_j|\mathrm{x}_j\right) = 1 + \Phi\left\{\frac{\ln t_j - (\beta_0 + \mathrm{x}_j\beta_x)}{\sigma}\right\} \tag{24}$$

For the log logistic distribution model, $\tau_j \sim loglogistic(\beta_0, \gamma)$ and

$$S\left(t_j|\mathrm{x}_j\right) = \left[1 + \left\{\exp(-\beta_0 - \mathrm{x}_j\beta_x)t_j\right\}^{\frac{1}{\gamma}}\right]^{-1} \tag{25}$$

The parameters, β_x, estimated in the AFT models give the proportional change in duration (survival) time given a one unit change in the explanatory variable, all else held equal.

CHAPTER 5: DATA AND DESCRIPTIVE STATISTICS

5.1 Data Sources

The data for this study comes from the survey of community seed banks conducted in 2012 in Nicaragua. The survey was conducted by the extension workers and promoters who were trained by the author in March 2012, during a round of regional training sessions for the BTD project. The extension workers and promoters were also trained in IRB requirements of protection of human subjects and how these requirements would impact the data collection process. The survey instrument used for this study captured the general characteristics of the CSBs, their membership profiles, and seed production experience. An English version of the final instrument is included in Appendix A.[6]

The regional coordinators of the BTD project collected the completed surveys from the extension workers and submitted them to the national INTA office in Managua for data entry. All the 207 CSBs that had participated in the BTD project in 2011-2012 (i.e., the first year of the BTD project) were targeted for this survey. By June 2012, 154 CSBs had submitted the completed surveys. Table 5.1 presents the total number of CSBs targeted for the survey versus included in this study by region. Multiple attempts were made by the author through requests to national INTA employees to obtain the surveys from all 207 CSBs, however, there remained 53 non-respondent CSBs. Table 5.2 presents the distribution of the surveyed CSBs by region and type of CSB.

[6] Unfortunately, the INTA leadership of the Centro Sur region circulated a draft version of the survey to the CSBs instead of a final version. As a result, certain variables regarding quality of the seed produced and feedback from beneficiaries (clients) were not obtained for the CSBs from this region. Since most of these CSBs were 'individual' seed banks where seed growers did not directly interact with their seed recipients but instead INTA collected, packaged and distributed the seed, responses to these questions would have been skipped in the survey for these types of seed banks that were common in the Centro Sur region.

Over the course of the BTD project, INTA staff submitted reports listing the CSBs that continued to operate in the final two years of the project as well as a selected group of CSBs that were supported in the 2014 agricultural season (after the official end of the BTD project). Information on which CSBs failed during the BTD project years 2 and 3, and which continued after the end of the BTD project is used in the duration analysis to determine which characteristics of the CSB are associated with variations in the CSBs failure rates and time of operation.

Table 5.1: Total number of CSBs targeted for the survey versus those that completed the survey and included in this study

Region	Total number of CSBs targeted	Number of CSBs that returned the completed survey (sample size for this study)
Centro Norte	41	37
Centro Sur	40	40
Las Segovias	44	29
Pacifico Norte	62	28
Pacifico Sur	20	20
Total	207	154

Table 5.2: Distribution of surveyed CSBs by region and type

	Type of Seed Bank			
Region	Classic	Parceled	Individual	All
Centro Norte	37	0	0	37
Centro Sur	0	10	30	40
Las Segovias	15	11	3	29
Pacifico Norte	7	21	0	28
Pacifico Sur	13	7	0	20
Total	72	49	33	154

5.2 Descriptive statistics of variables included in the model

Tables 5.3, 5.4 and 5.5 provide summary statistics of the variables included in the duration analysis. Since one of the objectives of this study is to characterize the differences and similarities between the CSB models, the statistics are presented by the three types of CSBs—classic, parceled and individual. The dependent variable in duration analysis is calculated as the duration of time (i.e., number of years) from a starting point (in this case the start of the BTD project) to the occurrence of an event (in this case the withdrawal of a CSB from the BTD project). The weighted average of the 'duration' variable (i.e., number of years participating in the BTD project) is lowest for Individual CSBs at 1.6 years and highest for Parceled banks at 2.2 years (Table 5.3). Individual banks as a group had a statistically different weighted average years of survival at a 10% level than the other two CSB types.

Table 5.3 Summary Statistics of variables used in the duration analysis: Differences across types of CSBs in community level characteristics, membership and operating procedures

	Type of Community Seed Bank						
	Classic		Parceled		Individual		TOTAL
# of Observations	72		49		33		154
Mean Years participation in BTD	2.07	a	2.22	a	1.61		2.02
# of Years (% Yes)							
1 Year	38.89	~	26.53	~	69.7	~	41.56
2 Years	29.17	~	30.61	~	12.12	~	25.97
3 Years	18.06	~	36.73	~	6.06	~	21.43
4 Years	13.89	~	6.12	~	12.12	~	11.04
CSB Organizational Structure							
# Years operation at beginning of BTD	0.24	a	0.31	a	0		0.21
# of CSB members	9.35	a	7.51	a	1		6.97
CSB or Community members had voice in use of seed produced (% Yes)	81.94	a	79.59	a	45.45		73.38
Number of monthly meetings	1.41	a	1.37	a	0		1.09
% of CSB members attending meetings	82.38	a	89.38	a	0		66.96
Meeting Minutes Recorded (% Yes)	54.17	a	61.22	a	0		44.81
CSB has written bylaws (% Yes)	54.17		73.47		0		48.70
% of CSB members with Immediate family members in CSB	40.71	a	31.42	a	0		29.03
% of CSB members with Extended family members in CSB	22.86		11.03	a	0	a	14.20
Community Characteristics							
Distance to paved road (KM)	14.21	a	12.52	a	8.24	a	12.40
Travel time to Municipal Seat in private car (minutes)	25.86	a	25.57	a	28.64	a	26.36
PCA of Community Level Development[1]	-0.10	a	0.30	a	-0.23	a	0
Leadership Characteristics							
President older than 30 (% Yes)	95.83	a	83.67		96.97	a	92.21
President's Gender (% Male)	90.28	a	87.76	a	84.85	a	88.31
Promoter's Gender (% Male)	87.50	a	85.71	a	84.85	a	86.36
President is Promoter (% Yes)	65.28	a	48.98	a	100		67.53
President’s years of education	5.58	a	7.29	b	5.73	ab	6.16

Notes:

[1] PCA means Principal Components Analysis

Types of CSBs that share a letter are not significantly different at the 10% level

~ indicates that a significance tests across groups has not been performed for these variable

5.2.a Characteristics of Individual Banks

There are several statistically significant differences in the descriptive statistics for individual banks compared to the other two types of CSBs (Table 5.3 and 5.4). As mentioned above, one such variable is the duration of BTD participation, the dependent variable in this study. Years of operation prior to the beginning of the BTD project was zero for individual banks, not from lack of seed production experience, but from not previously using the CSB operational structure.[7] The percent of promoters that are also the presidents of their CSBs, percent of CSB members related to another CSB member, and the variables related to CSB meetings are not relevant to individual seed banks due to the nature of this type of seed bank (Table 5.3). Training related to formation and organization of the CSB also did not occur for individual banks (Table 5.4). Additionally, less than half of the individual seed banks reported having a voice in the decision of use of seed (Table 5.3) due in part to INTA's seed distribution plan within the Centro Sur region described in Chapter 3.

5.2.b Organizational Structure of CSBs

Comparing classic and parceled CSBs in regards to indicators of organizational structure, there were only two variables that were statistically different (Table 5.3). A higher percentage of extended family members participated in classic CSBs than parceled CSBs and a higher share of parceled CSBs had written bylaws than the classic CSBs. Written bylaws are a good indicator of both following the CSB formation protocol given by INTA but also the organizational disciple of administering and planning required in a business orientated enterprise with several partners. No significant difference was detected in the number of meetings per month, average attendance per meeting and documenting minutes of the meetings between the two types of banks.

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[7] The survey instrument did not capture years of seed production experience, the relevant variable of interest for individual seed producers.

5.2.c Community Characteristics

No statistically significant differences were found between the three types of CSBs in the index of community development,[8] distance to paved road and travel time to town in a private vehicle. While these community level characteristics did not differ between types of CSBs, there were regional differences between the five INTA administrative regions presented in Table B.1 of Appendix B.

5.2.d Leadership Characteristics

In rural Nicaragua, age is closely associated with farming experience as urban to rural migration is rare. Most rural Nicaraguans would state that they have been farmers since they were born. Likewise, with age comes responsibility as community leadership roles are less likely to be held by youth. The presidents of over 95% of classic and individual banks were older than 30 years of age. Only 84% of presidents of parceled CSBs were older than 30 years representing a statistically significant difference compared to the other two types of CSBs.

While there was no statistical difference between the three types of CSBs in gender of the president and promoter, the presidents' of parceled CSBs had more years of education than classic CSBs. On average presidents of parceled CSBs completed more than 7 years of formal education while classic CSB presidents completed less than 6 years. The years of education of presidents of individual banks were not statistically different than the other two types of CSBs.

5.2.e Land Use in CSB Seed Production

Table 5.4 provides a summary of seed production inputs by types of CSBs. There was a large and statistically significant variation in ownership of land used for seed production between

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[8] A principal component analysis (PCA) of 14 community level characteristics (reflecting the infrastructure and amenities present/absent in the community) was used to generate this index of community development. Lower numbers represented communities with less access to public services and amenities. See section B9 of the survey included in the Appendix for a complete list of community level characteristics comprising the PCA index.

the three types of CSBs. While 81% of classic CSBs used land owned by a CSB member, the share was much lower among parceled (61%) and individual (15%) CSBs. Around a quarter of the classic and parceled CSBs rented land and were not significantly different, while only 3% of individual CSBs rented land. Some CSBs with multiple seed plots reported using CSB member land and renting it from another farmer, while some individual CSBs did not report using either source of land. Other sources of land possibly used by individual CSBs could be borrowed land (without paying rent) or a crop sharing agreement where the land owner provides the land and the seed bank (producer) provides the labor with the agreement of splitting the harvested production. Unfortunately, these other options were not included in the survey, and thus it is difficult to determine if and how many of the CSBs that did not report using their own land or rented land used these alternate sources of land or whether they simply did not respond to that question (and thus we potentially have the problem of missing data).

5.2.f Labor use for seed production

In terms of labor input, as expected, the classic CSBs reported statistically higher use of CSB members for labor than the parceled and individual CSBs. While low use of hired labor by classic banks was expected because CSB members provided labor, it was surprising that individual seed banks did not hire labor and instead mostly relied on household members for labor input. The similarities of seed production between the parceled and individual banks explain the lack of statistically significant difference in the use of CSB member labor. In the case of individual banks, the operator him/herself is in charge of production but for parceled banks they could have access to additional CSB members providing labor.

5.2.g Assets and access to facilities used for seed production

The CSBs also vary in terms of assets and access to facilities (Table 5.4). Number of silos is an important variable for CSBs because an additional silo provides the opportunity to store an additional variety of seed or grain while still maintaining the varietal distinction. Parceled CSBs had a significantly higher number of silos compared to classic and individual CSBs. Although the share of parceled banks that received silos from the BTD project was higher than the other two types, the difference is likely due to existing silo ownership prior to the BTD project. Some silos were inherited by CSBs from the MCC project in the *Pacifico Norte* region and 43% of parceled CSBs are in the *Pacifico Norte* region.

Backpack sprayers are an important tool used to apply inputs. Although there was no statistical difference between the three types of CSBs, over 76% of classic CSBs and 53% of parceled CSBs had this tool, while only 9% of the individual banks reported access to a backpack sprayer. If one CSB member had the tool, it is assumed that the CSB would have access to that tool. Therefore, the individual banks might be at a disadvantage compared to the classic and parceled if they are unable to borrow the tool from neighbors.

An area for drying seed is used during post-harvest treatment of seed. Twenty percent of parceled CSBs had access to a drying area while only 3% of parceled CSBs and no individual banks indicated having access to a drying area (Table 5.4).

A source of transportation is important to increase efficiency of moving plants or grain from the field to the drying area. There was no statistical difference between CSB types for the percent of CSBs with access to animals or a pickup for transportation.

Table 5.4 Summary statistics of variables used in the duration analysis: Differences across types of CSBs in seed production inputs

	Type of Community Seed Bank						
	Classic		Parceled		Individual		TOTAL
# of Observations	72		49		33		154
Land							
Land used for seed production (MZ)	1.19	a	1.00	a	0.99	a	1.09
Seed produced on CSB member land (% Yes)	80.56		61.22		15.15		60.39
Seed produced on rented land (% Yes)	23.61	a	28.57	a	3.03		20.78
Labor							
CSB members provided labor (% Yes)	90.28		69.39	a	69.70	a	79.22
Hired workers provided labor (% Yes)	12.50	a	57.14		0	a	24.03
Assets/facilities							
# of Silos	1.83	a	3.39		1.09	a	2.17
CSB received Silo from BTD Project (% Yes)	30.56	a	67.35		12.12	a	38.31
CSB has access to backpack sprayer (% Yes)	76.39		53.06		9.09		54.55
CSB has access to seed/grain drying area (% Yes)	2.78	a	20.41		0	a	7.79
CSB has access to transportation (pickup/mule/ horse/ox) (% Yes)	73.61	a	83.67	a	90.91	a	80.52
CSB has access to animal transportation (mule/ horse/ox) (% Yes)	73.61	a	83.67	a	69.70	a	75.97
Human Capital							
CSB trained in Formation and Organization (% Yes)	88.89	a	95.92	a	9.09		74.03
CSB trained in Seed Marketing (% Yes)	25.00	ab	36.73	b	12.12	a	25.97
CSB trained in Seed Production (% Yes)	90.28	a	95.92	a	90.91	a	92.21

Notes:

Types of CSBs that share a letter are not significantly different at the 10% level

5.2.h Human capital in seed production

As mentioned above, few individual seed banks received training on CSB formation and organization while the levels of this training were not significantly different for classic (89%) and parceled (96%) CSBs. Training on seed marketing, a skill deemed very important for sustainability as per the literature, was received by 37% of parceled banks, 25% of classic banks and 12 % of individual banks. There was no statistically significant difference between the classic CSBs and the other two types of banks, but the share of parceled banks receiving this training was significantly higher than individual banks (Table 5.4). Finally, seed production training was received by 92% of the CSBs and did not significantly differ among the types of CSBs.

5.2.i Output and efficiency indicators in Seed Production

As reported in Table 5.5, there are also differences and similarities in the output and efficiency indicators across the three types of CSBs as measured by yield, number of beneficiaries, loan repayment and meeting the varietal diversity needs of the communities served by these banks in the first year of their operation under the BTD project. On average, CSBs of all three types used one manzana (0.7 hectares) to produce a little over 1200 pounds of seed per manzana and marketed seed to just fewer than 29 (clients) beneficiaries per manzana. There was no statistical difference in potential yield[9] among the three types of CSB. The similarity in size, number of clients served, and yield can be attributed to recommendations by the BTD project and a similar input package distributed across types of CSBs.

Despite the similarities, parceled CSBs disseminated a statistically larger percentage of their seed production (58%) to beneficiaries than classic CSBs (43%). The percent of production distributed to beneficiaries of individual CSBs did not differ than the other two types of CSBs.

At the BTD project level, repayment terms for beneficiaries were established to be two pounds of grain for each pound of seed received from the CSB. The two-for-one scheme was to differentiate the value of seed compared to grain and recover production costs. The importance of ensuring repayment was not always understood by INTA staff and extension workers in all regions as noted in Table B.1 of Appendix B. The Centro Norte region, where 51% of the

[9] Potential yield is the highest yield achieved by a CSB during the BTD project. For CSBs that withdrew from the BTD project after Year 1, yield and potential yield are the same.

Classic CSBs are located, had an extremely low compliance rate of only 1% due to a regional implementation of a one pound of grain repayment for each pound of seed received. The classic banks' repayment rate as measured by compliance with the two to one guidelines was half that of the parceled and individual banks (Table 5.5). Similarly, the recovery rate of seed was only 49% for classic CSBs and 7% for the Centro Norte region compared to 76% among all CSBs.

Table 5.5 Summary statistics of variables used in the duration analysis: Differences across types of CSBs in seed production output indicators

	Type of Community Seed Bank						
	Classic		Parceled		Individual		TOTAL
# of Observations	72		49		33		154
Output and Efficiency Indicators							
Year 1 Yield (QQ/MZ)	11.05	a	14.07	a	12.78	a	12.38
Yield potential (QQ/MZ)	15.75	a	17.67	a	14.00	a	15.98
% of production distributed to beneficiaries	43.37	a	57.89	b	50.18	ab	49.45
# Beneficiaries per MZ Seed Production	25.16	a	30.86	a	33.45	a	28.75
% of Beneficiaries Fully Repaying (2lb per 1lb)	23.76		55.74	a	54.04	a	40.43
Recovery rate (repaid/seed distributed)	0.49		0.88	a	1.18	a	0.76
CSB supplied variety demanded (% Yes)	29.17		63.27	a	57.58	a	46.10

Notes:

Types of CSBs that share a letter are not significantly different at the 10% level

In year 1 of the BTD project, the CSBs had few options of varieties to offer to their communities. Most CSBs received registered seed of only one variety, INTA Rojo[10], because that was the main variety available from INTA and it was considered to be widely adapted to different conditions across the country, was resistant to diseases, and fetched a decent market

[10]A little over 83% of CSBs received INTA Rojo. Other varieties produced by CSBs in year 1 of the BTD project were INTA Sequia (12% of CSBs) and INTA Matagalpa (5% of CSBs).

price for grain[11]. But the availability of one main variety for seed production throughout the country implied that the location specific demand for diverse bean varieties was not met by all CSBs. Less than a third of classic CSBs offered a variety that was among the highest demanded seed varieties in their community. Supplying a demanded variety was higher among parceled (63%) and individual (58%) CSBs (Table 5.5).

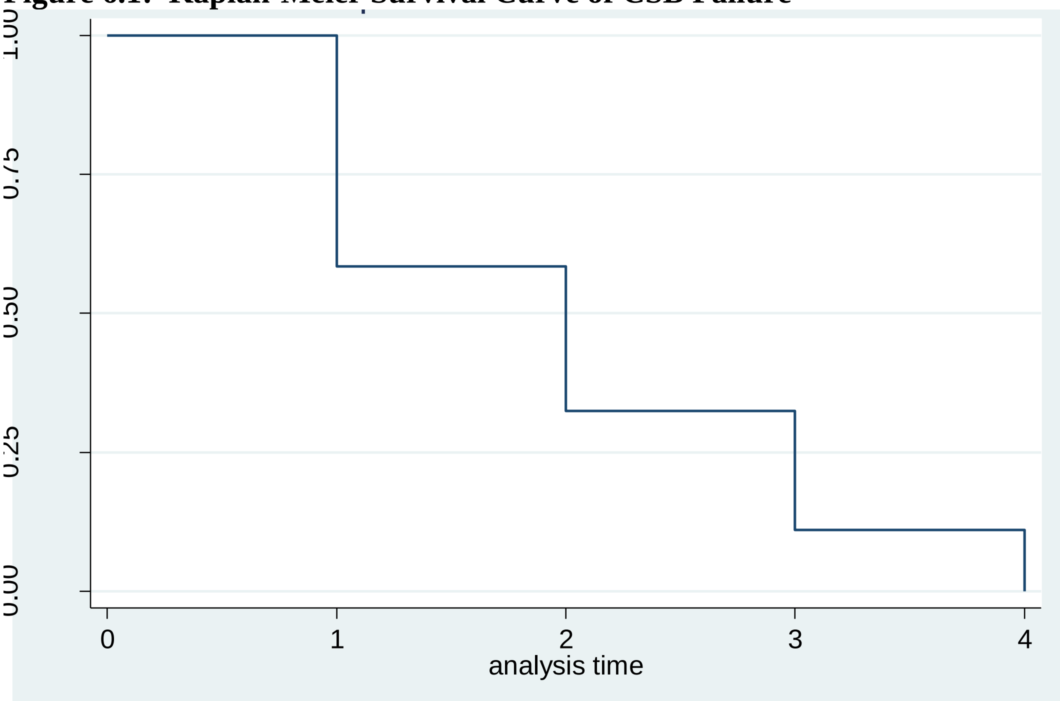
[11] The price for grain of a category of land race or *Criollos* varieties call *Rojo Seda* is largely assumed to be higher than INTA Rojo, however, no market prices were collected for this study.

CHAPTER 6: DURATION ANALYSIS RESULTS

6.1 Non-parametric duration analysis

A non-parametric technique of duration analysis is helpful to visually observe the data and different subgroups of the data (Kleinbaum and Klein 2012). The non-parametric technique used in this study is the Kaplan-Meier Survival (KMS) curves. Additionally, the log-rank test is used to test if multiple KMS curves are different. Figure 6.1 gives the KMS survival probabilities for each year of the BTD program.

Figure 6.1: Kaplan-Meier Survival Curve of CSB Failure

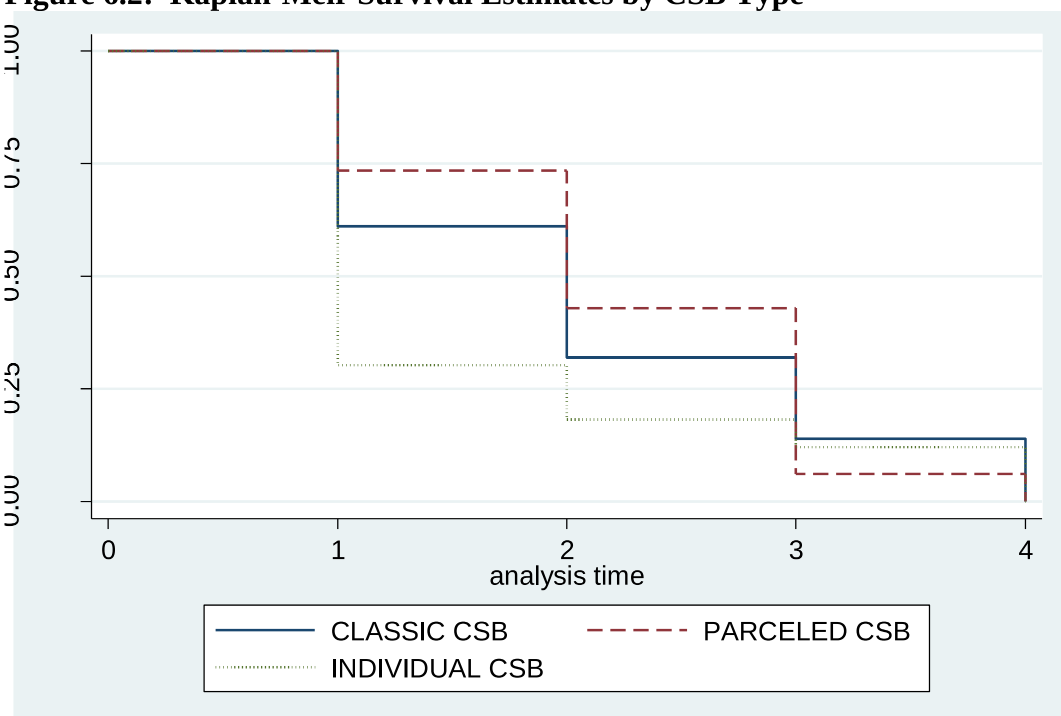


The horizontal axis represents the years of the BTD project. For example, t=0 is at the beginning of the BTD project and t=1 is the end of year 1, t=2 is the end of year 2, and so on. The agricultural year in Nicaragua begins with the rain in May, thus t=0 is May 2011, and t=1 is

May 2012 when the first year of the BTD project ended and the second year began. The vertical axis represents the percent of CSBs still operating, thus at t=0, the curve's y-value is 1 because none of the CSBs had failed. After year 1 of the BTD project or between t=1 and t=2, the function has the value of 0.58 because 58% of the CSBs remained in the BTD project. The speed of leaving the BTD project (or ending the spell) is highest at the beginning and slows near the end.

Of interest in this study are the differences between the three types of CSBs. KMS curves for each of the three types of CSB are given in Figure 6.2.

Figure 6.2: Kaplan-Meir Survival Estimates by CSB Type



After year one, the curve for parceled CSBs is higher than the curves for the classic and individual CSBs. These curves indicate that initially, parceled CSBs have the best probability of sustainability. However, after year 3, the curves for classic and individual CSBs are higher than parceled CSBs. These results indicate that the speed of failure is high initially for individual seed banks, but slows down considerably in subsequent years. There appears to be little change in the speed of failure of the parceled CSBs over the analysis time.

The KMS curves in Figure 6.2 indicate that the survival functions are not equal for all three CSB types. The log-rank test confirms with Chi squared(2)=4.96, *p*-value 0.0835, so at a 10% level we reject the null hypothesis that the survival functions of the three types of CSBs are equal. A second common test with the same null hypothesis is the Wilcoxon test and it confirms the results of the log-rank test at a higher level Chi squared(2)=10.84, *p*-value 0.0044. Since regional heterogeneity is anticipated, we can test for difference in survival curves while controlling for regional differences using a Wilcoxon test stratified by the five INTA regions. The results reveal the same conclusion, Chi squared(2)=6.11, *p*-value 0.0471, the null hypothesis, that the three survival functions are equal, is rejected at a 5% level.

As described in Chapter 4, three proportional hazard (PH) models are considered, the semi-parametric Cox model and two parametric models, the Weibull and Gompertz. The PH model assumption is that the hazard rates are constant and proportional to each other between all CSBs for the entire analysis time. A visual test by graphing the log-log KMS survival estimates of each CSB type plotted against the log of time, given in Figure 6.3, provides evidence of violations of the PH assumption.

Figure 6.3: Log Log Kaplan-Meier Curves by CSB Type

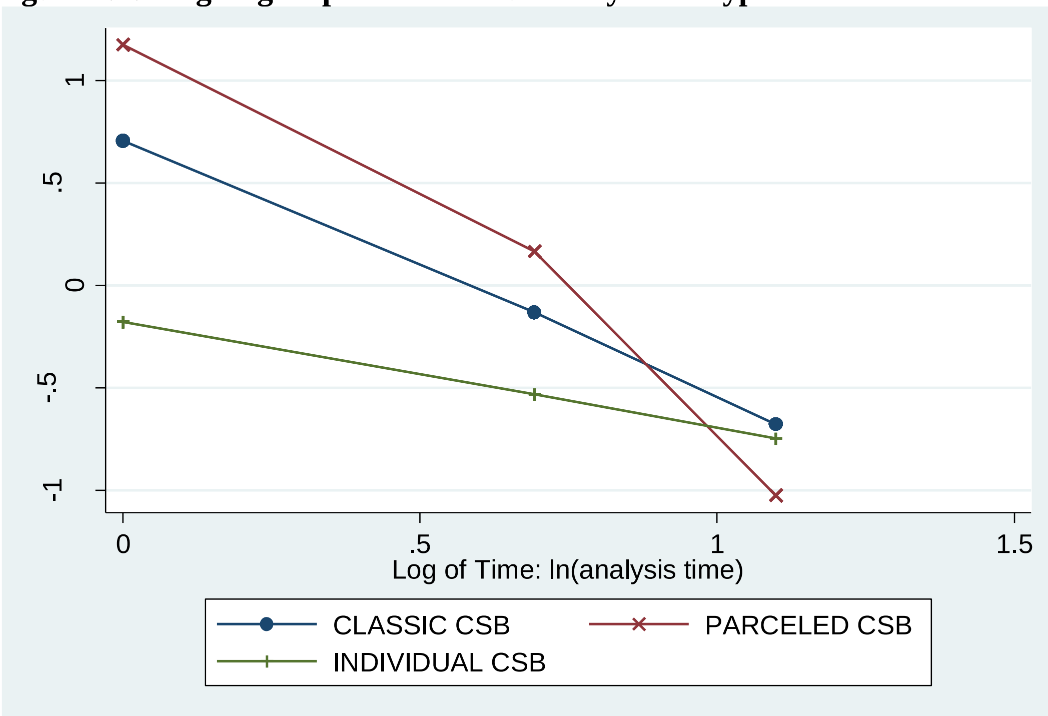


Figure 6.3 reveals that the three survival curves are not parallel and thus the PH assumption is violated. To confirm or reject this result, a post estimation test using Schoenfeld residuals will be used after fitting a Cox PH model. Figure 5.3 also indicates that the exponential distribution is not appropriate because the slope of the curves appear to differ from -1. The *p*-parameter of the estimated Weibull model will be able to confirm this result.

6.2 Parametric and semi-parametric duration analysis

To fit the model, first all of the variables considered important from the literature review are included. Three PH models, the Cox, Weibull and Gompertz, and two AFT models, the log-normal and log-logistic are estimated. Comparison of the models to determine the best model is performed by comparing the estimated log-likelihood (higher is better) and two post-estimation information criterion (lower is better)—the Akaike information criterion (AIC) and Schwarz's

Bayesian information criterion (BIC). Additionally, the significance levels of the coefficients are considered when comparing different models.

6.2.a Full and preferred duration analysis models

Table 6.1 provides summary information of the conditional probability of CSB failure for the five full and preferred models of duration analysis. The sign of the relationship between the independent variables and survival is given. A positive sign for the PH models indicate that the hazard ratio is less than one (one unit increase in the explanatory variable decreases the hazard of failure) while a negative sign indicates a hazard ratio greater than one (one unit increase in the explanatory variable increases hazard of failure). In AFT models, a positive sign indicates a positive coefficient and thus a delay in failure (one unit increase in the explanatory variable accelerates or stretches out time) while a negative sign indicates a negative coefficient and thus faster CSB failure (one unit increase in explanatory variable decelerates or condenses time).

The models give consistent results of the relationship between the dependent and independent variables when significant. There were few examples of variables found to be significant in the PH models but not in the AFT models. Four variables that are statistically significant in the PH models but not in the AFT models are: the dummy variables for Centro Sur (compared to Centro Norte), president's gender, parceled CSBs (compared to classic CSBs) and community voice in the seed use decision. Likewise, the dummy variable for Pacifico Norte was significant in two AFT models but not in the HP models.

The relationship between different characteristics of the CSB and its survival predicted by these models is generally aligned with expectations. Yield, repayment rate, number of silos, president's age, CSB headed by a male president, and the practice of recording meeting minutes all had a positive relationship with the survival variable. The number of beneficiaries per unit of land used for production had a negative relationship with survival, possibly due to limitation in the CSBs' networks for reaching potential clients. Once the CSBs had lent seed to all known farmers, they were forced to lend to unknown farmers who may not repay at the same rate due to lower levels of trust. The relationship of survival and voice of community member in the seed use decision was also found to be negative. The relationship of survival and share of family members in the CSB membership was negative possibly due to community perceptions that the CSB is exclusive to one clan or that poor management occurred because leadership roles were assigned for reasons other than qualification.

Travel time to the municipal seat (major city of local government with commerce and market) had a positive relationship with survival indicating that CSBs further from cities had higher survival rates. The opposite result was expected as an assumed decline in frequency and quality of supervision from INTA was predicted due to the increase in travel time. However, the results may be attributed to the fact that communities furthest from a commercial town may have low access to certified seeds and thus an increased interest in the CSB and greater support for having a local source for quality seed.

The relationship between the use of a CSB member's land for seed production was negative. While this was unexpected, it could be attributed to seed producers who do not use their own land know the soil quality limitations and seek soil of better quality than their own for seed production. Also, CSBs that used member's land might have had fewer resources to gain access to quality land for seed production.

From Table 6.1, the p-parameter on the Weibull models is not equal to 1 at a 5% level and thus we can officially rule out the exponential model as the hazard rates are not constant. Likewise, the γ-parameter on the Gompertz model is statistically different than 0 at a 5% level, confirming that the hazard rates are not constant. Since the shape parameters on the Weibull models are greater than 1 and those of the Gompertz model are positive, the probability of CSB failure increases with time.

Table 6.2 gives the summary statistics to determine the best model. Among the preferred models, the Weibull and Log Normal models had the highest log likelihood. The Log Normal also had the lowest AIC and BIC among AFT models. The Weibull model had a lower AIC and BIC results than the Gompertz model among parametric HP models. While the Weibull model included the most variables that were significant at a 10% level, it was the Log Logistic model that included the most significant variables among AFT models. The Weibull for parametric PH and Log Normal for AFT will be the choice models to use for the final results.

Table 6.1: Summary Results of Duration Analysis of CSBs

Variables	Cox Full	Cox Preferred	Weibull Full	Weibull Preferred	Gompertz Full	Gompertz Preferred	Log Normal Full	Log Normal Preferred	Log Logistic Full	Log Logistic Preferred
CSB Organizational Structure										
# Years operation at beginning of BTD	NS		NS		NS		NS		NS	
# of CSB member	NS	NS	NS	+*	NS	+*	NS	+**	NS	NS
1=Community had a voice	NS	-**	NS	NS	NS	NS	NS		NS	
# of monthly meetings	NS	-*	-*	-**	NS		NS		-*	NS
% of member attending meetings	NS		NS		NS		NS		NS	
1=Meeting minutes recorded	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***
1=written bylaws	NS		NS	NS	NS		NS	NS	NS	
% CSB members with immediate family member in CSB	-**	-***	-***	-***	-***	-***	-***	-***	-***	-**
% CSB members with extended family member in CSB	NS		NS		NS		NS		NS	
Community Characteristics										
Distance to paved road	NS	NS	NS		NS		NS		NS	
Travel time to city in private car	+***	+**	+***	+***	+***	+***	+***	+***	+***	+***
PCA	NS		NS		NS		NS		NS	
Leadership Characteristics										
1=President's age>30	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***
President male	+***	+***	+***	+***	+***	+***	+*	+**	NS	NS
Promoter Male	NS	NS	-*	-*	-*	NS	NS	-*	NS	
President is Promoter	NS	NS	+*	NS	NS		NS	NS	NS	
# Years Education of President	+***	+***	+***	+***	+***	+***	+***	+***	+***	+**
Land										
1=seed produced on CSB member land	NS	-*	-**	-***	NS	-**	NS	-**	NS	-*
1=land rented	NS	NS	-*	-*	NS	NS	NS		NS	
Labor										
1=labor from CSB members	NS	NS	-*	NS	-*	NS	NS	NS	NS	NS
1=hired labor	NS	NS	NS	NS	NS		NS		NS	

Table 6.1 (cont'd)										
	Cox		**Weibull**		**Gompertz**		**Log Normal**		**Log Logistic**	
Variables	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**
Assets/facilities										
# of Silos	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***
Did receive Silo from BTD	NS	NS	NS	NS	NS		NS	NS	NS	
1=backpack sprayer	NS		NS		NS		NS	NS	NS	NS
1=drying area	NS		NS		NS		NS		NS	
1=mule/horse/ox access	NS		NS		NS	NS	NS	NS	NS	NS
Human Capital										
1=trained in CSB formation	NS		NS		NS	NS	NS		NS	
1=trained in seed marketing	NS	-*	NS	NS	-**	-**	NS	NS	NS	
Year 1 Yield (qq/mz)	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***
% of production distributed to beneficiaries	NS		NS		NS		NS		NS	
beneficiaries/mz	-**	-**	-**	-**	-**	-***	-*	-**	NS	-***
% of beneficiaries repaying 2x1 lbs	+**	+***	+**	+***	+***	+***	+*	+**	+**	+***
1=Supplied variety demanded in community	NS		NS		NS	NS	NS		NS	
Region and Type of CSB										
Centro Sur dummy	NS	-*	-**	-**	-*	-**	NS	NS	NS	NS
Las Segovias dummy	-**	-***	-***	-***	-**	-**	NS	NS	NS	NS
Pacifico Norte dummy	NS	NS	NS	NS	NS	NS	NS	+*	NS	NS
Pacifico Sur dummy	+**	+***	+**	+***	+***	+***	+***	+***	+***	+***
Parceled Bank dummy	NS	NS	NS	NS	NS	-**	NS	NS	NS	NS
Individual Bank dummy	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Constant			NS	NS	NS	NS	-**	-***	-**	-**
Parameter			p=3.102	p=3.022	γ=1.280	γ=1.203	σ=0.381	σ=0.390	γ=0.219	γ=0.232

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

+ and – indicate whether the significant relationship is positive or negative

NS indicates that the variable was included in the model but it is not significant

Table 6.2: Summary of Decision Statistics to Determine Best Model

	Cox		Weibull		Gompertz		Log Normal		Log Logistic	
Statistic	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**	**Full**	**Preferred**
Log likelihood	-584.045	-585.957	-69.836	-72.727	-81.584	-86.888	-69.861	-73.648	-72.268	-80.045
Restricted LL	-625.129	-625.129	-124.207	-124.207	-133.747	-133.747	-118.378	-118.378	-127.337	-127.337
AIC	1246.090	1227.914	221.671	205.454	245.167	229.777	221.722	203.295	226.536	208.090
BIC	1364.531	1312.948	346.186	296.563	369.683	314.812	346.237	288.330	351.051	280.977
# of Significant Variables (at least 10%)	12	17	19	18	16	17	12	16	11	12

Table 6.3 provides the results of a likelihood ratio test that justifies the omission of non-significant variables with less than unity *t*-ratios in the preferred models. The null hypothesis is that the coefficients of the omitted variable are jointly not equal to zero. By failing to reject the null hypothesis, the preferred models have only removed a set of explanatory variables that jointly equal zero from the full model.

Table 6.3: Summary Statistics for Testing Coefficients of Omitted Variable

Statistic	Cox (PH)	Weibull (PH)	Gompertz (PH)	Log Normal (AFT)	Log Logistic (AFT)
Log likelihood[a]	-584.045 (-585.957)	-69.836 (-72.727)	-81.584 (-86.888)	-69.861 (-73.648)	-72.268 (-80.045)
Number of restrictions[b]	11	11	13	13	17
Calculated chi2	3.82	5.78	10.61	7.57	15.55
P-value	0.9748	0.8875	0.6435	0.8709	0.5556
Decision	not rejected	Not rejected	Not rejected	Not Rejected	Not Rejected

Notes
a: The log-likelihood for the full model is presented first and the log-likelihood for the full model is included in parenthesis.
b: The number of omitted variables are the same as the number of restrictions

6.2.b Interaction Terms

One of the important findings in the literature that is not confirmed in our initial duration analysis is the importance of training in marketing. It is also anticipated that interacting the types of CSBs with variables of interest will indicate differences in sustainability between the types of CSBs. Since the literature has not indicated specific interactions to be included in the model, a search for all possible interaction was conducted.

No interaction terms could be found to distinguish factors of sustainability between the types of CSBs. However, two interaction terms were discovered that are related to discussions in the literature. The dummy variable of president's gender and the dummy variable of access to animal transportation were significant. The animal transportation variable is a more restricted version of the transportation variable used in previous models. Unfortunately, the interaction term is not significant in the lognormal model.

A second interaction term was found for the dummy variable of seed marketing training and the continuous variable of yield in year 1. The results of the three models with these two added interaction terms and a discussion of the results are given in Table C.1 of Appendix C.

6.2.c Test of Proportionality Assumption

A test of the proportionality assumption of the Cox model using Schoenfeld residuals reveals that the model does not violate the assumption. The test results give a Chi squared (24) value of 28.47, and a *p*-value of 0.2409. We fail to reject the null hypothesis of no proportionality and it is assumed that the model does not violate the proportionality assumption. The test does provide results for each independent variable and the dummy variable for the Pacifico Sur region violates the proportionality assumption with a *p*-value of 0.0357. The hazard ratio describing the effect of a CSB located in this region is inappropriate if observed without the hazard ratios of other independent variables. One way to correct for this violation of the PH assumption is to allow the baseline hazard function to vary with the region. We accomplish this in the frailty section below.

6.3 Duration analysis of a dataset without Individual CSBs

By the structure of individual banks, many potential determinants of sustainability related to group organization are not relevant. For example, individual banks do not hold meetings or record meeting minutes and therefore, the presence of individual banks in the data may distort the influence of these variables. To ensure the results are not distorted, survival regressions are obtained for a subset of the data that excludes individual seed banks. The sign on the hazard ratios does not change and thus there are no distortions to the variables of interest mentioned above. Table D.1 in Appendix D provides a comparison of the Weibull model with and without Individual CSBs.

Since the parceled and classic CSBs were directly involved in the seed distribution process (unlike the Individual banks in the Centro Sur region where INTA distributed the seed) the number of communities reached (market size) and the feedback received from clients or seed recipients (quality) are available. Table D.2 in Appendix D provides the results that indicate quality, as measured by positive client feedback, has a positive relationship with sustainability. The impact of market size on sustainability was found to be positive as CSBs that distributed seed to exactly two communities had a lower hazard ratio than CSBs that only distributed seed to one community. No significant difference was found, however, between CSBs that reached more than 2 communities with seed compared to CSBs that focused only on one community.

6.4 Frailty models to remove heterogeneity

Duration analysis comes from medical survival studies where frailty is a random component to capture unobserved factors that impact survival. Using Kleinbaum and Klein's (2012) example, two male smokers of the same age may have different failure times and different survival functions because one might be more "frail" than the other. Some CSBs may have additional factors not captured in the data that explain why they have different survival functions than CSBs with identical observed characteristics.

6.4.a Individual Frailty

It has been assumed that each CSB, after controlling for all observable differences, are homogeneous. If they are not homogeneous, the results of the determinants of sustainability, or variables, in the duration analysis will be affected. Also, the share parameters could be wrong (we had concluded that risk of failure increases with time). Although heterogeneity can come from misspecification of functional forms, it can also occur due to unobserved variation between CSBs. A frailty model includes an additional multiplicative term, with assumed mean of 1 and constant variance estimated as theta from the data. When the estimated frailty is greater than 1, than the CSB (or group in Shared Frailty below) has an increased hazard and decreased probability of survival compared to the other CSBs (or groups in Shared Frailty below). A likelihood-ratio test that theta is equal to zero, indicating no heterogeneity, is preformed using the preferred log-normal model from above with a frailty distribution of gamma. No individual heterogeneity was detected; indicating that after controlling for observable differences in CSBs, no individual CSB (or group in Shared Frailty below) experience any increased or decreased hazard of failure.

6.4.b Shared Frailty

Although heterogeneity has been controlled for between CSBs in our preferred model, there still may be unexplained differences between the INTA administrative regions. Just as frailty models accounted for individual differences, shared frailty models account for differences in survival functions from unobserved factors. If we have not controlled for all of the differences between regions, once again our shape parameters and duration analysis results will be affected. We anticipate regional heterogeneity because of the unique seed production history of each region detailed in Chapter 3. While the previous models controlled for these differences through the fixed effects method, it is now necessary to test and adjust the preferred models for the presence of heterogeneity.[12]

All three preferred models indicate the presence of shared frailty. The log-normal model has the highest *p*-value, 0.082, of the three models indicating that at a 5% level shared

[12] Appendix E presents two alternative methods to shared frailty to remove the regional heterogeneity effects.

heterogeneity is not detected. However, due to the low *p*-values in the Cox and Weibull (frailty distribution of gamma) models (0.011 and 0.001 respectively), and given that at a 10% level the null hypothesis of no heterogeneity is rejected, it is assumed that shared heterogeneity is present. The results with regional heterogeneity effects removed are presented in Table 6.4. Only the AFT model is displayed because the hazard ratios in PH models are affected by frailty. In PH models, the hazard ratios obtained are only the hazard ratios for *t*=0 (Cleves et al 2010, Gutierrez 2002).

Table 6.4 Log Normal (AFT) Duration Analysis results with Heterogeneity Removed

Variables	Coefficient		Std. Err.
1=Meeting minutes recorded	0.251	***	0.095
% CSB members with immediate family member in CSB	-0.231		0.143
Travel time to city in private car (minutes)	0.001		0.002
1=President's Age>30	0.420	***	0.160
1=President is male	0.248		0.216
1=CSB has Horse, Mule or Ox	0.186		0.227
Interaction President male and CSB has animal	-0.148		0.238
# of Years of President’s Education	0.020	*	0.012
1=seed produced on CSB member land	-0.088		0.087
# of Silos	0.059	**	0.021
1=access to backpack sprayer	0.158	*	0.093
1=trained in CSB formation	-0.158		0.125
1=trained in seed marketing	0.258		0.191
Max Yield (yield potential) (qq/mz)	0.028	**	0.005
1=trained in seed marketing*yield	-0.022	**	0.010
# of beneficiaries/mz	-0.005	***	0.002
% of beneficiaries repaying 2x1 lbs	0.251	**	0.114
1=Parceled Bank	-0.109		0.107
1=Individual Bank	-0.290	*	0.164
Constant	-0.626	*	0.329
Shape Parameter	σ=0.390		0.029
Shared Frailty Parameter	θ=0.083		0.092
LR test of θ=0	$\chi 2$=2.02		p-val=0.077
Log likelihood	-78.230		
Restricted LL	-113.214		
Frailty Distribution	Gamma		
AIC	200.461		
BIC	267.274		

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

The results indicate that at an 8% confidence level we reject the null hypothesis that the shared heterogeneity parameter *theta* is equal to 0. Therefore, the shared frailty model is the final and preferred model for our analysis of CSBs.

The results from Table 6.4 reveal that an additional beneficiary for a CSB producing seed on a plot of one manzana, and all else held equal, decrease the time to failure by 0.5%. As repayment compliance rates increase by 10%, time to failure is 2.5% longer. An additional silo delays time to failure by 5.9% while CSBs with presidents aged 31 and older survive 42% longer than CSBs with presidents aged 30 or younger. An additional year of CSB president's education decreases failure time by 2%. Individual banks fail 29 % faster than classic CSBs. CSBs that meet, and record meeting minutes survive 25% longer than CSBs that do not record meeting minutes. CSBs with access to a backpack sprayer survive 16% longer than those without the device.

6.4.c Additional Potential Source of Bias

Because continuation in the BTD program in each year is not only a CSB level decision but also decided by INTA's regional or national staff or the extension worker (see Chapter 4 for additional details) one could argue that survival in Year 4 was an exogenous decision of the CSBs based on funding at best but also potentially political connections. To ensure that inclusion of year 4 is actually modeling BTD participation or survival and not a decision of INTA staff, duration analysis of a truncated data set with the same number of observation but "failure" of the 17 CSBs that had previously survived until Year 4 occurring in Year 3 reveal small changes in the coefficient values but minimal changes in significance level. Additionally, when the 4th year was included by right-censoring the 17 CSBs in year 3, similar results were obtained. Table F.1 in

Appendix F provides the results of duration analysis of these two truncated data sets with heterogeneity effects removed and a comparison of the final model.

CHAPTER 7: CONCLUSIONS, POLICY IMPLICATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

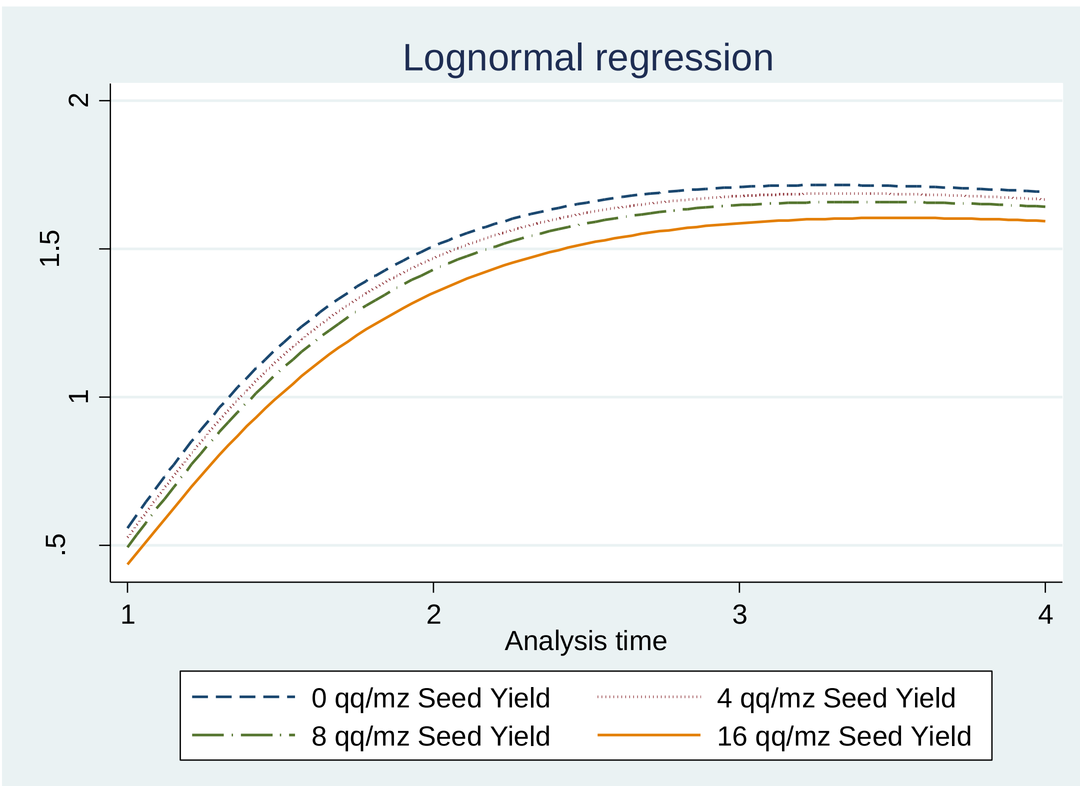
Eight main results are found from the duration analysis of the CSBs in Nicaragua, which were supported as part of the BTD project. Each has implications for future iterations of CSB projects but also larger scale seed enterprises focusing on the production and distribution of improved variety of bean seed.

First of all, the analyses show that type of CSB does matter. Individual seed banks may provide a good contract farming option to NARS and extension programs for meeting project driven seed requirements, but based on the evidence from this study, they do not provide a sustainable model for a community based seed production system. Individual CSBs, as implemented in the BTD project, failed 29% faster than the classic CSBs. As against this, there was no statistically significant difference in the survival rate between the parceled and the classic CSB models. Furthermore, the number of membership had no effect on the sustainability of the CSBs. Recording the minutes of the meeting is found to be one of the determinants of sustainability and indicates the importance of formality of operations and documenting decisions within community groups in the longevity of community based seed organizations. Evaluating the hazard functions of parceled and classic CSBs (similar to Figure 7.4 below) indicate that the importance of recording meeting minutes was the same for both types of CSBs.

A second finding is that training on seed marketing is a determinant of CSB sustainability. As Witcombe et al. (2010) found in Nepal, marketing training was necessary to build demand, establish partnerships and ultimately self-finance improved variety seed production. The results from the CSBs in Nicaragua suggest that in the first years of seed production, the impact of training is noted through an interaction term with yield.

The results indicate that a one unit (qq/mz) increase in yield for a CSB without marketing training and holding all else equal, will decrease failure time (and thus increase survival time) by 2.8%. The same one unit increase in yield for a CSB with marketing training and holding all else equal, will decrease failure time by 0.6%. For further discussion from earlier models of the implications of training, please see Appendix E. The implication is best seen graphically in the figures below.

Figure 7.1: Hazard Functions of CSBs with Training at Four Seed Yield Levels



Figures 7.1, 7.2 and 7.3 show the hazard rates at four levels of seed yield (0 qq/mz, 4 qq/mz, 8 qq/mz and 16qq/mz) for CSBs trained (Figure 7.1) in seed marketing and CSBs without seed marketing training (Figure 7.2). When the eight hazard curves are plotted together in Figure 7.3, it becomes clear that CSBs with training have lower hazard curves than CSBs with the same

level of yield but without training at levels of yield up to 15 qq/mz. The data from yield in year one of the BTD project reveals that 37% of the CSBs produced 8 qq/mz or less, 33% produced between 8 and 15 qq/mz, and 30% produced more than 15 qq/mz. Training reduces the variation in hazard functions and is clearly beneficial for CSBs with less than 15 qq/mz yield. Given the variation in seed production possible even with a package of technical inputs, seed marketing training is an important determinant of success of CSBs.

Figure 7.2: Hazard Functions of CSBs without Training at Four Seed Yield Levels

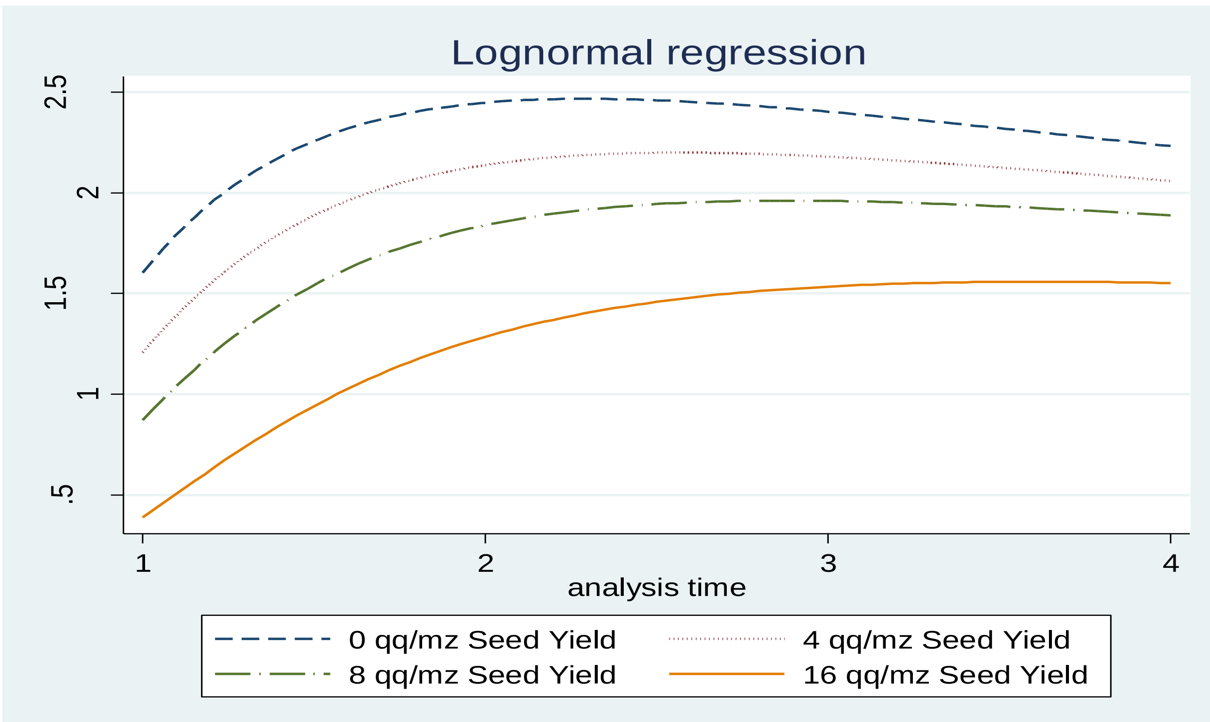
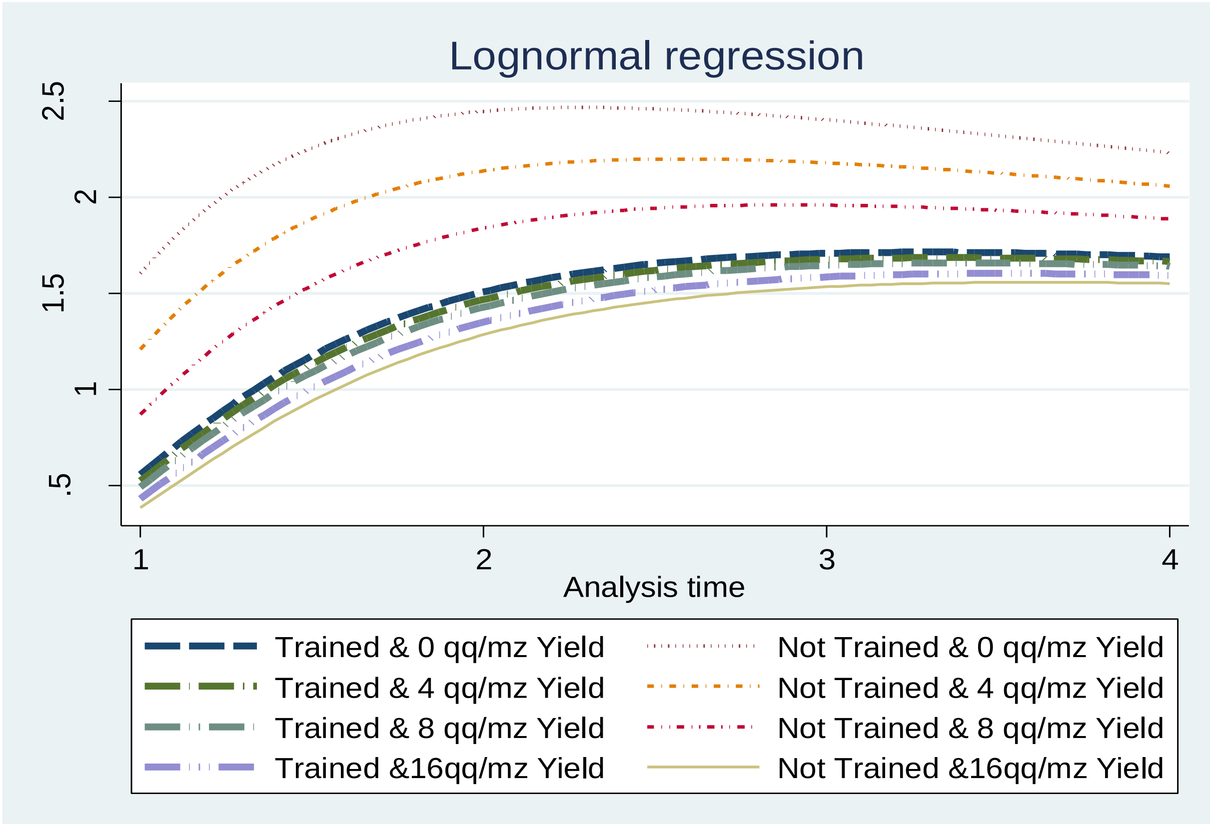


Figure 7.3: Hazard Functions of CSBs with and without Training at Four Seed Yield Levels

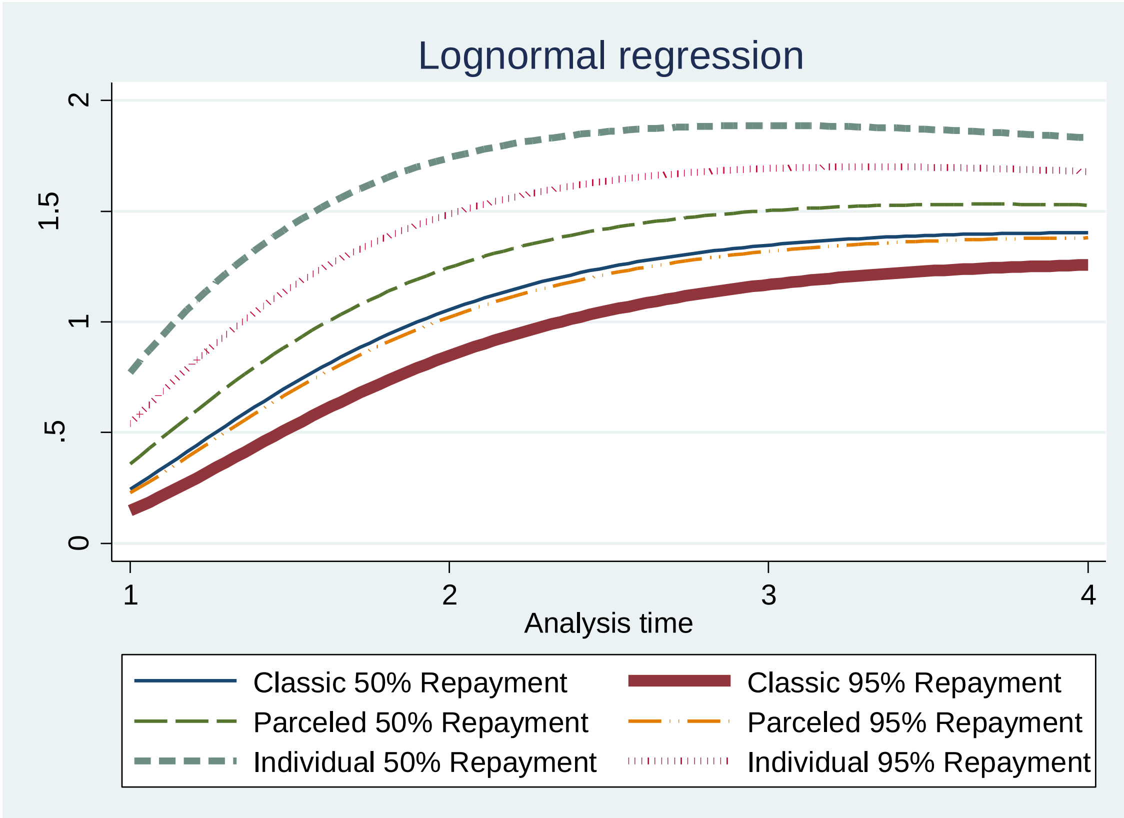


Providing the variety demanded by the community had no effect on sustainability. These results are expected to be different in the long run as CSBs that do not offer varieties that are demanded will not be able to generate revenue due to lack of sales. In the context of the BTD project, however, the CSBs changed the seed varieties available to farmers and a subsequent change in demand is expected. Calculations by the author from the survey data of beneficiary farmers of the BTD project (Maredia et al. 2014) found that 85% of the CSB seed recipients had not previously used the variety they received[13]. It is not surprising, therefore, that failure rates were the same for CSBs that did and did not supply a variety demanded in their communities.

[13] Just less than 85% of farmers receiving INTA Rojo, 72% receiving INTA Matagalpa and 96% of farmers receiving INTA Sequia reported planting the variety for the first time in 2011 or 2012 (Author’s calculation).

Third, cost recovery is often mentioned in the literature as necessary for sustainability. Two necessary business skills of CSBs offering seed purchase through loans to farmers is to judge the probability of repayment of each farmer at the moment of seed lending and successful reduction of seed loan delinquency through loan collection. Plotted for each type of CSB in Figure 7.4 are the hazard functions at 50% repayment and 95% repayment. The hazard function curves of all three CSB models shifted down proportionally with the increase in repayment rate from 50% to 95%. While the time to failure of parceled and classic CSBs where not statistically different as indicated in the results in Table 6.4, the difference is noted by comparing the two types of seed bank at the same repayment level. The classic CSBs have lower hazard function curves than parceled CSBs. In fact, the parceled CSBs needed a repayment rate of 95% to have a lower hazard function curve than the classic CSBs with a repayment rate of 50% holding all else equal.

Figure 7.4: Hazard Functions at two Repayment Rates by Type of CSB



While increases in loan repayment rate have a positive relationship with sustainability, the number of clients (per unit area of seed production) had a negative effect on sustainability. The results indicate that CSBs face increased risk of failure when they lend seed to more farmers per unit of operation (i.e., when the intensity of seed operation is very high). The faster time-to-failure of CSBs with more clients per unit of land used for seed production indicates operational deficiencies and diminishing capacity of CSBs to manage a large number of clients. This result again emphasizes the importance of seed marketing training as well as training in business operations to increase the operational efficiencies of CSBs and their survival rates.

Fourth, quality of seed produced is important. The results of duration analysis of classic and parceled CSBs presented in Appendix D reveal that CSBs with positive feedback on the quality of seed have a 43% lower hazard ratio than CSBs that received mixed or negative feedback. The results also indicate that land tenure has no effect on sustainability. One possible interpretation of this result is that the quality and suitability for seed production of the land are more important criteria for choosing land for seed production than choosing based on land owned by a CSB member or renting land.

Unfortunately, CSBs could not provide reliable data on important seed quality indicators such as germination test results, humidity at time of storage and seed purity after post-harvest treatment (the percent of seeds free of lumps or divots, fungus, germinated, contrasting or seed of other varieties)[14]. Thus, we are not able to evaluate the importance of seed quality as measured by these indicators. But as a good practice guideline, it is important that technicians and seed producers are trained on the importance of producing seed that meet these quality criteria in future promotion of decentralized seed production.

Fifth, number of silos is an important determinant of CSB sustainability. On average CSBs had just over 2 silos but only 38% of CSBs received silos in the first year of the BTD project. Although transportation of silos to remote communities might present considerable challenges when roads are in poor condition or do not exist in mountain communities, silos are a necessary asset for seed producing organizations and efforts to coordinate their delivery are rewarded in the form of longer time to failure in CSBs.

Sixth, CSBs with high concentrations of immediate family members (defined here as parents, children or siblings) had higher hazard ratios than CSBs with few or no immediate relatives in the Weibull proportional hazards models. Although no effect was found in the final heterogeneity removed model, efforts should be made to form CSBs that are more representative

[14] See Arraya and Fonseca (2007) for details of seed purity criteria in Central America.

of the community by including members from different families rather than more members from a few families. This will increase the stakeholder base within a CSB, which can increase the community support as the bank will be viewed as an equitable source of seed for the entire community. The impact of extended family members (cousins, uncles and aunts, nieces and nephews) on sustainability was non-significant in all models indicating that in a village community where such relationships are likely to exist and perhaps unavoidable, this should not be a source of concern when forming a CSB.

Seventh, experienced leaders are an important determinant of survival. As stated earlier, age is often associated with experience and for the CSBs in the BTD project with presidents older than 30 year of age, failure occurred 33% later in time than CSBs lead by younger presidents. When plotted to compare differences in types of CSBs (similar to Figure 7.4), the effect of president's age had the same effect on all three types of CSBs. No effect was found for the age of the promoters, indicating that youth leadership in seed production and implementation of new technologies can be as effective as their older peers and should not be discouraged.

Female headed CSBs face additional challenges. Although no difference was found in the final model, there was evidence in earlier (albeit less robust models) that female led CSBs have higher failure rates and can benefit more from transportation assets. While this finding should not discourage policymakers implementing a project like BTD from including female leadership, it should be considered in the planning process, and efforts should be made to facilitate access to readily available and appropriate transportation and other assets. The identification of needed assets and their acquisition methods (i.e., renting, cash purchase and financing the purchase) should form part of the initial training.

Finally, a comprehensive needs assessment by extension worker or supervision staff should precede the implementation of project supported CSBs. Evidence of the importance of liquidity and access to (or ownership of) assets such as backpack sprayers and silos was found to be significant in the final model. Additionally, yield was a determinant of sustainability and thus liquidity to purchase inputs at the onset of disease or presence of pests to prevent crop failure should be a consideration to increase the viability and sustainability of a CSB.

The PESA guide to CSBs did not consider access to productive assets and financial services as important for choosing a community suitable for a CSB. The PESA guide lists the opposite as a community level condition for implementing a CSB in a given community as it should have little or no technical and financial assistance from other organizations. While the goal of reaching the most needed communities is noble (and demand for quality seed may be highest in such communities), project budgets will need to include purchase of such productive assets when they are not accessible in the community.

In conclusion, the results confirm much of the literature regarding factors contributing to the sustainability of community based seed production including the importance of training (seed marketing and business skills), ownership of productive asset (especially silos), experience of leadership, cost recovery, quality and quantity of seed produced, and operational formality in the form of conducting meetings and documenting decisions made at meetings with minutes. The two communal CSBs, supported during the BTD project, provided a production and delivery model that lasted longer than individual banks. The policy implication of these results is that CSBs present a more sustainable dissemination channel of improved variety seed to farmers than small scale contract-based seed production by individual farmers.

There remain several opportunities for future research on CSBs. First of all, a follow up survey and interviews with the leaders of the 154 CSBs included in this study and the INTA technicians and regional/national staff involved in the promotion of CSBs in Nicaragua can provide many missing pieces of information to explain the factors that went into their decision to continue and/or discontinue a CSB beyond project support. Secondly, reliable production cost data has been difficult to obtain despite efforts by the author and others. A study of community based seed production costs similar to Katungi et al. (2011) that value all aspects of seed production of *Apta* seed (i.e., QDS) in Nicaragua is needed to obtain a clear picture of the benefits to the CSB members and community as a whole. Finally, better knowledge of the determinants of purchase of replacement seed is needed to understand demand. While lack of access and affordability are often cited as the reason for low use of improved varieties, farmers that have technical training in bean grain production and increased resources from grain sales still have low rates of improved variety use in Nicaragua (Sain 2011, Carter et al. 2012). The literature is replete with studies that look at determinants of adoption of improved varieties (or decision to replace traditional/local varieties with new/modern varieties) (Feder et al. 1985, Mwangi et al. 2015). However, similar studies are needed to understand determinants of farmer behavior regarding replacement seeds post-adoption. Such information can help guide researchers, extension agents, policy makers and NGOs to better design sustainable seed production and distribution models in a developing country context such as Nicaragua.

Finally, it is important to identify the limitation to this study. Only the CSBs established in the first year of the BTD project that responded to the survey were considered for this study due to the data collection process. A more robust analysis would include the CSBs that began in the second and third year of the BTD project as well. Additionally, this study ended tracking the

CSBs at the end of the BTD project in 2014. INTA employees insist that some CSBs continued to operate with or without external support after 2014. Information about all of the CSBs' survival or status in years following the BTD project was not available to include in this study. Had this information been readily available, it would provide valuable additional information regarding CSBs sustainability beyond the years of the BTD project. Given these limitations, the results and conclusions of this study should be used in the context of survival of a CSB within the BTD project timeframe only.

APPENDICES

APPENDIX A: English Version of the Survey

INSTRUCTIONS: ***Meet with the people primarily in charge of the Community Seed Bank (CSB) leadership such as the president, vice president, secretary, treasurer and/or promoter. If at least four members are not available, ask to schedule a meeting when they will be available.***

Read the Consent Statement (page 2) and answer any questions group member have before continuing with the survey.

Most questions will give number codes for the possible answers. Please clearly record the code on the line provided. Some questions require specific prices or quantities. Please refer to CSB records whenever possible to confirm the amounts that CSB members are reporting.

Section G requests a list of seed bank members. If the secretary has a list of CSB members, it might be wise to start by writing in the names of the member in "column a" and then answering the information about each member.

[If the bank ***only consists of a producer*** *(usually cases like this only occur in the* ***South Central region****) then the producer is the only person to meet with and answer questions personally. The CSB is the person, so if the question relates to the support received by the CSB, it is actually asking for the support received by the individual.]*

Thank you for participating in this survey.

<u>INSTRUCTIONS</u>*: *The consent statement should be read by an INTA staff member who will be mainly responsible to collect the information. Read the following Consent Statement to the CSB members that will be providing the information solicited through an interview and a record keeping booklet. Since the information will be collected over time through multiple group or one-on-one meetings, the consent should be obtained only at the first meeting when all of the key CSB members are present.

The USAID-funded Dry Grain Pulses CRSP at Michigan State University, in collaboration with INTA is conducting a study on documenting the experience gained in implementing the Community Seed Bank model of bean seed production in Nicaragua. As part of this study, we are interviewing a few key members of all the CSBs in Nicaragua and systematically collecting information using a structured questionnaire and a record keeping booklet. The type of information we are collecting includes community setting, the membership of CSBs, its operation, and bean seed production practices, costs and outcomes. Some of the information will be collected by asking you some questions either as a group or individually and some will be collected by requesting you to keep a record in the booklet provided.

The completion of this study will require several short meetings or visits by me throughout the Primera 2012 season to collect and document data on seed production activities. Your participation in this study is **voluntary**. Your refusal to participate or to withdraw from the study **carries no penalty or loss of any benefits**. You are free to not answer any of the questions I will ask. However, I hope that you will answer all my questions and provide the information requested, as your responses will help us better understand the CSB model and to derive lessons for improving it here in Nicaragua and elsewhere. Any information about individuals collected from you will be **kept private** and included in reports only in aggregate analysis without the individual's name.

Do you have any questions about this study?

<***Pause and respond to any questions raised, then continue with the following statement***>

If you don't have any questions or if I have addressed your questions satisfactorily, I would like to start the interview. By answering my questions, you indicate your willingness to <u>voluntarily</u> participate in the study. During the course of this study, if you have any questions/concerns, you may contact Dr. Mywish Maredia, at Michigan State University by phone: 001 517 353 6602 or Aurelio Llano the local contact for information.

Consent statement was read and discussed, and the CSB members agreed to be interviewed (check one) ☐1=Yes .☐2=No

A. INTA Information

A.1. INTA Region (write one)______

[1] Centro Norte
[2] Centro Sur
[3] Las Segovias
[4] Pacifico Norte
[5] Pacifico Sur

A.2.a. INTA Technician Name in charge of this seed bank: ________________________
A.2.b. INTA Technician's telephone number(s)__________________ __________________
A.2.c. INTA Technician's email address ____________________________
A.2.d. Was this INTA Technician the interviewer? (*circle one*) [1] Yes [2] No

If answer to A.2.d. was YES, skip to question A.4.

A.3.a. This Interviewer's name is:____
A.3.b. Interviewer's telephone number(s) ______________________ _____________________
A.3.c. The Interviewer's email address ___________________________________
A.3.d. Interviewer is (write one)_______

[1] INTA Staff
[2] Seed Bank Promoter
[99] Other (specify)___________________________

A.4. Date of the interview: Day_____ Month__________ Year_2012 .

B. General Information of Seed Bank

B.1 Name of the Community Seed Bank (CSB) ________________________________

B.2. Name of Village/town of CSB operation _______________________

B.3. Name of Villages/towns where 2011 seed (loan) recipients live and approximate travel time: **minutes that take to walk from recipient's village/town to the town where the CSB operates**

(If you do not know the name of the community or it is not possible to travel to the community walking, please include a note to explain the situation)

a. Community Name ________________________ 1. Travel time: __________minutes walking
b. Community Name ________________________ 2. Travel time: __________minutes walking
c. Community Name ________________________ 3. Travel time: __________minutes walking
d. Community Name ________________________ 4. Travel time: __________minutes walking
e. Community Name ________________________ 5. Travel time: __________minutes walking

B.4.a. Name of the Municipality where CSB is operating ____________________________
B.4.b. Name of Municipal Capital City __________________________
B.4.c. How many minuets must you walk from the community of CSB operation (B2) to the closest bus stop to board a bus traveling to the **Municipal** Capital City _______________minutes walking. (*If the bus stop is in the community, answer will be 0 minutes*)

B.4.d. Once you have boarded the bus at the closest bus stop, what is the travel time from closest bus stop to the community of CSB operation (B2) to the **Municipal** Capital City in ***bus*** in *minutes*: _______________minutes

B.4.e. Frequency of bus route from (closest bus stop to) the community (B2) to **Municipal** Capital City

B.4.e.1 Trips per day __________

B.4.e.2 Days per week ____________ (*If the buses run Monday to Saturday, the answer will be 6. If the buses run Monday through Sunday, the answer will be 7*)

B.4.f. How many minuets must you walk from the community of CSB operation (B2) to the closest point that a ***car*** can get to your community? _________minutes walking. (*If a* ***car*** *can enter your community, the answer will be 0*)

B.4.g. Travel time from (the closest point that a ***car*** can get to) your community of CSB operation (B2) to **Municipal** Capital City in ***car*** in *minutes* _______________minutes

B.5.a. Name of the Department ___________________________

B.5.b. Name of Department Capital City _________________________

(If Department Capital City is the same as Municipal Capital City, go to B.6.)

B.5.c. How many minuets must you walk from the community of CSB operation (B2) to the closest bus stop to board a bus traveling to the **Department** Capital City _______________minutes walking. (*If the bus stop is in the community, answer will be 0 minutes*)

B.5.d. Once you have boarded the bus at the closest bus stop, what is the travel time from closest bus stop to the community of CSB operation (B2) to the **Department** Capital City in ***bus*** in *minutes*: _______________minutes

B.5.e. Frequency of bus route from (closest bus stop to) the community (B2) to **Department** Capital City

B.5.e.1 Trips per day __________

B.5.e.2 Days per week ____________(*If the buses run Monday to Saturday, the answer will be 6. If the buses run Monday through Sunday, the answer will be 7*)

B.5.f. How many minuets must you walk from the community of CSB operation (B2) to the closest point that a ***car*** can get to your community? _________minutes walking. (*If a* ***car*** *can enter your community, the answer will be 0*)

B.5.g. Travel time from (the closest point that a ***car*** can get to) your community of CSB operation (B2) to **Department** Capital City in ***car*** in *minutes* _______________minutes

B.6. Distance from community of CSB operation (B2) to closest paved or brick road _____KM (*answer will be 0 if community boarders or is crossed by paved road)*

B.7.a. Name of city or community where CSB would sell harvested grain___________________

B.7.b. What is the condition of the road from the community (B2) to the city mentioned above? ________

[1] Paved in good condition
[2] Paved in poor condition
[3] Some paved some unpaved
[4] Unpaved in good condition
[5] Unpaved in poor condition
[6] Impassable at times during the rainy season (river crossings)

B.8 In this village, what is the main bean producing season (write one)? ____

[1] Primera
[2] Postrera
[3] Apante

B.9. Which of the following services are available in the village (B2)?

	B9a	B9b	B9c
Service	ID	Is this service currently available in your community/village? [1] YES [2] NO	If NO, what is the distance to the closest available service center? KM
Access to electricity	11		
Access to water service (network)	12		
Access to wells	13		
Access to radio	14		
Access to television network	15		
Access to cell phone network	16		
Access to telephones (landlines)	17		
Access to health centers	18		
Access to private bank services	19		
Access to community/rural banks	20		
Is there a primary school in this village?	21		
Is there a secondary school in this village?	22		
Is there a government's extension service office in this village?	23		
Are there any NGOs providing agricultural-related services in this village?	24		

B.10. Which of the following options best describes your CSB? _________

[1] The CSB is made up of several members of the community (partners or members) and bean seed is grown in **an area of approximately one manzana (possibly only one field) with one promoter.** The members of the CSB make decisions about which seed variety to use (beginning in 2012), what input to use, who should receive seed (loan), and how to secure repayment of grain (loan repayment).

(If answered [1] continue with all sections)

[2] The CSB is made up of several members of the community (partners or members) and bean seed is grown in on **several lots with several promoters.** The members of the CSB make decisions about which seed variety to use (beginning in 2012), what input to use, who should receive seed (loan), and how to secure repayment of grain (loan repayment).

(If answered [2] continue with all sections)

[3] The CSB is made up of one individual who grows the seed and makes decisions, sometimes with the help of INTA, as to who should receive the seed (loan).

(If answered [3], please skip to section E and answer the questions on a personal basis. The CSB is the person, so if the question asks, who supports the CSB it is actually asking who supports the individual)

C. Information about the Establishment of the Community Seed Bank

C.1 When was the first President elected (CSB founded)?
C1a. Month___________ C1b. Year___________

C.2 What organizations supported the seed bank when it was first established?
[1] Yes [2] No
C.2.a INTA ____
C.2.b FAO ____
C.2.c NGO ____ (***if yes, include name***)
____
C.2.d Other ____ (***if yes, describe support and include name***)___________________
____

C.3 How many CSB members founded the seed bank and voted for the original president/secretary/promoter? ___________ members

C.4 Of the number of founding members listed in C.3, how many were men and how many were women?
C4a. Number of Men: _____________
C4b. Number of Women: ______________

C.5 During the first year after the CSB was established, indicate which of the following SEED was produced by the CSB [1] Yes [2] No

C.5.a: Beans ______
C.5.b: Rice ______
C.5.c: Maize _____
C.5.d. Sorghum ______
C.5.e. Other (specify):________

D. Seed Bank Operations

D.1 How often does the CSB have regular meetings per month?
__________________ times per month

D.2 Of the active members, on average how many attend regular meetings?
_______________members

D.3 Are minutes kept at the meetings? _______
[1] YES
[2] NO (***if no, go to D5***)

D.4.a If meeting minutes are kept, is someone responsible for recording them? _____ [1] Yes [2] No
D.4.b If yes, who is responsible for recording minutes? _______
[1] President
[2] Secretary
[3] Treasurer
[99] Other

D.5 Regarding the CSB's formal written copies of laws and planning? [1] Yes [2] No

D.5.a Does the CSB have internal by-laws? ____________

D.5.b Is there a *written* lending policy? ____________

D.5.c Is there a production plan with projected planting area, date and costs?__________

D.5.d Is there a training plan that identifies training needs? ____________

D.5.e Does the CSB have a bank account to deposit cash? ____________

D.5.f Are there financial records and reports available? ____________

(*If yes, please* ***list*** *which financial reports are available*)

D.5.f.1 ____

D.5.f.2 ____

D.5.f.3 ____

D.6. How were the CSB members selected?

____

____

____

____

D.7 Can anyone become a member of this CSB? __________ [1] Yes [2] No *If No, to go section E*

D.8 If yes, to become a new member, must the person looking to join the CSB be:

[1] Yes [2] No

D.8.a A resident of the community? ________________

D.8.b A BEAN grower? ________________

D.8.c Be recommended by a current member? ________________

D.8.d Have seed production experience? ________________

D.8.e Be a relative of a current member? ________________

D.8.f Other ________________ (*if yes please describe*)

____

____

__

E. Seed Bank Information (Current situation)

E.1. What groups currently support the CSB? [1] Yes [2] No

E.1.a INTA ____

E.1.b FAO ____

E.1.c NGO ____ (***if yes, include name***)

____

E.1.d Other ____ (***if yes, describe support and include name***)______________________

____

E.2 Does the CSB have access to the following vehicles and are they available for transport of grain/inputs? (select one option) [1] Yes-- [2] No

E.2.a Pickup truck ________
E.2.b. Tractor ________
E.2.c Horse, mule or donkey ________
E.2.d Other (describe) ________ (***if yes please name and describe***)____________
____

E.3 Does the CSB currently have access to the following facilities?
(select one option) [1] Yes- [2] No
E.3.a Bodega for equipment _______
E.3.b Area for drying seed/grain _______
E.3.c Threshing machinery ________
E.3.d Automatic dryer ________
E.3.e Pump/backpack sprayer for applying inputs ________
E.3.f Sewing machine for sacks ________

E.4 a. How many silos for grain or seed storage does the CSB currently have? ________
(*Include silos used by the CSB even if they were not acquired through the project USAID-MSU-INTA*)
E.4.b. If the CSB has *one* or *more* silos, how many quintals of grain can be stored in *ALL* these silos? ________ QQ
E.4.c Were any of the Silos donated to the CSB? ___________ [1] Yes [2] No
(*Include silos used by the CSB even if they were not acquired through the project USAID-MSU-INTA*)

E.5 Will this CSB continue in the project USAID-MSU-INTA in Primera 2012? ____ [1] Yes [2] No

E.6 In what types of training/capacity building activities have the CSB members participated?
[1] Yes [2] No
E.6.a CSB organization and formation ______
E.6.b Bean seed production (agronomics, pest management ______
E.6.c. Post-harvest treatment, handling and storage (threshing, drying, cleaning, packaging) ______
E.6.d. Seed bank management (financial, administrative, accounting) ______
E.6.e. Seed marketing ______

F. Seed Production ONLY FROM USAID-MSU-INTA project

F.1 How much planting material (registered BEAN seed) was received from INTA in 2011, how much area was planted with this seed and how much was produced and distributed?

F101	F102	F103a	F103b	F104	F105	F106a	F106b	F107	F108	F109	F110	F111	F112
		Date Received		Seed Received (qq)	Area Planted (MZ)	Date Harvested		Total Production of Seed (qq)	Total Distributed as Seed to Farmers (qq)	Total Retained for Storage (qq)	Total Sold (qq)	Total Seed distributed among CSB members (qq)	Other (qq)
ID	Variety	Day	Month			Day	Month						
1													
2													
3													

(*The sum of F108, F109, F110, F111and F112 must equal F107)*

F.2 Was bean seed grown on the promoter's land in Primera 2011? _____ [1] Yes [2] No (*If no, go to F.3*)

F.2.a How much land was used? ______MZ

F.2.b How was the promoter compensated?__________

[1] Was not compensated [2] Received equal amount of seed as other CSB members ***(go to F.2.d)***

[3] Received cash ***(go to F.2.c)*** [4] Received more seed than other CSB member ***(go to F.2.d)***

[5] Received other form of compensation (specify) ______________________

F.2.c (*If answer* ***for F2b was [3] Received Cash****, please answer:)* What was the cash amount of compensation?

Cordobas ____________

F.2.d (*If answer* ***for F2b was [2] Received equal amount of seed… or [4] Received more seed…****, please answer:)*

How much seed did the promoter receive as his/her compensation? ___________ (lbs)

F.3 Was bean seed grown on another CSB member's land in Primera 2011? ______ [1] Yes [2] No (*If no, go to F.4*)

F.3.a How much land was used? ______MZ

F.3.b How was the CSB member compensated?__________

[1] Was not compensated [2] Received equal amount of seed as other CSB members ***(go to F.3.d)***
[3] Received cash ***(go to F.3.c)*** [4] Received more seed than other CSB member ***(go to F.3.d)***
[5] Received other form of compensation (specify) _______________________

F.3.c (*If answer* ***for F3b was [3] Received Cash****, please answer:)* What was the cash amount of compensation? Cordobas ____________

F.3.d (*If answer* ***for F3b was [2] Received equal amount of seed… or [4] Received more seed…****, please answer:)* How much seed did the CSB member receive as his/her compensation? ___________ (lbs)

F.4 Was bean seed grown on the rented land in Primera 2011? _____ [1] Yes [2] No (*If no, go to F.5*)

F.4.a How much land was rented? ______MZ

F.4.b Was the land owner compensation paid in cash?_______ [1] Yes (***go toF4c)*** [2] No (***go to F4d***)

F.4.c (*If answer* ***for F4b was Yes****, please answer:)* What was the cash amount of compensation? Cordobas ____________

F.4.d (*If answer* ***for F4b was No,*** *please answer:)* How was the land owner compensated? (detail) _____________________

F.5 Did the CSB receive material inputs for seed production in Primera 2011 from the following organizations?

[1] Yes [2] No

F.5.a INTA ___________(*if yes, list inputs*) ______________________________

F.5.b FAO ___________(*if yes, list inputs*) ______________________________

F.5.c NGO ___________(*if yes, name NGO and list inputs*) ____________
____

F.5.d Other ___________(describe) ______________________________
____

F.6 Who provided labor for bean seed production in Primera 2011?

[1] Yes [2] No

F.6.a CSB Members ___________

F.6.b Hired labor ___________

F.6.c Community members ___________

If the response was yes for F.6.a, please ask the following question:

F.6.a.1: How were the CSB members who provided their labor compensated?___________

[1] Were not compensated (worked voluntarily)
[2] Compensated in-kind (e.g., a share in seed production)
[3] Compensated in cash
[4] Received other form of compensation (specify)_________________

If the response was yes for F.6.c, please ask the following question:

F.6.c.1: How were the community members who provided their labor compensated?________

[1] Were not compensated (worked voluntarily)
[2] Compensated in-kind (e.g., a share in seed production)
[3] Compensated in cash
[4] Received other form of compensation (specify)_________________

F.7 Quality of Bean Seed Produced, Germination Rate, Humidity and Observed Physical Purity

F701	**F702**	**F703**	**F704**	**F705a**	**F705b**	**F705c**	**F706d**	**F706e**
Name of Variety	**Germination Test result (% of seed germination)**	**Humidity of Seed after drying (%)**	**Pure Seed (% of acceptable seed from random 100 seeds selected)**	**lumps/divots (Terrones in Spanish) (%)**	**Germinated (Germinado in Spanish) (%)**	**Distinct Characteristics (Contraste in Spanish) (%)**	**Fungus (Hongo en Semilla in Spanish) (%)**	**Other Varietyies (Semilla otras variedades) (%)**

F.8 Amount of Bean Seed distributed (loaned) in 2011 (and Apante 2012)

F801	**F802**	**F803**	**F804**	**F805a**	**F805b**	**F805c**
Season	**Total amount of seed distributed in pounds (lbs)**	**Total number of farmers (persons) who received seed**	**Total number of farmers (persons) who paid back 2 lbs of grain for every pound of seed received**	**Total pounds of grain received for repayment (lbs)**	**Value of Grain accepted for repayment (Cordobas/lb)**	**Total value of non-grain repayments (Cordobas)**
Primera 2011						
Postrera 2011						
Apante 2012						

F.9. How were the seed (loan) recipients chosen?

____

____

____

F.10 In Primera 2011, who made the decision on how to utilize the harvested seed from the CSB? __________

[1] General Assembly of CSB members
[2] Board of Directors of CSB
[3] INTA
[99] Other (describe)____

F.11 What is the most popular bean variety seed demanded in this community? ______

[1] INTA Rojo
[2] Rojo de Seda
[3] INTA Matagalpa
[4] INTA Sequia (Fuerte Sequia)
[99] Other (name)___________________________

F.12 Was the CSB able to meet the demand in the community for the variety of seed it produced in Primera 2011? _________ [1] Yes [2] No

F.13 Were other bean seed varieties that were not offered by the CSB requested by the community? _________ [1] Yes [2] No

F.14 (*If answered Yes is F13)* Please list the other bean seed varieties requested.

a.___________________________
b.___________________________
c.___________________________

F.15 What feedback or comments did the CSB receive from the farmers who received seed?

____

____

____

F.16.a Were labels attached to the bags of seed distributed? _______ [1] Yes [2] No (*If No, go to G.1*)

F.16.b Did the labels include the following: [1] Yes [2] No

F.16.b.1 Name of seed variety _________
F.16.b.2 Germination rate _________
F.16.b.3 Weight of bag _________
F.16.b.4 Date of production _________

G.1 Information about the Board of Directors (CSB members)

a. Name	b. Title/Designation [1] President [7] Vocal [2] Vice President [3] Secretary [8] Member [4] Treasurer [5] Promoter [6] Fiscal [99] Other	c. Age [1] Less than 18 [2] 18-30 years [3] 31-50 years [4] 51-65 years [5] Older than 65	d. Gender [1] Male [2] Female	e. Years serving as a member in the Seed bank [1] Less than 1 [2] 1-3 Years [3] More than 3	f. Education Level [1] No formal [2] Grade 1-5 [3] Finished 6 [4] Finished 9 [5] Finished 12 [6] More than 12	Does this member has a… g. Brother/Sister, Father/mother, or son/daughter in this seed bank? [1] Yes [2] No	Does this member has a… h. Uncle/Aunt, Grandparent, Grandchild or Cousin in this CSB? [1] Yes [2] No	i. Name of the Village where this member lives
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
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a. Name	b. Title/Designation [1] President [7] Vocal [2] Vice President [3] Secretary [8] Member [4] Treasurer [5] Promoter [6] Fiscal [99] Other	c. Age [1] Less than 18 [2] 18-30 years [3] 31-50 years [4] 51-65 years [5] Older than 65	d. Gender [1] Male [2] Female	e. Years serving as a member in the Seed bank [1] Less than 1 [2] 1-3 Years [3] More than 3	f. Education Level [1] No formal [2] Grade 1-5 [3] Finished 6 [4] Finished 9 [5] Finished 12 [6] More than 12	Does this member has a… g. Brother/Sister, Father/mother, or son/daughter in this seed bank? [1] Yes [2] No	h. Uncle/Aunt, Grandparent, Grandchild or Cousin in this CSB? [1] Yes [2] No	i. Name of the Village where this member lives
15.								
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APPENDIX B: Descriptive Statistics by INTA Administrative Region

Table B.1: Summary statistics of variables used in the duration analysis: Difference across INTA Administrative Regions

	INTA Administrative Region										
Variables	Centro Norte		Centro Sur		Las Segovias		Pacifico N.		Pacifico S.		TOTAL
# of Observations	37		40		29		28		20		154
Mean Years participation in BTD	1.68	a	1.68	a	2.10	a	2.07	a	3.15		2.02
Failure after Year (% Yes)											
1	48.65	~	55.00	~	41.38	~	35.71	~	10.00	~	
2	40.54	~	32.50	~	20.69	~	21.43	~	0.00	~	
3	5.41	~	2.50	~	24.14	~	42.86	~	55.00	~	
4	5.41	~	10.00	~	13.79	~	0.00	~	35.00	~	
CSB Organizational Structure											
# Years operation to beginning of BTD	0.00	a	0.00	a	0.62	b	0.00	a	0.70	b	0.21
# of CSB members	7.70	a	1.00		15.31		4.00		9.65	a	6.97
CSB or Community had voice in use of seed produced (% Yes)	86.49	b	57.50	a	75.86	ab	78.57	ab	70.00	ab	73.38
Number of monthly meetings	1.71	b	0.40		1.14	a	1.14	a	1.20	ab	1.09
% of CSB members attending meetings	78.77	ab	25.00		66.26	a	96.43	b	88.75	ab	66.96
Meeting Minutes Recorded (% Yes)	32.43	a	22.50	a	82.76	b	50.00	a	50.00	ab	44.81
CSB has written bylaws (% Yes)	21.62	b	10.00	b	82.76	a	85.71	a	75.00	a	48.70
% of CSB members with Immediate family members in CSB	51.64	b	0.00		33.86	a	32.14	a	33.90	ab	29.03
% of CSB members with Extended family members in CSB	24.97	b	0.00	c	20.69	ab	7.14	ac	23.13	ab	14.20
Community Characteristics											
Distance to paved road (KM)	21.48		9.75	a	10.86	a	9.91	a	6.58	a	12.40
Travel time to Municipal Seat in private car (minutes)	34.19	a	23.38	a	27.93	a	22.61	a	20.85	a	26.36
PCA of community Level Development	-0.57	a	-0.40	a	-0.03	a	1.14	b	0.29	ab	0.00
Leadership Characteristics											
President older than 30 (% Yes)	97.30	a	97.50	a	96.55	a	75.00	b	90.00	ab	92.21
President's Gender (% Male)	81.08	a	80.00	a	89.66	a	100.00	a	100.00	a	88.31
Promoter's Gender (% Male)	81.08	a	80.00	a	96.55	a	89.29	a	90.00	a	86.36
President is Promoter (% Yes)	75.68	a	100.00		72.41	a	14.29		55.00	a	67.53

Table B.1: cont'd

Variables	Centro Norte		Centro Sur		Las Segovias		Pacifico N.		Pacifico S.		TOTAL
Land											
Land used for seed production (MZ)	1.06	a	0.99	a	1.13	a	0.68		1.85		1.09
Seed produced on CSB member land (% Yes)	78.38	a	7.50		82.76	a	71.43	a	85.00	a	60.39
Seed produced on rented land (% Yes)	18.92	a	25.00	a	27.59	a	3.57	a	30.00	a	20.78
Labor											
CSB members provided labor (% Yes)	94.59	a	75.00	a	79.31	a	50.00		100.00	a	79.22
Hired workers provided labor (% Yes)	8.11	a	25.00	ab	17.24	a	50.00	b	25.00	ab	24.03
Assets/facilities											
# of Silos	1.35	bc	1.10	b	3.72	a	2.93	a	2.50	ac	2.17
CSB received Silo from BTD Project (% Yes)	16.22	b	10.00	b	58.62	a	75.00	a	55.00	a	38.31
CSB has access to backpack sprayer (% Yes)	94.59	b	10.00		44.83	a	42.86	a	100.00	b	54.55
CSB has access to seed/grain drying area (% Yes)	2.70	a	12.50	a	13.79	a	0.00	a	10.00	a	7.79
CSB has transportation assets (pickup/mule/ horse/ox) (% Yes)	86.49	ac	95.00	a	48.28	b	96.43	a	65.00	bc	80.52
CSB has animal transportation assets (mule/ horse/ox) (% Yes)	86.49	ab	77.50	ab	48.28	c	96.43	b	65.00	ac	75.97
Human Capital											
CSB trained in Formation and Organization (% Yes)	89.19	a	27.50		89.66	a	100.00	a	80.00	a	74.03
CSB trained in Seed Marketing (% Yes)	10.81	a	32.50	ab	20.69	a	50.00	b	15.00	a	25.97
CSB trained in Seed Production (% Yes)	83.78	a	90.00	a	93.10	a	100.00	a	100.00	a	92.21
Output and Efficiency Indicators											
Yield (QQ/MZ)	12.29	ab	16.42	b	11.20	a	11.68	ab	7.19	a	12.38
Potential Yield (QQ/MZ)	14.73	a	17.20	a	14.15	a	11.90	a	24.25		15.98
% of production distributed to beneficiaries	21.59		45.88	a	47.20	ab	80.90	c	67.35	bc	49.45
# of Beneficiaries per MZ seed production	17.97	a	38.40	b	18.07	a	39.58	b	29.74	ab	28.75
% of Beneficiaries Fully Repaying (2lb per 1lb)	1.25		66.78	b	42.62	a	41.69	a	55.25	ab	40.43
Recovery rate (repaid/seed distributed)	0.07		1.22	a	0.80	a	0.85	a	0.98	a	0.76
CSB supplied variety demanded (% Yes)	27.03	a	70.00	b	34.48	a	50.00	ab	45.00	ab	46.10

Notes: INTA Administrative Regions that share a letter are not significantly different at the 10% level

~ indicates that a significance tests across groups has not been performed for these variable

APPENDIX C: Interaction Terms in Three Distributional Forms and Interpretation

Table C.1 Duration Analysis with Interaction Variable

Variables	COX (PH) Hazard Ratio		COX (PH) Std. Err.	Weibull (PH) Hazard Ratio		Weibull (PH) Std. Err.	Log-Normal(AFT) Coef.		Log-Normal(AFT) Std. Err.
1=Community had a voice	1.687	**	0.413	2.054	***	0.517			
1=Meeting minutes recorded	0.392	***	0.100	0.304	***	0.082	0.337	***	0.100
% CSB members with immediate family member in CSB	1.005		0.003	1.008	**	0.004	-0.003	**	0.001
Travel time to city in private car (minutes)	0.990	**	0.005	0.986	***	0.005	0.004	**	0.002
1=President's Age>30	0.322	***	0.125	0.234	***	0.094	0.402	***	0.151
1=President is male	0.267	**	0.161	0.152	***	0.095	0.241		0.226
1=CSB has Horse, Mule or Ox	0.316	*	0.203	0.166	***	0.111	0.287		0.240
1=President male and CSB has animal	3.158	*	2.102	5.405	**	3.723	-0.263		0.253
1=seed produced on CSB member land	1.424		0.342	2.017	**	0.567	-0.177	*	0.096
1=land rented				1.526		0.449			
1=labor from CSB members	1.441		0.394	1.533		0.428			
# of Silos	0.873	**	0.050	0.843	***	0.050	0.062	***	0.023
1=access to backpack sprayer							0.143		0.102
1=trained in CSB formation	1.766		0.666	2.025	*	0.805	-0.212		0.131
1=trained in seed marketing	0.571		0.257	0.452	*	0.212	0.256		0.163
Year 1 Yield (qq/mz)	0.940	***	0.015	0.926	***	0.016	0.024	***	0.006
1=trained in seed marketing*yield	1.078	**	0.036	1.092	***	0.037	-0.022	*	0.011
beneficiaries/mz	1.013	**	0.007	1.017	**	0.007	-0.006	***	0.002
# of beneficiaries repaying 2x1 lbs	0.347	***	0.127	0.305	***	0.114	0.300	**	0.126
1=Supplied variety demanded in community	0.744		0.150	0.748		0.153			
Centro Sur	1.636		1.193	1.940		1.427	-0.097		0.273
Las Segovias	1.654		0.684	1.874		0.804	-0.119		0.168
Pacifico Norte	0.649		0.308	0.632		0.310	0.317	*	0.187
Pacifico Sur	0.309	***	0.136	0.248	***	0.113	0.615	***	0.163
1=Parceled Bank	1.663		0.530	1.682		0.542	-0.107		0.119
1=Individual Bank	2.074		1.348	3.174	*	2.102	-0.221		0.229
Constant				1.853		1.491	-0.420		0.317
Parameter				p=2.944		0.192	σ=0.403		0.023
Log likelihood	-589.330			-77.620			-78.592		
Restricted LL	-625.129			-124.207			-118.378		
AIC	1226.660			209.239			205.1839		
BIC	1299.547			291.237			278.0708		
Variable Significant (at least 10%)	13			18			12		

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

Only in the Weibull model are all three hazard rates included in each of the two interactions are statistically significant. The Weibull model indicates that for two CSBs without access to the animals used for transportation, the male headed CSB has a (1-0.152=0.848) 84.8% lower hazard ratio, or failure rate, than the CSB with a female president. Also from the Weibull results, a CSB with a female president and access to animals used for transportation has a (1-0.166=0.834) 83.4% lower failure rate than a female headed CSB without access to animals used for transportation.

To calculate the difference between male headed CSBs with access to animals and a male headed CSB without access as well as the difference between male and female headed CSBs with animals, hazard rates are used to calculate the variables' coefficients. Here the coefficients of the president's gender (ln[0.152]=-1.884), access to animals (ln[0.166]=-1.796) and the interaction term (ln[5.405]=1.687) are obtained. STATA also provides the coefficients by using the *nohr* command to request that the default display with hazard ratios is not displayed.

Comparing two CSBs with animals, [exp(-1.796+1.687)=0.897] the hazard ratio is (1-0.897=0.103) 10.3% lower for CSBs with male presidents than those with female presidents. Comparing two CSBs with male presidents, [exp(-1.884+1.687)=0.821] the hazard ratio is (1-0.821=0.179) 17.9% lower for CSBs with animals than those without.

Still using the Weibull model results, a 1 qq/mz increase in yield for a CSB without marketing training, holding all else equal, will lower the failure rate by (1-0.926=0.074) 7.4%. After finding the coefficient for yield, (ln[0.926]=-0.077) the effect of a 5 qq/mz increase in yield is calculated [exp(-0.077*5)=0.68] to lower the hazard rate by (1-0.68=0.32) 32%, all else equal. For CSBs that experienced crop failure in year 1, (yield was zero) the CSBs with seed marketing training had a(1-0.452=0.548) 54.8% lower hazard rate.

After calculating the coefficients for the interaction term (ln[1.092]=0.088), the effect of a 1 mz/qq increase in yield [exp(-0.077+0.088)=1.011] will increase the failure rate by 1.1% and a 5 qq/mz increase in yield will increase the failure rate by 5.7% holding all else equal. These results, without considering their effect at different levels of yield, appear to suggest that training increases failure rates. However, graphical analysis is useful to further explain the effect of marketing training.

Figure C.1: CSB Hazard Curves with Training

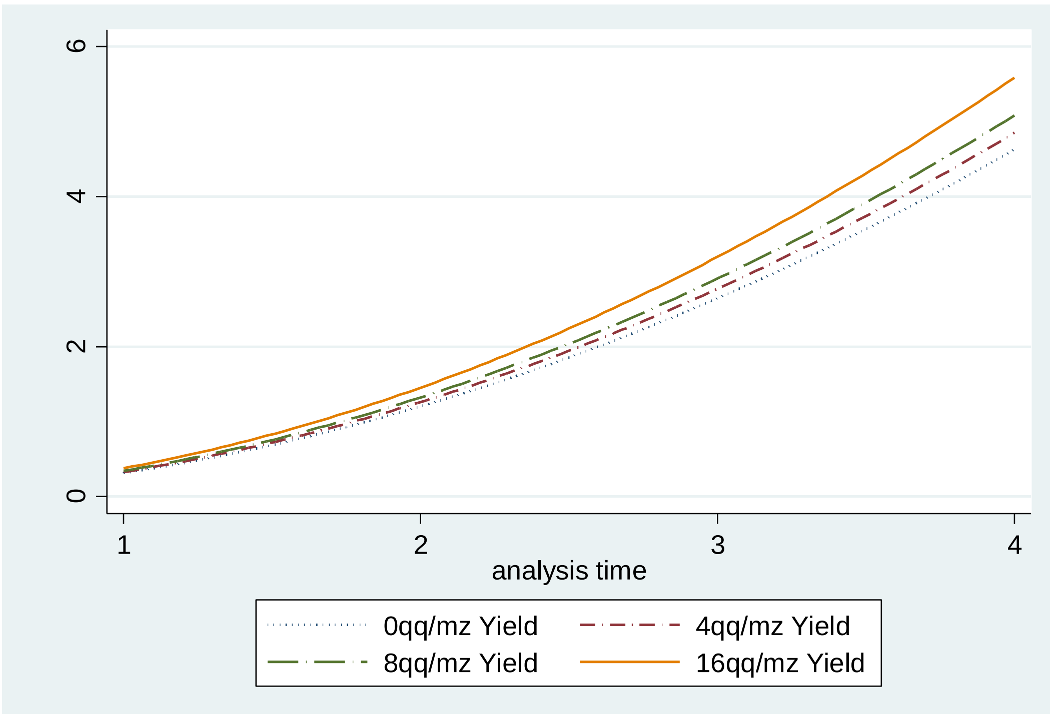


Figure C.1 provides the hazard function curves predicted from the Weibull model for CSBs that received training at four levels of yield in year 1, 0 qq/mz (crop failure), 2 qq/mz, 8qq/mz and 16 qq/mz. The curves of the hazard functions are slightly higher at each level as the results above suggest.

Figure C.2: CSB Hazard Curves without Training

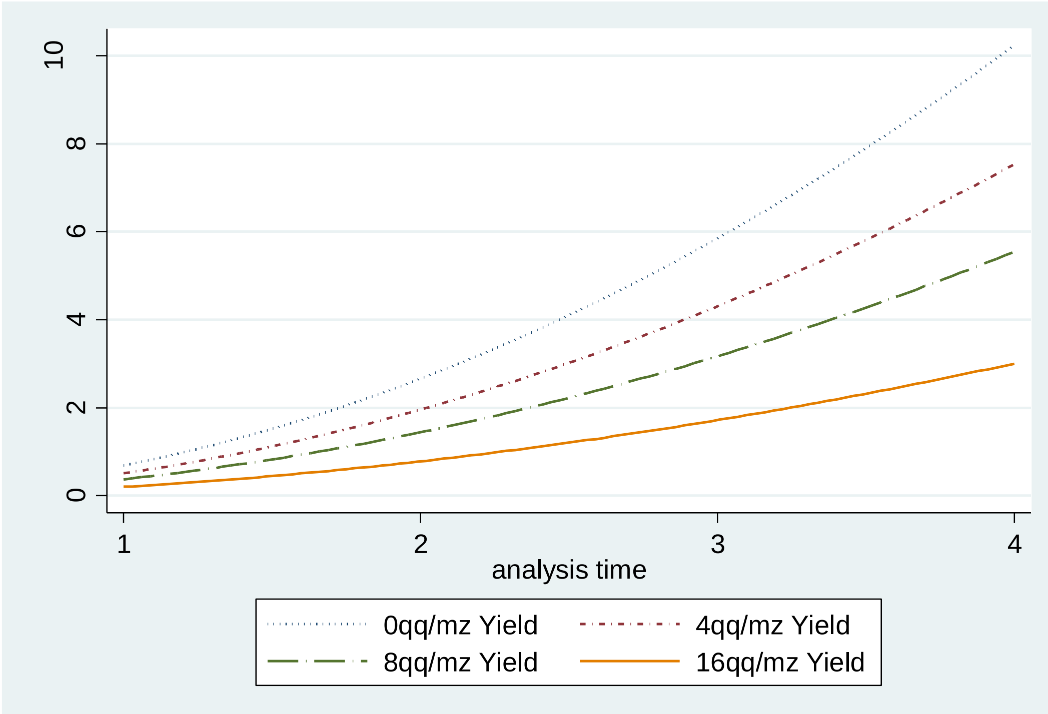
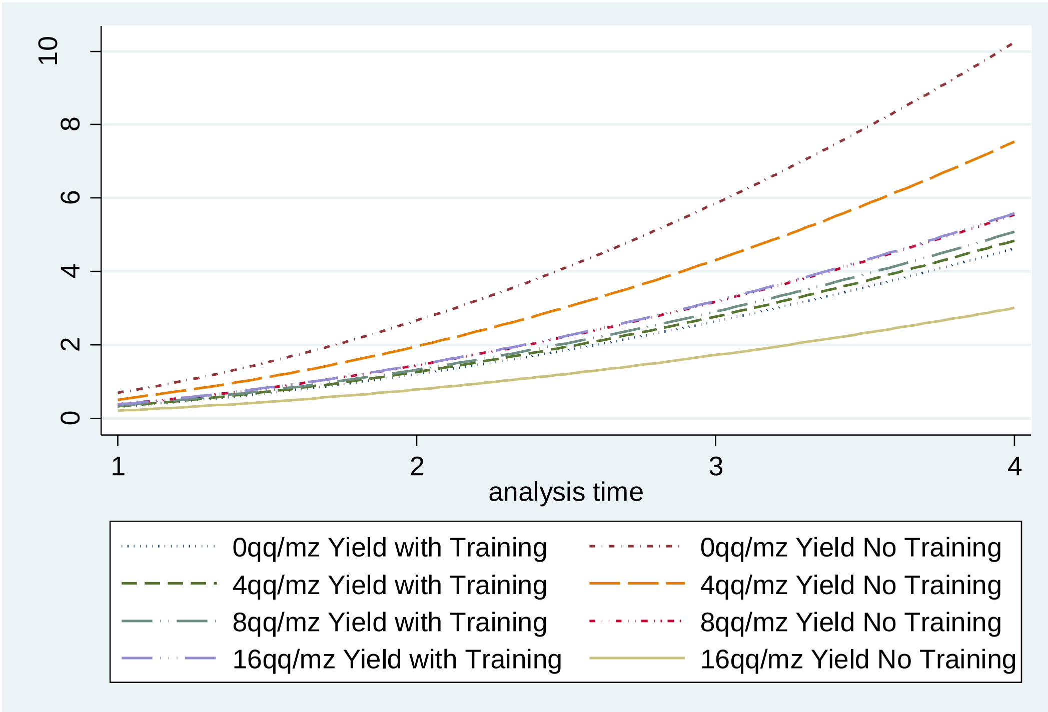


Figure C.2 provides the hazard function curves predicted from the Weibull model for CSBs that did not receive training at the same four levels of yield in year 1. Here, the hazard function curves decrease as yield increases. When the eight total curves from Figure C.1 and Figure C.2 are displayed together, Figure C.3 shows that the curves of the hazard functions for CSBs with training had little variation while the curve of the hazard function for the CSBs without training varied greatly. More importantly, for CSBs with less than 8qq/mz seed production in year 1, the hazard rates were lower for CSBs that received seed marketing training than the CSBs without the training. The data reveals that 37% of the CSBs produced less than 8 qq/mz, 23% produced between 8 and 12 qq/mz, and 40% produced more than 12 qq/mz in year one of the BTD project. Training reduces the variation in hazard functions and is clearly beneficial for CSBs with less than 8 qq/mz production and marginally beneficial for CSBs with production between 8 and 12 qq/mz.

Figure C.3: CSB Hazard Curves with and without Training



The data from the Weibull model might lead the reader to conclude that training has a negative effect on CSBs that produced more than 12 qq/mz. From the Log normal AFT model, it is clear that even with training, an increase in yield by as little as 1 qq/mz delays CSB failure by (0.024-0.022=0.002) 0.2%. Thus the models suggest that seed marketing training is able to counteract the effect of variation in first year yields on the hazard of CSB failure.

While the interpretation of the results regarding CSB seed marketing training confirms what is found in the literature, an alternative explanation must be noted. Given the nature of the BTD project, survival did not entirely depend on meeting a need (demand) for seed through an economically profitably local enterprise. Higher survival rates can also be due to extension worker's bias, political connections and other factors yet to be measured. The interaction of yield and seed marketing training could thus be explained by an extension worker's bias towards the trained CSBs despite poor yields in year 1. The friendship or trust developed through the training process might supersede yield (or productivity) consideration if the extension worker is asked to make a decision regarding which CSB to exclude from the BTD project in subsequent years. Additionally, the decision to invest the time in training a CSB might be made by a preexisting bias of the extension worker in favor of one CSB over another.

APPENDIX D: Differentiation of Types of CSBs: With and Without Individual CSBs

Table D.1 Weibull Model Duration Analysis without Individual Seed Banks

Variables	With Individual Banks (Same as Table C.1) Haz. Ratio		Std. Err.	Without Individual Banks Haz. Ratio		Std. Err.
1=Community had a voice	2.054	***	0.517	1.610		0.558
1=Meeting minutes recorded	0.304	***	0.082	0.278	***	0.090
% CSB members with immediate family member in CSB	1.008	**	0.004	2.439	**	0.899
Travel time to city in private car (minutes)	0.986	***	0.005	0.989	**	0.005
1=President's Age>30	0.234	***	0.094	0.224	***	0.104
1=President is male	0.152	***	0.095	0.279		0.277
1=CSB has Horse, Mule or Ox	0.166	***	0.111	0.214		0.222
Interaction: male President and CSB has animal	5.405	**	3.723	2.542		2.646
1=Seed produced on CSB member's land	2.017	**	0.567	2.098	**	0.788
1=Land rented	1.526		0.449	1.433		0.506
1=Labor provided by CSB members	1.533		0.428	2.516	**	1.006
# of Silos	0.843	***	0.050	0.828	***	0.053
1=Trained in CSB formation	2.025	*	0.805	2.096		1.002
1=Trained in seed marketing	0.452	*	0.212	0.483		0.275
Year 1 Yield (qq/mz)	0.926	***	0.016	0.933	***	0.020
1=Trained in seed marketing*yield	1.092	***	0.037	1.073	*	0.046
Beneficiaries/mz	1.017	**	0.007	1.026	***	0.008
# of beneficiaries repaying 2x1 lbs	0.305	***	0.114	0.121	***	0.058
1=Supplied variety demanded in community	0.748		0.153	0.963		0.220
Centro Sur	1.940		1.427	5.469		6.052
Las Segovias	1.874		0.804	2.626	**	1.289
Pacifico Norte	0.632		0.310	0.948		0.544
Pacifico Sur	0.248	***	0.113	0.292	**	0.144
1=Parceled Bank	1.682		0.542	1.738		0.622
1=Individual Bank	3.174	*	2.102			
Constant	1.853		1.491	0.631		0.715
Parameter	p=2.944		0.192	p=3.309		0.244
Log likelihood	-77.620			-47.441		
Restricted LL	-124.207			-88.696		
AIC	209.239			146.881		
BIC	291.237			219.572		
Variable Significant (at least 10%)	18			13		

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

Table D.1 displays the results that show that the sign on the hazard ratios did not change. As a reminder, hazard ratios over 1 indicate a negative relationship between the independent variable and survival, while hazard ratios below 1 indicate a positive relationship between the variable and survival. The variables that are no longer significant, beside the individual bank dummy variable, are seed marketing training (although its interaction with yeild remains significant), community's voice in the seed use decision, CSB formation training, president's gender, access to animal transportation, and the interaction of presidents gender with animal transportation.

Two variables that were not significant with the full set of observations but are now significant after excluding the individual seed banks are the regional dummy for Las Segovias and the indicator for whether CSB members provided the labor during seed production. CSBs in the Las Segovias region have a significantly higher failure rate than the Centro Norte region and use of CSB member labor increases the failure rate of CSBs at a 5% confidence level (Table D1).

Since the parceled and classic CSBs were directly involved in the seed distribution process (unlike the Individual banks in the Centro Sur region where INTA distributed the seed) the number of communities reached (market size) and the feedback received from clients or seed recipients (quality) are available. Table D.2 gives the results of the Weibull model without Individual CSBs by adding these two variables.

Table D.2 Weibull Model Duration Analysis With Quality and Network Variables

Variables	Haz. Ratio		Std. Err.
1=Community had a voice	1.385		0.510
1=Meeting minutes recorded	0.364	***	0.105
% CSB members with immediate family member in CSB	2.092	*	0.858
Travel time to city in private car (minutes)	0.987	**	0.006
1=President's Age>30	0.172	***	0.084
1=President is male	0.618		0.215
1=seed produced on CSB member land	1.623	*	0.457
1=labor from CSB members	3.469	***	1.565
# of Silos	0.851	**	0.056
1=CSB has Horse, Mule or Ox	0.416	***	0.132
1=trained in CSB formation	1.547		0.706
1=trained in seed marketing	1.085		0.394
Year 1 Yield (qq/mz)	0.947	***	0.018
beneficiaries/mz	1.025	***	0.009
# of beneficiaries repaying 2x1 lbs	0.102	***	0.048
1=Seed distributed to 0 Communities (Crop Failure)	0.467		0.338
1=Seed distributed to 2 Communities	0.558	*	0.198
1=Seed distributed to 3 Communities	0.789		0.386
1=Seed distributed to 4 Communities	1.743		0.701
1=Seed distributed to 5 Communities	0.602		0.230
1=Positive feedback from Beneficiaries (Clients)	0.570	*	0.166
Centro Sur	7.039	**	6.641
Las Segovias	1.506		0.757
Pacifico Norte	0.753		0.443
Pacifico Sur	0.233	***	0.123
1=Parcelled Bank	1.672		0.551
Constant	1.001		0.880
Parameter	p=3.493		0.262
Log likelihood	-42.24		
Restricted LL	-88.696		
AIC	140.479		
BIC	218.761		
Variable Significant (at least 10%)	15		

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

Banks that distributed seed to 2 communities had a (1-0.558=0.442) 44.2% lower hazard ratio than CSBs that only distributed to one community (Table D.2). There was no statistically significant difference between CSBs that reached more than 2 communities with seed compared to CSBs that focused only on one community.

The literature indicates that CSBs will be more sustainable if they have a larger market and thus have more consistent annual demand for seed. Table 5.1 indicates that less than half of the CSBs offered one of the two most popular seed varieties in their communities. While it is possible that the CSB choose to lend to farmers beyond their community of operations, the decision may have been due to the lack of demand for the variety produced in year 1.

The results also confirm that quality of seed produced has a positive relationship with sustainability. Holding all else equal, CSBs that received positive feedback from their clients had a (1-0.57=0.43) 43% lower failure rate than CSBs that did not receive positive feedback. The positive feedback is also an indicator of satisfaction with the variety, as positive attributes of the seed quality are affected both by the seed produced and attributes associated with the seed variety. The seed might have been free of disease from good agronomical seed production process but also from varietal resistance to the disease.

APPENDIX E: Three Options for Removing Heterogeneity Effects

One of the other two options is to obtain Huber/White/sandwich estimators of variance. By specifying this approach, the data is no longer treated as 154 independent observations across 5 regions but instead 5 independent "clusters" of observations. There are only four degrees of freedom in this model, no Wald test is obtained and the log pseudo-likelihood is the highest compared to the log likelihood ratios of the other two models with heterogeneity removed. The information criterion AIC and BIC, however are the lowest compared to the other two models.

A less extreme approach is to allow the baseline survivor function of the AFT model (or baseline hazard function for the HP model) to vary by region. This is called a stratified model. One advantage of this model is that we also allow time to accelerate or decelerate with respect to region in addition to the differing baseline survivor functions and as such obtain adjusted coefficients for each region as we had when only controlling for fixed effects. Although the model does produce the best log likelihood and a better AIC than the shared frailty model, the BIC is the worst of the heterogeneity adjusted models.

The Huber/White/sandwich estimators of variance, the stratified model and the shared frailty model for removing regional heterogeneity are compared in Table E.1. The interaction of transportation and gender of president are no longer significant and are dropped in Table E.1.

Table E.1 Log Normal Duration Analysis with Heterogeneity Removed

	STRATIFIED BY REGION			FRAILTY BY REGION			VCE CLUSTERS BY REGION		
Variables	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
1=Meeting minutes recorded	0.369	***	0.091	0.295	***	0.098	0.276		0.202
% CSB members with immediate family member in CSB	-0.325	**	0.128	-0.315	**	0.151	-0.383	***	0.125
Travel time to city in private car (minutes)	0.004	**	0.002	0.003	*	0.002	0.003	**	0.001
1=President's Age>30	0.326	**	0.131	0.258		0.165	0.167		0.103
1=seed produced on CSB member land	-0.115		0.093	-0.100		0.094	-0.076		0.108
# of Silos	0.055	**	0.023	0.058	**	0.023	0.050	***	0.018
1=access to backpack sprayer	0.139		0.109	0.219	**	0.102	0.257	*	0.144
1=CSB has Truck, Horse, Mule or Ox	0.120		0.090	0.101		0.100	0.103		0.087
1=trained in CSB formation	-0.288	**	0.123	-0.217		0.142	-0.284		0.188
1=trained in seed marketing	0.251		0.153	0.314	*	0.165	0.310	***	0.065
Year 1 Yield (qq/mz)	0.022	***	0.006	0.017	***	0.007	0.012	**	0.005
1=trained in seed marketing*yield	-0.023	**	0.011	-0.030	***	0.011	-0.031	***	0.004
beneficiaries/mz	-0.006	***	0.002	-0.003		0.002	-0.001		0.002
% of beneficiaries repaying 2x1 lbs	0.392	***	0.124	0.343	***	0.130	0.415	**	0.198
1=Parceled Bank	-0.079		0.100	-0.082		0.117	-0.019		0.102
1=Individual Bank	-0.267		0.234	-0.455	**	0.184	-0.522	*	0.284
Centro Sur dummy	-0.159		0.275						
Las Segovias dummy	-0.143		0.168						
Pacifico Norte dummy	0.250		0.174						
Pacifico Sur dummy	0.548	***	0.140						
Constant	-0.115		0.234	-0.034		0.258	0.114		0.315
Shape Parameters				σ=0.429		0.031	σ=0.440		0.010
Centro Sur Shape Parameter	0.148		0.175						
Las Segovias Shape Parameter	0.113		0.203						
Pacifico Norte Shape Parameter	0.075		0.196						
Pacifico Sur Shape Parameter	-0.447	**	0.225						

Table E.1 (cont'd)

	STRATIFIED BY REGION			FRAILTY BY REGION		VCE CLUSTERS BY REGION
Constant Shape Parameter	-0.943	***	0.129			
Shared Frailty Parameter				θ=0.084	0.095	
LR test of θ=0				1.95	0.081	
Log likelihood	-75.684			-91.156		-92.133
Restricted LL	-116.149			-113.214		-118.378
Degree of Freedom	26			19		4
AIC	203.368			220.311		192.266
BIC	282.329			278.014		204.414
Variable Significant (at least 10%)	10 (not including region variables)			10		9

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

APPENDIX F. Results of Duration Analysis Accounting for Fourth Year

Table F.1 Comparison of Results Without Fourth Year and Right Censored Data

	With Year 4			Three Years			Three Years w/ Censored 4th Year		
Variables	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
1=Meeting minutes recorded	0.300	***	0.098	0.264	***	0.091	0.303	***	0.099
% CSB members with immediate family member in CSB	-0.318	**	0.151	-0.333	**	0.140	-0.296	*	0.152
Travel time to city in private car (minutes)	0.003	*	0.002	0.003	*	0.002	0.003	*	0.002
1=President's Age>30	0.284	*	0.167	0.266	*	0.156	0.325	*	0.169
1=President is male	0.196		0.234	0.173		0.212	0.190		0.229
1=CSB has Horse, Mule or Ox	0.208		0.249	0.214		0.226	0.225		0.243
Interaction President male and CSB has animal	-0.151		0.261	-0.148		0.237	-0.162		0.256
1=seed produced on CSB member land	-0.112		0.094	-0.122		0.087	-0.124		0.095
# of Silos	0.056	**	0.023	0.052	**	0.021	0.058	**	0.023
1=access to backpack sprayer	0.221	**	0.102	0.215	**	0.093	0.206	**	0.103
1=trained in CSB formation	-0.216		0.142	-0.195		0.129	-0.195		0.145
1=trained in seed marketing	0.300	*	0.167	0.275	*	0.153	0.300	*	0.170
Year 1 Yield (qq/mz)	0.017	***	0.007	0.014	**	0.006	0.019	***	0.007
1=trained in seed marketing*yield	-0.028	***	0.011	-0.023	**	0.010	-0.027	**	0.011
beneficiaries/mz	-0.003		0.002	-0.003		0.002	-0.004		0.002
% of beneficiaries repaying 2x1 lbs	0.326	**	0.131	0.244	**	0.119	0.294	**	0.136
1=Parceled Bank	-0.066		0.118	-0.036		0.110	-0.083		0.120
1=Individual Bank	-0.421	**	0.184	-0.373	**	0.172	-0.381	**	0.191
Constant	-0.194		0.327	-0.133		0.300	-0.253		0.329
Shape Parameter	σ=0.429		0.030	σ=0.394		0.028	σ=0.424		0.035
Shared Frailty Parameter	θ=0.087		0.098	θ=0.089		0.102	θ=0.162		0.146
LR test of θ=0	$\chi 2$=1.94		p-val=0.082	$\chi 2$=1.74		p-val=0.094	$\chi 2$=4.22		p-val=0.020
Log likelihood	-90.947			-77.465			-96.065		
Restricted LL	-113.21			-99.924			-117.722		

Table F.1 (cont'd)

Variables	With Year 4 Coef.	With Year 4 Std. Err.	Three Years Coef.	Three Years Std. Err.	Three Years w/ Censored 4th Year Coef.	Three Years w/ Censored 4th Year Std. Err.
Frailty Distribution	Gamma		Gamma		Gamma	
AIC	223.894		196.930		234.130	
BIC	287.670		260.706		297.906	
Variable Significant (at least 10%)	11		11		11	

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively

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