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THESIS

DURATION ANALYSIS OF HYBRID MAIZE ADOPTION IN THAILAND

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A Thesis Submitted in Partial Fulfillment of
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Sutthiporn Poolsawas 2012: Duration Analysis of Hybrid Maize Adoption in Thailand. Master of Science (Agricultural Economics), Major Field: Agricultural Economics, Department of Agricultural and Resources Economics. Thesis Advisor: Mrs. Orachos Napasintuwong Artachinda, Ph.D. 86 pages.

There were several previous studies on hybrid maize adoption in Thailand, but none emphasized the adoption in a dynamic framework, especially the factors that influenced the timing of adoption. Therefore, the objectives of this study are to indicate the adoption and diffusion patterns of hybrid maize in Thailand and to apply duration analysis to examine the impact of time-varying and time-invariant factors on the duration of hybrid maize varieties adoption. Three hundred and thirty five maize farmers were interviewed between May and June 2011. The study focused on the timing of hybrid maize adoption since 1980, the year in which hybrid maize was first available until 2011.

The results from the study revealed that farmers with less experienced on maize cultivation are among the earlier adopters, and farm being closer to input dealer will further speed up adoption. The findings also suggest that the communication from the public sector may reduce the speed of adoption, but an extension service from input dealers and credit for maize cultivation from the private sector could increase the adoption speed.

This implies that in order to expedite the adoption of new variety, extension programs to less experienced farmers might be emphasized. The increase of input accessibility also enhances adoption. Effective communication from the public sector, such as the transfer of knowledge and information about new crop varieties is needed, along with a sufficient extension service through input dealers and credit loans for inputs from the private sector.

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CHAPTER I

INTRODUCTION

This chapter contains the statement of problem, the objectives, the expected benefits and the scope of the study. The outline of the study is described in the last section of this chapter.

Statement of Problem

Plant breeding program plays an important role in the development of agriculture in particular, the improvement of high-quality and high-yielding of crop varieties in order to response to the growth of demand for staple foods from the increasing of world population. In Thailand, plant breeding research program has been started with rice since 1900s followed by the other majors crop such as maize, cassava and sugarcane. Most of the plant varieties research and development were driven by the public sector until the entry of private sector during 1970s that led to the liberalization and privatization in many agricultural commodities i.e. plant breeding, farm machinery, livestock, aquaculture and agriculture biotechnology.

Nonetheless, although the Thai Government tried to encourage private investment in research at the first stage, these efforts appear to have had only limited success (Thailand Development Research Institute, 1990). Policies to support private research have included tax incentives and subsidized loans, but the overall demand for these subsidies appeared to have been small. However, public sector encouragement of the private seed industry appears to have been a significance factor in stimulating private plant breeding especially in developing hybrid seed for field crops like maize, sorghum, sunflower and several vegetables.

Maize (*Zea mays L.*) was first planted in Thailand in the 1950s in the uplands and highlands, and used only for home consumption and animal feed at the household level. After Thailand launched its first National Economic and Social Plan in 1961, maize became an important cash crop along with rice, cassava and sugarcane from the 1960s to the 1980s (Ekasingh *et al.*, 2004). In the meantime, the National Corn and Sorghum Research Center (NCSRC) was established in 1969 in Nakhon Ratchasima province to encourage maize R&D, especially in maize breeding to improve average yield and to stimulate increases in maize area and production. This resulted in an increase of maize area from 0.73 million hectares during 1965-1970 to be the highest level in 1986 – 1990 with 1.81 million hectares, but thereafter maize area began to decline continuously and occupied only 1 – 1.1 million hectares in recent years. In addition, the growth in the livestock industry lead the demand for maize to grow during the past three decades to nearly 5.5 million tons in 2011 (Thai feed mill association, 2011). Nevertheless, the maize yield is likely to increase owing to the R&D from both the public and private sectors. This has resulted in an increase in maize production of 3-4 times since the 1960s with production rising from around 1 – 1.3 million tons to 4 – 4.4 million tons in the last decade as shown in Table 1.1.

Table 1.1 Planted area and the production and yield of maize, 1961 – 2010.

Year	Planted Area ('000 hectares)	Production ('000 tons)	Yield (ton/hectare)
1961 – 1965	436.22	815.59	1.87
1966 – 1970	738.75	1,389.69	1.88
1971 – 1975	1,112.94	2,225.23	2.00
1976 – 1980	1,358.84	2,590.06	1.91
1981 – 1985	1,746.36	3,832.60	2.19
1986 – 1990	1,813.82	3,975.93	2.19
1991 – 1995	1,382.71	3,782.55	2.74
1996 – 2000	1,342.19	4,348.21	3.24
2001 – 2005	1,163.57	4,288.07	3.68
2006	1,024.75	3,918.33	3.82
2007	1,018.24	3,890.22	3.82
2008	1,070.69	4,249.35	3.97
2009	1,108.54	4,430.39	4.00
2010	1,138.48	4,454.44	3.91

Source: Office of Agricultural Economics (2011)

The primary phase of maize R&D in Thailand was under the administration of the public sector through the NCSRC which collaborated with Kasetsart University, the Department of Agriculture (DOA), the Department of Agriculture Extension (DOAE), the Rockefeller Foundation and the International Maize and Wheat Improvement Center (CIMMYT). In 1975, Suwan-1, the first Open-pollinated variety developed by the NCSRC was released. However, since the first release, the public sector could produce only 2,200 tons of seeds annually, which was inadequate to distribute to the interested maize farmers (Kasetsart University Research and Development Institute, 2009). Until 1979, Charoen Pokphand Group (CP Group) has administered maize seed production in Lopburi province. It produced 2,000 tons of seed per year and grew to 4,000 and 5,000 tons for the next cropping season, respectively. The first private involvement in maize seed production led to the widespread adoption of Suwan-1, and it became well-known by domestic farmers and farmers in other countries (Suwantaradol, 2001).

After the achievement of the Suwan-1 variety, the NCSRC successfully developed the first hybrid maize variety, Suwan-2301, in 1980 and distributed 1.92 tons of seeds within the first year. Later, the NCSRC released the inbred lines Ki 1 – Ki 19 in 1982 to encourage the private companies to develop the new varieties along with the public developed varieties. This appears to be the start of the privatization of the hybrid maize seed industry, and it brought to a shift in Thailand's maize research system from public to private seed development and distribution. However, NCSRC still released the hybrid varieties and OPVs as presented in Table 1.2.

Table 1.2 The release of maize varieties in Thailand by NCSRC

Years of released	OPVs	Hybird varieties	Inbred lines
1975	Suwan 1	-	-
1979	Suwan 2	-	-
1980	-	Suwan 2301	-
1982	-	-	Ki 1 - Ki 19
1984	-	-	Ki 20
1985	-	-	Ki 21 - Ki 22
1986	-	Suwan 2602	-
1987	Suwan 3	-	Ki 23 - Ki 30
1991	-	Suwan 3101	-
1992	-	-	Ki 31 - Ki 44
1993	Suwan 5	Suwan 3501 - 3504	-
1995	-	Suwan 3601	Ki 45
1997	-	Suwan 3851	-
1999	-	Suwan 3853	-
2002	-	-	Ki 46 - Ki 47
2003	-	Suwan 4452	-

Source: IICRD (2012)

Since the release of hybrid varieties during the 1980s, due to the lack of information and experience about the new varieties, the farmers' perception was limited and adoption was slow. Furthermore, most of the first-generation hybrid varieties were top-cross, double top-cross and double-cross hybrid varieties which had some variation in characteristics such as erratic height, size of ear shape and uneven kernel color. The quality of these hybrids was not better than general Open-pollinated varieties (OPVs) maize in the opinion of farmers. In addition, the lower price of maize grain and the higher price of hybrid seeds resulted in farmers' hesitation in adopting the new varieties (Suwantaradol, 2001). Around the early 1990s, there was a fundamental shift in the maize seed industry in Thailand, marked by substantial changes in production technology and market outlets. Several private multinational and national companies such as Pioneer, Cargill (purchased by Monsanto), Novartis (now Syngenta), Pacific Seed and CP Group started to produce maize hybrid seeds and began to dominate maize production. For instance, CP Group successfully commercialized the single-cross hybrid CP-DK888 which became popular, accounting for around 50% of the hybrid maize seed market from the 1990s until in the early 2000s (Gerpacio, 2001).

Although the development of hybrid varieties has a broad acceptance and adoption by farmers, there is a decrease in the planted area of public developed hybrid seeds. Even though the public sector has upgraded the R&D, released new hybrid varieties into the market and transferred the extension programs to the farmers, those public-developed hybrid varieties could not compete with private-developed hybrid varieties. The role of the private sector in agricultural technology development has become increasingly important. Though the benefits of high-yield variety developments from the private sector appear evident, the question of higher seed prices and lower profitability that farmers have to face, remain unanswered.

Most of the hybrid maize adoption studies in Thailand have only addressed factors influencing the probability of adoption in a static framework (Ruttanapracha, 1993; Ekasingh *et al.*, 2004; Limsombunchai and Kao-ian, 2010), but none has evaluated it in a dynamic framework. In particular, there have been no previous studies analyzing the timing of adoption or the effect of factors on the time farmers waited before they first adopted these hybrid varieties. Therefore, realizing factors that affect the timing of the adoption of hybrid maize varieties are essential for public and private sectors to understand the determinants of adoption speed and to find a way to promote new varieties to farmers.

Objectives of the Study

This study attempts to analyze the key determinants of the timing of hybrid maize adoption. Therefore, the specific objectives are as follows;

1. To indicate the adoption and diffusion patterns of hybrid maize in Thailand.

2. To examine the impact of time-varying and time-invariant factors on the duration of hybrid maize varieties' adoption.

Expected Benefit of the study

The evidence from this research could suggest an appropriate policy to stimulate the adoption and diffusion of modern crop technologies and to determine the role of the public and private sectors in providing the access of technologies to farmers. The results from the study may also contribute to both public organizations and private companies to formulate extension and promotion strategies for the release of new varieties.

Scope of the Study

To characterize the duration of hybrid maize adoption and the factors that influence farmers' perceptions, this research focuses on the timing of hybrid adoption from 1980, the year in which the varieties first became available in Thailand until the 2011 crop year,. The information was gathered from farmers who cultivated maize in the first crop season between May 2011 and June 2011. The hybrid varieties which farmers adopted included single cross, three way cross and double cross hybrid varieties from both the public and private sectors.

Outline of the Thesis

This thesis is divided into five chapters. This chapter introduced the importance of the study. The second chapter reviews the related literature and the theoretical background of the study. The third chapter is related to the research methodology and model specifications. The fourth chapter reveals the general characteristics of the sample maize farmers in the study site, and the results of the study and discussions. The last chapter concludes the findings and suggests recommendations for future research and the conclusion of the thesis.

CHAPTER II

LITERATURE REVIEW

In order to apply the method for the empirical study model, this chapter is divided into two parts; the first part is a review of the theoretical concepts that are relevant to adoption and diffusion. The second part summarizes the literature which is related to the adoption of new technology in agriculture.

Review of Theoretical Framework

Technology Adoption

1. Adoption and Diffusion Studies

Adoption and diffusion are the processes governing the utilization of innovations. Studies of adoption behavior emphasize factors that are evident if and when a particular individual begins to use an innovation. Measures of adoption indicate both the timing and extent of new technology utilization by individuals. It may be depicted as more than one variable by a discrete choice; whether or not to utilize an innovation, or by a continuous variable that indicates to what extent a divisible innovation is used (Sunding and Zilberman, 2001).

Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003), or can be interpreted as aggregate adoption. There may be several indicators to determine the diffusion of a specific technology as with adoption studies. It is helpful to use the term “adoption” to depict individual behavior towards an innovation and “diffusion” to depict aggregate behavior. For example, one measure of diffusion may be the percentage of the farming population that adopts new innovations or technology.

2. Adoption Process

The adoption or innovation-decision process is the process that characterizes the type of decision-making by an individual. It consists of a series of choices and actions over time through a system that evaluates a new idea and decides whether or not to incorporate the innovation into practice. The notion of stages in the innovation-decision process was first conceptualized by Ryan and Gross (1943) and later Rogers (1962) identified five stages to be: awareness, interest, evaluation, trial and adoption. Rogers (2003) classified the innovation-decision process into five stages as follows:

Knowledge: the stage at which an individual is first exposed to an innovation but lacks complete information about this innovation. An individual gains only an understanding of how it functions.

Persuasion: this stage occurs when an individual is interested, actively seeks information about the innovation and also forms a favorable or an unfavorable attitude towards the innovation.

Decision: this stage takes places when an individual assesses the advantages or disadvantages of using the innovation and decides whether to adopt or reject the innovation.

Implementation: an individual employs the innovation to a varying degree depending on the situation and determines the usefulness of the innovation at this stage.

Confirmation: the last stage occurs when an individual seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation.

3. Adopter Categorization

Adopters can be classified into five categories following Rogers's concept in order to standardize the usage of adopter categories in diffusion research (Rogers, 2003). The innovativeness measurement, which evaluates the time at which an individual adopts new technology, is continuous and partitioned by laying off standard deviations (sd) from the average time of adoption ($\bar{x}$). The first category is the "innovators" who are the first individuals to adopt an innovation. Their interest in new innovations leads them to play an important role in the diffusion process by launching modern technology in the system. This category must be able to cope with a high level of risk and be willing to accept an occasional setback when new technology proves unsuccessful.

The second category is the "early adopters" who have the highest degree of opinion leadership in most systems. The early adopter is considered by many as "the individual to check with" before using a new idea. Because early adopters are not too far ahead of the average individual in innovativeness, they serve as a role model for many other members of a social system. The third category is the "early majorities" who adopt new innovations just before the average members of a system. This category gets its information largely from the early adopters. The early majority's unique position between the very early and the relatively late to adopt makes them an important link in the adoption process.

The fourth category is the "late majorities" who adopt new ideas just after the average member of a social system. Adoption may be both an economic necessity and the answer to increasing network pressures, and the late majority does not adopt until most others in their social system have done so. "Laggards" are the last in a social system to adopt an innovation. They are the most local in their outlook of all adopter categories. Their traditional orientation slows the innovation decision process to a crawl, with adoption lagging far behind awareness of a new idea. This resistance to innovations on the part of the late adopters is entirely rational from their viewpoint. These five categories are illustrated in Figure 2.1 as follows:

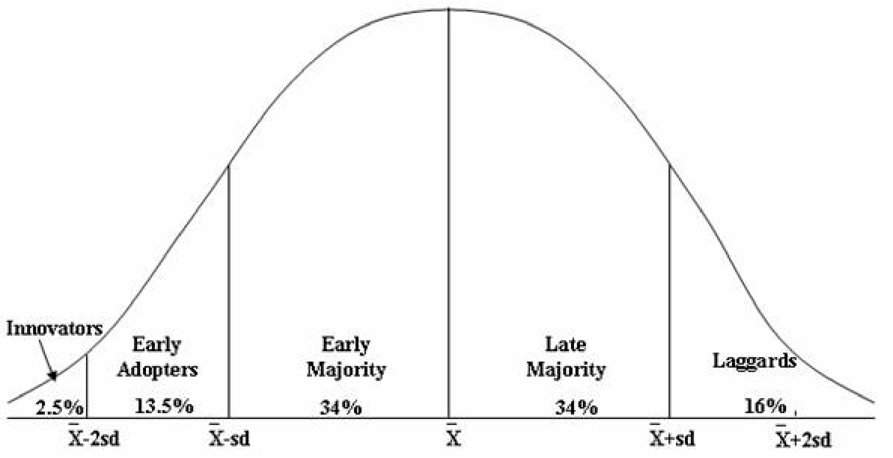

Figure 2.1 Adopter categorization on the basis of innovativeness
Source: Rogers (2003)

In this study, it is assumed that farmer perceptions, along with other cross-sectional and time-dependent farms, personal characteristics and other variables related to hybrid maize varieties that contribute to each individual farmer's utility of adoption as time progresses. This study is based on the concept that maize farmers hold particular perceptions regarding the effects of hybrid varieties' adoption, and this subjectivity can be an important determinant in their adoption decision (D' Emden, 2006). However, this subjectivity is constantly reviewed, so the question of adoption probability becomes a question of time to adopt.

Statistical Models for Technology Adoption

In the investigation of the use of new agricultural technology, there have been two main statistical approaches: adoption and diffusion studies as mentioned above. Adoption studies have employed cross-sectional data in a discrete choice framework to measure the adoption at the farm level at a point in time. However, this approach fails to allow for the timing of an adoption decision and the impact that time-varying factors may have on it (Burton *et al.*, 2003).In addition, diffusion studies have modeled the timing of the adoption rate at the aggregate level. However, they do not address the specific issue why some farmers adopt earlier than others. Both research approaches are unsuitable to answer why farmers adopt at a particular point in time

(Matuschke and Qaim, 2008). Hence, to bridge the gap between adoption and diffusion studies, Duration Analysis was chosen in this study to explore the information which includes why a farmer adopted the new technology, and the timing of the adoption decision.

However, the other statistical models that are used widely to determine the factors influencing the adoption of agricultural innovations are as follows:

Ordinary Least Squares (OLS) Regression

OLS regression is a statistical method used to provide empirical estimation of the effects of various explanatory variables on the adoption decision. In addition, this method is used to investigate the effects of variables on the level of adoption of a particular practice, or the adoption of a number of potential practices. However, the disadvantage of the OLS approach is that it does not available for the improper time aggregation of the continuous time model or if parameters are nonlinear function (Srinivason and Mason, 1986).

Logit, Probit and Tobit Regression

Logit and probit models can be used to estimate the relative effects of independent variables on the probability of adopting if the adoption decision is expressed as a binary dependent variable. Logit models assume a logistic distribution of error terms, while the probit model assumes that error terms are normally distributed. A Tobit model, or censored normal regression, has been used to account for the intensity of adoption and variables that have upper or lower limits will not be considered. However, the first two models, Logit and Probit can account only the basic adoption/non-adoption decision but can not account for the intensity of adoption while Tobit approach belongs to the same general class of models as Duration model but Duration model represents a major advance in the ability to model the adoption over time (D’ Emden, 2006).

Duration Analysis

Duration Analysis was primarily developed in biomedical research and is typically called survival analysis, where the duration of interest is the survival time of a subject (Woolridge, 2002). This method was first developed and applied in social science literature by Lancaster (1978) who used this technique to study the factors influencing unemployment spells. However, the lack of quality microeconomic time-series data is a major impediment to its broader application. Later, it has been used widely more recently in labor economics with some examples in the context of technology literature (Hannan and MacDowell 1984, 1987) and mainly in the analysis of unemployment duration (Lancaster, 1978; De Una-Alvarez *et al.*, 2003; Iwai *et al.*, 2005; Cooper *et al.*, 2008). In addition, the Duration Model has been applied in a number of agricultural economics studies to capture the dynamic aspects of technology adoption as in Fuglie and Kascak (2001), who estimated the long-term trends in the adoption and diffusion of conservation tillage by U.S. farmers. Burton *et al.* (2003) explored the determinants of adoption of organic horticultural technology in the UK, Dadi *et al.* (2004) estimated the impact of variables on the timing of adoption by small holders in Ethiopia, Abdulai and Huffman (2005) explained the diffusion and farmer's adoption of crossbred-cow technologies in Tanzania, D'Emden *et al.* (2006) investigated the significant variables on soil-conserving adoption by grain farmers in Australia, Matuschke and Qaim (2008) studied the dynamics of hybrid pearl millet adoption in India, and Pornpratansombat *et al.* (2010) investigated the factors that affecting the speed of organic rice farming adoption in Thailand.

To study technology adoption, the start date would be set either at the time when the first adoption of a new technology took place or at the time when a farmer started their farms if farmer was started after the release of technology. The end of a spell is the time when a farmer adopts the technology. In duration analysis, therefore T is a non-negative continuous variable and represents the length of time farmers wait before adopting. The *cumulative distribution function (cdf)* of T is defined as;

$$F(t) = P(T \le t), \qquad t \ge 0 \tag{2.1}$$

it denotes the probability that duration time, T, is smaller or equal to some value t. The *probability density function (pdf)* of T can be derived as;

$$f(t) = \frac{\partial F(t)}{\partial t} \tag{2.2}$$

The *survival function* in the case of a farmer waits before adoption, the probability of an individual not adopted until or beyond time t is defined as;

$$S(t) = 1 - F(t) = \Pr(T > t) \tag{2.3}$$

The *hazard function* can specify the instantaneous rate of leaving per unit time period at t or represents the probability that a farmer adopts the new technology at time $t + \Delta t$. The *hazard function* for T is defined as;

$$\begin{aligned} h(t) &= \lim_{\Delta t \to 0} \frac{\Pr(t \le T < t + \Delta t \mid T \ge t)}{\Delta t} \\ &= \lim_{\Delta t \to 0} \frac{F(t + \Delta t) - F(t)}{\Delta t} \cdot \frac{1}{1 - F(t)} \\ &= \lim_{\Delta t \to 0} \frac{f(t)}{1 - F(t)} \end{aligned} \tag{2.4}$$

or $$h(t) = \frac{f(t)}{S(t)} \tag{2.5}$$

where the *hazard rate* ($\frac{\partial h}{\partial t}$) may be constant, positive or negative.

The hazard function can be separated into two components: the first part is dependent on individual characteristics and the other one is not. The latter is sometimes called as *baseline hazard* which can be semi-parametric following Cox's proportional hazards model (Cox, 1972) where covariates shift the baseline hazard function and no assumptions need to be made about the shape of it. However, parametric models are more efficient in their use of data because they do not reject what happens to covariates where adoptions occur. Therefore, functional forms that have been used for parametric duration models include the exponential, Weibull, Gompertz, the logistic, the lognormal and the log logistic probability distribution (Cleves *et al.*, 2004). And of all of them, the three most commonly used are the exponential, Weibull and Gompertz distributions.

The exponential distribution is characterized by the *hazard function* with a constant rate, $h(t) > \lambda$ where $\lambda > 0$, denotes that the duration time (length of spells) does not affect the hazard rate.

Baseline hazard; $h_0(t) = \lambda$; $\lambda = \exp(\beta_0)$

or $$h_0(t) = \exp(\beta_0) \quad (2.6)$$

where β_0 is the only ancillary parameter to be estimated. The result of this model is the expected remaining time to adoption and is independent of prior survival times.

The Weibull distribution is characterized by the *hazard function* as

$$h(t) = \lambda p t^{p-1} \quad ; \lambda > 0 \text{ and } p > 0 \quad (2.7)$$

if $p > 1$, it exhibits the increasing hazard

$p < 1$, it exhibits the decreasing hazard

$p = 1$, it exhibits the constant hazard and collapses to the exponential distribution model.

The Gompertz distribution is the model which was applied in the duration of adoption study by Matuschke and Qaim (2008) and characterized by the hazard function,

$$h(t) = \lambda \exp t^{\gamma t} \quad (2.8)$$

Where $\lambda = \exp(X_i \beta)$ and γ is a shape of parameter. The Gompertz model is useful for monotone hazard rates that either increase or decrease exponentially with time (Cleves *et al.*, 2004).

The explanatory variables can be introduced in a number of ways, and the most common is to assume a proportional hazard model to estimate the distribution of durations. The simplest ways to include covariates are those which do not change over time, such as gender and farm size which may be assumed to be time-invariant.

$$h(t, X, \theta, \beta) = h_0(t, \theta)\exp(X, \beta) \tag{2.9}$$

where $h_0(t, \theta)$ denotes the baseline hazard which is independent of covariates X.

β is a vector of parameters characterizing the explanatory variables. In terms of interpretation, a value greater than one means that parameter has a positive impact on the hazard of adoption, a value less than one has a negative impact and a value of one means no impact.

θ is a vector of parameters characterizing the baseline hazard.

$\exp(X, \beta)$ exhibits multiplicatively on the baseline hazard models.

Once an appropriate parameterization is selected, the estimation of parameters will follow the maximum-likelihood methods. Assuming a sample of the n observations adopted in the duration, t_i^*, and each individual's time is independent from the time of others, the likelihood function is

$$L = \sum_{i=1}^{n} f\left(t_i^*, \theta\right) \tag{2.10}$$

where $f\left(t_i^*, \theta\right)$ is the density function and θ is the vector of parameters. But, in cases where censored observations are included, information on their durations is not suitable (individuals who do not adopt within the spells). To account for these censored observations, the likelihood function must be transformed to

$$L = \sum_{i=1}^{n} \left[f\left(t_i^*, \theta\right)\right]^{d_i} \cdot \sum_{i=1}^{n} \left[S\left(t_i^*, \theta\right)\right]^{1-d_i} \tag{2.11}$$

where $d_i = 1$ if the individual time to adoption is uncensored

$d_i = 0$ if the individual time to adoption is censored

Thus, the log-likelihood can be defined as

$$L(\theta) = \sum_{i=1}^{n} d_i \ln f\left(t_i^*, \theta\right) + \sum_{i=1}^{n} (1 - d_i) \ln S\left(t_i^*, \theta\right) \tag{2.12}$$

Therefore,

$$L(\theta) = \sum_{i=1}^{n} d_i \ln h(t_i, \theta) + \sum_{i=1}^{n} \ln S(t_i, \theta) \tag{2.13}$$

assuming $t_i = \min\left(t_i^*\right)$ and maximum likelihood procedures can be used to estimate the θ parameters.

Review of Related Studies

There is a large amount of literature relating to agriculture technology adoption since the Green Revolution in the 1960s. On the study of hybrid maize varieties adoption, there is much literature (eg. Griliches, 1957; Sain and Martinez, 1999; Iqbal *et al*., 1999; Chirwa, 2005; Salasya *et al*., 2007; Simtowe *et al*., 2009) while only few studies have addressed the adoption issue in Thailand. Most of the existing studies use choice models that rely on cross-sectional data to determine the significance of factors influencing the adoption decisions as measured at a static prospect. The following review outlines the factors influencing the adoption of hybrid and improved maize including new technology and new crop varieties from previous technology adoption studies.

Factors Influencing the Adoption of High-Yielding, Improved and Hybrid Crops Varieties

The factors that influence the adoption of new crop varieties from the previous studies can be separated into three groups as follows:

Personal Characteristics

Education is the most important factor that has been observed to be an influential factor in the study of new maize varieties adoption (Feder and Omara, 1981; Iqbal *et al.*, 1999; Salasya *et al.*, 1999). Most of the studies indicated that educated farmers have a better opportunity to acquire and process information on new technologies. In addition, education also played an important role on the speed of new technology adoption as mentioned in the review of duration analysis (Fuglie and Kascak, 2001; Burton *et al.*, 2003; Dadi *et al.*, 2004; Matuschke and Qaim, 2008).

Household size or the size of the family is one of the factors that has been included in adoption studies (Sain and Martinez, 1999; Burton *et al*., 2003). This variable is measured by the number of persons who live in the household. Farmers who have smaller families have been found to be more likely to adopt. This hypothesis is based on the argument that larger families use a greater proportion of their total revenue to satisfy vital needs and therefore they may have greater budgetary restrictions on the acquisition of hybrid maize seed (Sain and Martinez, 1999).

Years of farming experience was found to be an influential factor of new plant variety adoption in Gamba *et al.* (2003)'s study. The result revealed that experience in wheat cultivation had a positive impact on the adoption of a new variety. This variable is hypothesized based on the concept that more years on farming cultivation or farming experience contributes to better decision making.

Age is also included as one of the significance factors that affects the decision of farmers to adopt new technology as in Chirwa (2005), Simtowe *et al.* (2009) and Dadi *et al.* (2004). However, it showed a negative sign on the coefficient for all of these studies following the hypothesis that younger farmers are associated with higher risk-taking behavior than elderly farmers (Simtowe *et al.*, 2009).

Furthermore, the relationship between social activity and adoption of new crop varieties appeared in the study of Matuschke and Qaim (2008). The hypothesis of this factor is that the farmers with more formal meetings with other farmers, participation in field days or crop visits to learn about new seed varieties and informal meetings such as the attendance at social festivals or a local ceremony, might be able to get information on the existence and performance of new seed technologies faster and might therefore adopt earlier than their less socially active colleagues.

Farm Characteristics

The distance from the farm to input market has been included as an important factor affecting farmers' decisions as in Sain and Martinez (1999), Hintze *et al.* (2003), Chirwa (2005), Salasya *et al.* (2007) and also Matuschke and Qaim (2008). This factor came with the hypothesis that an individual farmer who has a maize farm located close to input markets incurs less transaction cost, which lowers the ultimate cost of seed and, consequently, they are more likely to adopt.

Farm size is a major influential factor that is widely found in numerous adoption of new agricultural technology studies (Feder and Omara, 1981; Sain and Martinez, 1999; Iqbal *et al.*, 1999; Hintze *et al.*, 2003; Salasya *et al.*, 2007; Simtowe *et al.*, 2009). The major hypothesis of this factor is that a farmer with a large size of farm area will be a greater financial and higher risk-taker for new technology adoption. Consequently, a farmer with a large farm size may adopt new varieties earlier than smaller-scale farmers.

Other Variables Related to Hybrid Maize Varieties

Attitudes toward maize traits of each variety are the factors that have been identified in the studies of Hintze *et al*, (2003) and Salasya *et al*. (2007). The studies found that the higher yield and earlier maturity of new maize varieties were the two most important characteristics influencing the adoption decision followed by the good quality of maize grain and drought tolerance. However, the study of the maize farmers' preferences for desired attributes in Thailand revealed that Thai maize farmers identified seed with lower prices as the major attribute for adoption decision followed by higher yield, drought tolerance and good grain quality, respectively (Ekasingh *et al*.,2004).

Extension of the new technology is the factor that is employed in numerous studies to explain the relationship between the channel of information received and new technology adoption. It was expected that farmers who have more chance to access extension services will receive more information and possibly adopt new technology more rapidly (Sain and Martinez, 1999; Iqbal *et al.*, 1999; Hintze *et al*., 2003; Dadi *et al.*, 2004; Ekasingh *et al*., 2004; D'Emden *et al*., 2006; Cavane, 2011; Mugisha and Dirro, 2010). In Thailand, there were four sources of information provided to farmers such as the extension program from public organizations, private companies, advice from the input and output market, and advice from neighboring farms (Ekasingh *et al.*, 2004). Hence, this variable is measured as the access of hybrid maize extension that farmers received at the first adoption.

Farmers' access to credit for inputs is an important factor in the adoption decision as reported in the study of Sain and Martinez (1999), Iqbal *et al.* (1999), Simtowe *et al.* (2009) and Dadi *et al.* (2004). This literature represented that the access to credit will facilitate the use of inputs purchased outside the farm, especially for seed acquisition.

Technology Adoption Using the Duration Analysis

There have been a few studies that have applied duration analysis to investigate the factors influencing technology adoption but there have been no studies conducted directly about technology adoption by this statistical method in Thailand. Thus, to investigate the factors influencing the timing of adoption, a review of related studies that applied duration analysis from others will be considered as follows:

Fuglie and Kascak (2001) were among the first who employed duration analysis to examine the agricultural adoption in a dynamic framework. They explored the duration of technology adoption and the diffusion of three agricultural practices that can improve farm productivity and conserve environmental resources, i.e. conservation tillage, soil nutrient testing and integrated pest management (IPM). The data were obtained from the Area Studies Survey by the United States Department of

Agriculture (USDA) during 1991-1993. A basic statistical approach, such as mean, was employed to describe the data, and the logistic distribution function was used to study the impact of factors on the diffusion path. The analysis found that farmer and farm characteristics, such as education, farm size, and land quality have an effect on technology diffusion. In addition, they also added the estimation of the lag time in adoption that is associated with farm characteristics to be time-varying determinants and the results were that differences in farm size, farmers' education and land quality give rise to lags of as much as one or two decades in technology adoption between the most favored and least favored farms.

Later, between 2003 and 2006, there were few studies that applied duration analysis in agricultural practices as in Burton *et al.* (2003), Dadi *et al.* (2004) and D' Emden *et al.* (2006). In 2003, Burton *et al.* used duration models to investigate the determinants of the adoption of organic agricultural practices in the UK horticultural sector. The results from 86 organic farmers and 151 conventional farmers were analyzed by the piece-wise continuous specification and Weibull models. The results from the study indicated that gender was the most important determinant and indicated that female farmers were more likely to adopt new technology. However, some important variables in this study were found to be negative and were found not to affect the time to adopt such as education, farm size and the household size of farmers which is in contrast with previous adoption studies. This study concluded that this might be due to the difference in country and commodity coverage because none of the previous studies has been in the UK. In addition, in Dadi *et al.* (2004)'s study, which determined the impact of time-varying and time-invariant variables on the timing of fertilizer and herbicide adoption in Ethiopia, the analysis of results from 200 sample farmers in the central highlands of Ethiopia were obtained from the exponential and Weibull models. The estimated results revealed that the economic incentives (i.e. prices) were the most significant determinant influencing the speed of adoption. Other agricultural inputs such as area of farm, labor and credit along with farmers' personal characteristics such as education, gender and age of farmers appeared to have a significant positively effect on adoption.

The study of D' Emden *et al.* (2006) investigated the significance of cross-sectional variables and time-dependent economic and environmental variables on the adoption of soil-conserving cropping practices in Australia during 1983-2003. A phone survey of 384 farmers across Southern Australia, comprising 240 no-till adopters and 144 non-adopters were used to describe the speed of adoption. Basic statistical approaches such as mean and S.D. were employed to describe the explanatory variables. The results from the exponential duration model study demonstrated that the herbicide cost-effectiveness (e.g. the reduction of glyphosate price) was the most important factor influencing the probability of no-tillage adoption. It also suggested that localized information and learning opportunities were particularly important in adoption decisions.

Matuschke and Qaim (2008) applied duration analysis to examine the impacts of privatization on farmers' technology access to new crop varieties, and this also represented the first use of the method in the adoption of new plant varieties. They analyzed the dynamic prospects of hybrid pearl millet adoption of 266 farm households in Maharashtra, the state with the second largest area of pearl millet in India. They adopted the Gompertz distribution which took the lowest Akaike information criterion (AIC) and fitted the model best when compared to the exponential and Weibull models. The findings showed that the education of farmers, the distance to the main source of information and a good market infrastructure were the determinants that speeded up the adoption of pearl millet hybrids. The increasing role of private companies led to competitive improvement in R&D and led to better technology. They also concluded that the main sources of information for farmers are input dealers and participation with other farmers.

In the most-recent study, Pornpratansombat *et al.* (2011) conducted research in Thailand related to the adoption of organic rice farming in the North-Eastern region with Cox's proportional hazard. The data from 90 organic rice farms and 90 conventional farms were collected for the analysis. The basic statistical analysis, i.e. mean, mode, frequency and percentage were employed to describe the important variables of rice sample farmers. The variable of interest is the length of time farmers wait until they adopt organic farming. The estimated results showed that better access to water, a higher farm price of rice and a stronger attitude toward the conventional cultivation problems were the important factors to encourage adoption decisions. Therefore, the recommendations from the study were to support the internal input use by increasing water accessibility, promoting the organic paddy markets at the local level and that the conductibility on the improvement of organic rice problem-solving should be considered to increase the speed of organic rice farming adoption.

In conclusion, the information received from this review of related literature points out that duration analysis can be applied to analyze the timing or spell of technology adoption, especially in the agricultural sector. In Thailand, there were a great number of research issues related to technology adoption at a point in time as well as research in other countries, but none of these studies applies duration analysis to investigate the factors that influence the timing of adoption. Therefore, this study does not only provide the results of factors that influence adoption timing, but it also provides guidelines and the basis for applying analytical tools in the analysis of new plant varieties adoption in Thailand.

CHAPTER III

RESEARCH METHODOLOGY

The contents of this chapter are separated into three main sections. The first section describes the analytical framework of the study followed by sampling procedure and methodology for data collection in the second section. The data analysis and empirical model specification are explained in the last section.

Analytical Framework

The analytical framework is developed based on the review of literature in the previous chapter. This study focuses on the effect of factors on the duration of hybrid maize adoption. Therefore, duration analysis is employed to model the adoption over time. This analysis can bridge the gap between the adoption studies which fail to measure the timing or duration of a technology adoption and the diffusion studies which model the aggregate timing of adoption but fail to investigate the impact from any factors as to why some adopt earlier. Hence, the variables in this study are divided into three groups: personal or farmer characteristics, farm characteristics and other variables related to hybrid maize varieties as mentioned in Table 3.5. For each group, the variables are separated into two types: time-invariant variables which are static over time and time-varying which vary over time. Therefore, the analytical framework of this study to test whether these variables have any effect on the duration of adoption is illustrated in Figure 3.2.

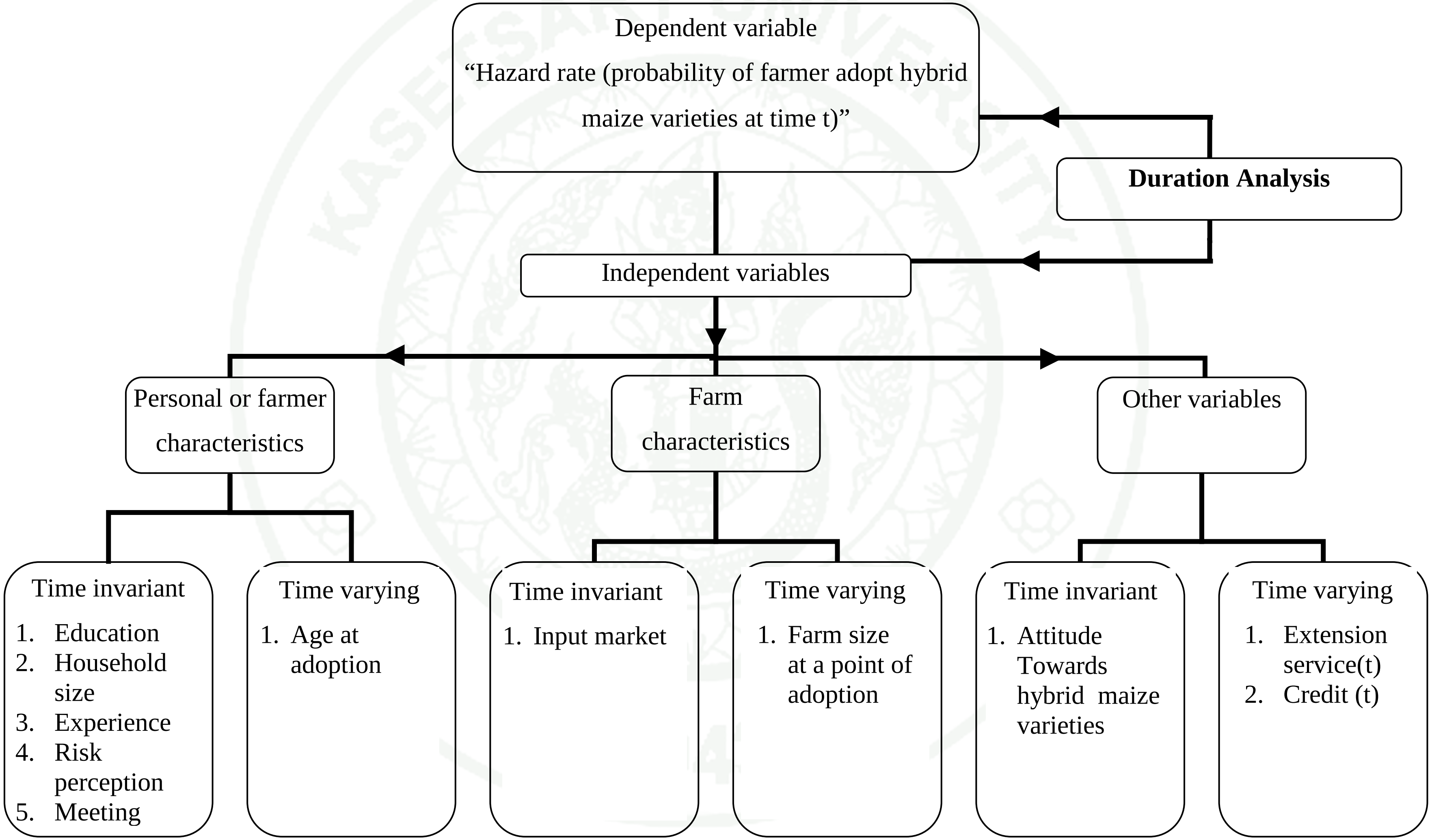

Figure 3.1 The analytical framework of the study

Sampling Procedure

The focus of this study is the duration of hybrid maize adoption in Thailand between 1980 and 2011. Therefore, this study employs a three stage stratified sampling technique in order to extend questionnaire coverage in the study area.

In the first stage, the intensity of maize planted area was adapted to classify the level of maize production capacity by calculating the proportion of maize area to total crop area from 40 maize cultivation provinces (the average of the proportion of maize area to total crop area from all provinces is 10.08%). The differences in intensity of maize area by province could show the different levels of extension service, the sources of information and the social activities of farmers which are assumed to be the important factors in adoption decisions. The first group, the major maize zone, comprising 13 provinces with a percentage greater than 10.08% and the second group, the minor maize zone which consists of 15 provinces are shown in Table 3.1 and Table 3.2, respectively. However, the 12 maize provinces are omitted because the percentage is less than 1%, which represents a very small area for maize cultivation.

Table 3.1 Provinces in major maize zone

Province	Total area for agriculture ('000 hectares)	Maize cultivated area ('000 hectares)	Proportion of maize area from total agricultural area (percent)
Nan	126.81	83.58	65.91
Tak	188.42	93.57	49.66
Phetchabun	592.92	161.82	27.29
Loei	370.11	98.15	26.52
Phrae	105.91	27.38	25.86
Chiang Rai	346.15	68.81	19.88
Phayao	177.46	35.28	19.88
Saraburi	158.93	30.82	19.39
Lamphun	542.50	15.78	18.18
Lopburi	375.48	59.85	15.94
Uthai Thani	223.70	28.35	12.68
Nakhon Ratchasima	1,257.27	131.00	10.42
Phitsanulok	399.80	40.28	10.10

Source: Department of Agriculture Extension (2011)

Table 3.2 Provinces in minor maize zone

Province	**Total area for agriculture ('000 hectares)**	**Maize cultivated area ('000 hectares)**	**Proportion of maize area from total agricultural area (percent)**
Sa kaeo	330.83	32.07	9.69
Nakhon Sawan	642.82	59.71	9.29
Chiang Mai	224.30	19.97	8.91
Uttaradit	204.67	17.09	8.35
Lampang	153.55	12.39	8.07
Kamphaeng Phet	427.79	22.20	5.19
Sukhothai	314.84	15.32	4.87
Kanchanaburi	326.82	13.95	4.27
Nongbua Lamphu	237.40	9.24	3.89
Chaiyaphum	551.49	19.27	3.49
Mae Hong Son	40.06	1.25	3.13
Suphanburi	339.43	9.22	2.72
Chanthaburi	260.19	5.61	2.16
Phichit	326.57	6.69	2.05
Si Sa ket	553.28	7.03	1.27

Source: Department of Agricultural Extension (2011)

The second stage is shown in Table 3.3, both maize zones are stratified by the establishment of a research center following the hypothesis that farmers who have more chance to access knowledge or information adopt new technology more rapidly. In this stage, Nakhon Ratchasima and Nakhon Sawan are automatically selected because both major and minor maize zones have only one province where there is a public research center. However, there are four provinces where there is a private research center in the major maize zone and a great number of provinces with no research center located in either major or minor maize zones. One province from each group was randomly selected due to the limitation of time and the budget constraint.

Table 3.3 The second-stage stratified sampling

Establishment of research center	Major maize zone	Minor maize zone
Public research center	Nakhon Ratchasima*	Nakhon Sawan*
Private research center	Lopburi**, (Lamphun, Phitsanulok, Saraburi)	-
None research center	Phetchabun**, (Chiang Rai, Loei, Nan, Phayao, Phrae, Tak, Uthai Thani)	Kamphaeng Phet**, (Chaiyaphum, Chanthaburi, Chiang Mai, Kanchanaburi, Lampang, Mae Hong Son, Nongbua Lamphu, Phichit, Sa Kaeo, Si Sa Ket, Sukhothai, Suphanburi, Uttaradit)

* Automatically selected

** Randomly selected

In the last stage, one district from five targeted provinces in Table 3.3 was selected randomly. The sample technique was adapted from Krejcie and Morgan (1970) to determine the sample size and assumed a five percent statistical significance level. For the major maize zone, Pak Chong, Chong Sarika and Namron districts were selected from their provinces with 19, 83 and 108 sample farmers, respectively. In addition, Suksamran and Angthong districts were also chosen for the study area in the minor maize zone with 95 and 35 samples. Therefore, the total sample size of this study is 341 based on a total of 2,997 maize farm households from five districts as shown in Table 3.4 and the study area is illustrated in Figure 3.1.

Table 3.4 Three stage stratified sampling and the sample size of the study

Stage I: Intensity of maize area	Stage II: Research center exists	Stage III: Sample districts	Total Maize farming household (person)	Sample size (person)	Sample proportion (percent)
Major maize province	*Public*:				
	Nakhon Ratchasima	Pak Chong	169	19	0.05
	Private: Lopburi	Chong Sarika	735	84	0.25
	None: Petchabun	Namron	949	108	0.32
Minor maize province	*Public*:				
	Nakhon Sawan	Suksamran	832	95	0.28
	Private: -	-	-	-	-
	None :				
	Kampangphet	Angthong	312	35	0.10
	Total		2,997	341	1.00

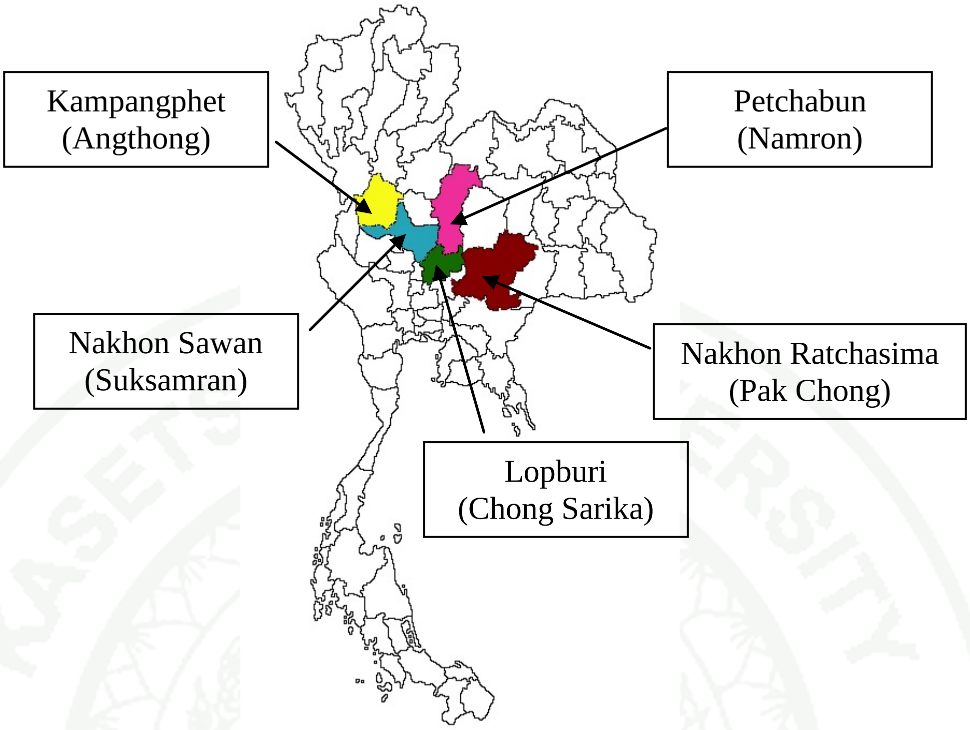

Figure 3.2 Study area in the selected province and district

Research Instrument

A structured questionnaire was employed to collect data from maize farm households. The questionnaire was created from relevant documentation and previous adoption research as guidelines. It consists of four sections as follows

Section 1: Current farm and maize cultivation information (2011).

Section 2: Farm and maize cultivation information for the past 30 years (1980 – 2010)

Section 3: Attitudes toward the advantages of hybrids over OPVs and local varieties.

Section 4: The characteristics of the respondents.

Data Collection

A total of 341 questionnaires were obtained by interviewing maize farmers from the study sites between May and June, 2011. However, the six questionnaires

(1.7%) were not included in the study because of incomplete information. The expected and actual sample sizes of the study are shown in Table 3.5.

Table 3.5 Expected and actual sample size of the study

Study area	Expected sample size (person)	Expected sample proportion	Actual sample Size (person)	Actual sample proportion
Major maize zone				
Nakhon Ratchasima (Pak Chong)	19	0.05	22	0.06
Lopburi (Chong Sarika)	84	0.25	76	0.23
Petchabun (Namron)	108	0.32	106	0.32
Minor maize zone				
Nakhon Sawan (Suksamran)	95	0.28	101	0.30
Kampangphet (Angthong)	35	0.10	30	0.09
Total	341	1.00	335	1.00

Data Analysis

After gathering the data from the completed 335 survey samples, all questionnaires were edited and coded in order to be analyzed by a STATA (version 11.1).

1. To achieve the first objective, the simple statistical approaches (i.e. means, frequencies), the adopter categorization concept as mentioned in Chapter II (pages 10-11) and the review of maize R&D in Thailand are employed to describe the frequency and cumulative distribution of hybrid maize adopters to characterize the diffusion of hybrid maize in Thailand over time.

2. To achieve the second objective, the impact of time-varying and time-invariant factors on the duration of hybrid maize adoption is analyzed using duration

analysis. This approach is appropriate to analyze the data which comprises the time-independent or vary on time data together.

Since time plays an important role in explaining the farming decision, a duration analysis is used to model the adoption of hybrid maize varieties. In this approach, the dependent variable is the length of time since the farmer started maize cultivation until they adopted hybrid varieties or until the measurement is taken. An important feature of this approach is that one can estimate the probability that a farmer will adopt hybrid maize in a particular year.

Because the research focuses on the farmers who adopt hybrid maize varieties, the start year (t = 0) is 1979 when the first hybrid maize was tested and its information was introduced. For farmers who started maize cultivation before 1979, the spell comprises the time between 1979 until the year in which they adopted hybrid maize. For farmers who started maize cultivation after 1979, the spell comprises the time between the first year of cultivating maize and the year of hybrid adoption. The farmers who used hybrid varieties in the first year when they started maize cultivation, the spell amounted to one year. It is assumed that the farmers received the information about those hybrid varieties one year before maize cultivation.

Following the review of the theoretical framework in Chapter II, the three parametric models are employed for this study includes exponential, Weibull and Gompertz distributions as in equation (2.6), (2.7) and (2.8). A proportional hazard model is assumed to introduce the individual covariates. Therefore, the exponential distribution can be defined as

$$h(t;X) = \exp(\beta_0)\exp(\beta, X_t) \tag{3.7}$$

the Weibull distribution can be defined as

$$h(t) = pt^{p-1}\exp(\beta_0)\exp(\beta, X_t) \tag{3.8}$$

and the Gompertz distribution is defined as

$$h(t) = \exp(\gamma t)\exp(\beta_0)\exp(\beta, X_t)$$

Express $\exp(\beta, X_t)$ in terms of explanatory variables

Let $\exp(\beta, X_t) = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_n X_n)$ (3.9)

The explanatory or the independent variables for the analysis are classified into three groups, personal characteristics, farm characteristics and other variables related to hybrid maize varieties. Each group comprises two types of variable: time-invariant and time-varying as described in Table 3.6.

Table 3.6 Definition of explanatory variables.

Variable	Description
	Personal characteristics
Time invariant	
Education (EDU)	Formal education received. (years)
Household size (HHS)	Number of people in household. (persons)
Experience (EXPE)	Years of maize cultivation or maize experience. (years)
Risk perception (RISK)	Money spent for lottery by month. (baht per month)
Social Meeting (PUBM, PRIM, SHOPM)	Average times farmer meet (times per year); Meet with public researchers or extension officers. (PUBM) Meet with private researchers (PRIM) Meet with input shop or input dealer (SHOPM)
Time varying	
Age (AGET)	Age of farmers when they first adopted hybrid maize varieties. (years)
	Farm characteristics
Time invariant	
Distance farm to input market (INDIST)	Distance from the farm to the input market or input dealer. (km)
Time varying	
Farm size (FARMT)	Total maize cultivated land when farmers adopted hybrid maize varieties. (hectare)
	Other variables related to hybrid maize varieties
Time invariant	
Attitude (ATTI)	The attitude of farmers toward the advantage of hybrid maize traits over OPV traits. This variable contains 8 attributes: 1. High yielding 2. Early maturity

Table 3.5 (Continued)

Variable	Description
	3. Better maize grain weight and shape 4. Drought tolerance 5. Pest and chemical resistance 6. Easy to harvest 7. Rust or downy mildew resistance 8. Higher maize grain price (Attitude were measured using a 5-point Likert scale approach with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. Hence, the summed score ranged from 8 – 40 point, the farmers who given a response less than 24 points are allocated into unfavorable attitudes and the farmers who given a response equal or greater than 24 points are allocated to favorable attitudes.)
Time varying	
Extension service (PUBEXTT, PRIEXTT, SHOPEXTT)	Farmers received hybrid maize information or extension at first adoption from; (1 if yes, 0 if no) Public officers or public research center (PUBEXTT) Private companies or private research center (PRIEXTT) Input shop or input dealer (SHOPEXTT)
Credit (PUBCDTT, PRICDTT, SHOPCDTT)	The farmer's accessibility to credit at adoption year from; (1 if yes, 0 if no) Public organization or public research center (PUBCDTT) Private companies or private research center (PRICDTT) Input shop or input dealer (SHOPCDTT)

The estimation of parameters will follow maximum-likelihood methods. From equation (2.10), assuming a sample of the n observations adopted in the duration, t_i^*, and each individual's time is independent from the time of others, the likelihood function is

$$L = \sum_{i=1}^{n} f\left(t_i^*, \theta\right) \tag{3.10}$$

where $f\left(t_i^*, \theta\right)$ is the density function and θ is the vector of parameters. But, in cases where censored observations are included, the likelihood function can be defined as

$$L(\theta) = \sum_{i=1}^{n} d_i \ln h(t_i, \theta) + \sum_{i=1}^{n} \ln S(t_i, \theta) \tag{3.11}$$

To evaluate whether the model fit supports the distribution choice, the Akaike information criterion (AIC) which was proposed by Akaike (1974) to test the goodness of fit of an estimated statistical model is employed for this study. For the parametric duration models, the AIC is defined as

$$AIC = -2\ln(likelihood) + 2(k + c) \tag{3.12}$$

Where k is the number of parameters, c = 1 for the exponential model, c = 2 for the Weibull and the Gompertz model (Klein and Moeschberger, 1997). Lower AIC indicates better likelihood and fits the model best.

CHAPTER IV

RESULTS

This chapter consists of three parts: the adoption and diffusion of hybrid maize in Thailand, the descriptive statistics and the empirical estimates. The first part indicates the adoption and diffusion pattern of hybrid maize varieties from survey data compare and contrast with a review of previous studies and documentation. The next part presents the descriptive statistics including demographic characteristics of farmers, farm characteristics and attitudes toward the advantages of hybrid maize varieties over OPVs and local varieties. The last part presents the estimation of exponential and Weibull models based on the model developed in the previous chapter.

The Adoption and Diffusion Pattern of Hybrid Maize in Thailand

The hybrid maize research program was first started in Thailand since 1978 by NCSRC and the first maize hybrids were introduced in 1980. Therefore the start point of hybrid maize diffusion was in 1980 cropping season. From the 335 survey samples of the study, maize farmers in Thailand can be classified into five categories using Roger's adopter categorizations criterion as aforementioned in Chapter II. As illustrates in Figure 4.1 and Table 4.1, respectively, there are seven farmers or 2.09% who adopted hybrid varieties during 1980 to 1983 and they are classified as the innovators. Because the lack of information and experience along with the variation of the varieties, these farmers still paid attention to adopt and they represented a high level of risk taking when new technology proves unsuccessful.

During 1983 to 1990, the 69 farmers or 20.60% who adopted at this time are classified as the early adopters. Because the hybrids seed price were two or three times higher than OPVs, farmers in this category still adopted and had the high degree of risk taking not too far ahead of the farmer in innovativeness. Later, the incoming of several private seed companies and seed dealers during the early 1990s led to the expansion of hybrid seed production capacity and it appeared to be the start of the privatization of the hybrid maize seed industry. In addition, the public extension program in 1994, led hybrid maize became well-known among maize growers in Thailand. Therefore, the 118 farmers or 35.22% who adopted hybrid varieties between 1991 and 1996 are classified as early majority because this category got large information and knowledge and they have more chance to access the technology.

The 84 farmers or 25.07% who adopted hybrid maize between 1997 and 2003 are classified into the fourth category, late majority. These farmers did not adopt until most others had done so and they adopted just after the average member of a social system. However, some farmers in this category still preferred OPVs but the insufficient of seed provided by public sector led them to adopted hybrids. The last category is the laggards, there are 57 farmers or 17.02% who adopted hybrid varieties between 2004 and 2010 classified into this group. These farmers are the last in a social system to adopt because after year 2001, more than 90% of farmers already used hybrid varieties and are almost 100% in 2009 (Office of Agricultural Economics, 2011).

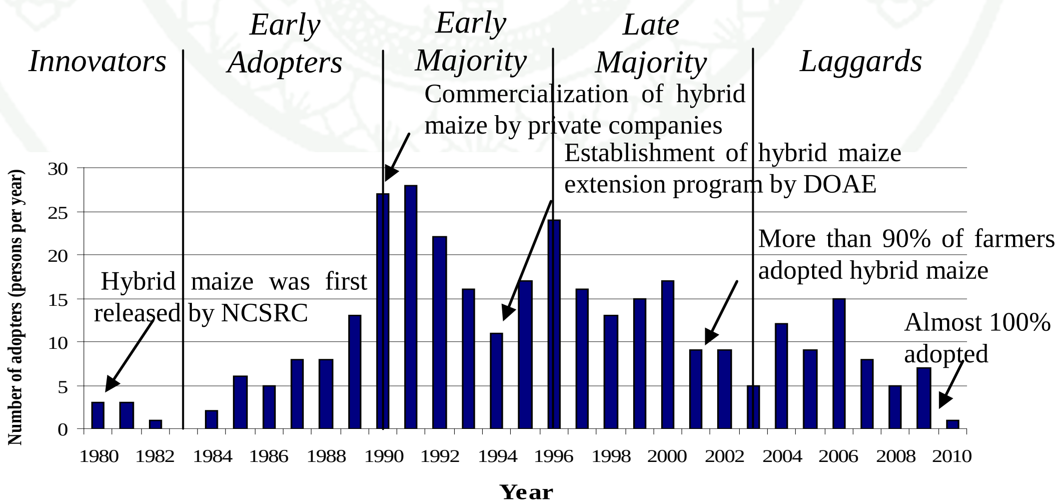

Figure 4.1 Distribution pattern of hybrid maize adoption by year in Thailand 1980 – 2010

Source: Survey sample (2011)

Table 4.1 Categorization of the hybrid maize adopters in Thailand, 1980-2010

Adopter categorization	Year	Number of farmers	Percentage
Innovators	1980 - 1983	7	2.09
Early Adopters	1984 – 1990	69	20.60
Early Majorities	1991 – 1996	118	35.22
Late majorities	1997 – 2003	84	25.07
Laggards	2004 – 2010	57	17.02
Total		335	100

Hence, the cumulative of hybrid maize adoption and aggregate diffusion in Thailand from survey data can be illustrated as in Figure 4.2. The figure is consistent to the previous study in Suwantaradol (2001) and Ekasingh *et al.* (2004) that the farmers' acceptance and adoption of hybrid varieties during the first stage was limited and slow. However, after year 1990 the adoption increased dramatically due to the incoming of several private companies in seed industry. After year 2002, the adoption increased gradually when compared to the previous period because most of Thai maize farmers already adopted these varieties and only a few farmers who did not adopted yet.

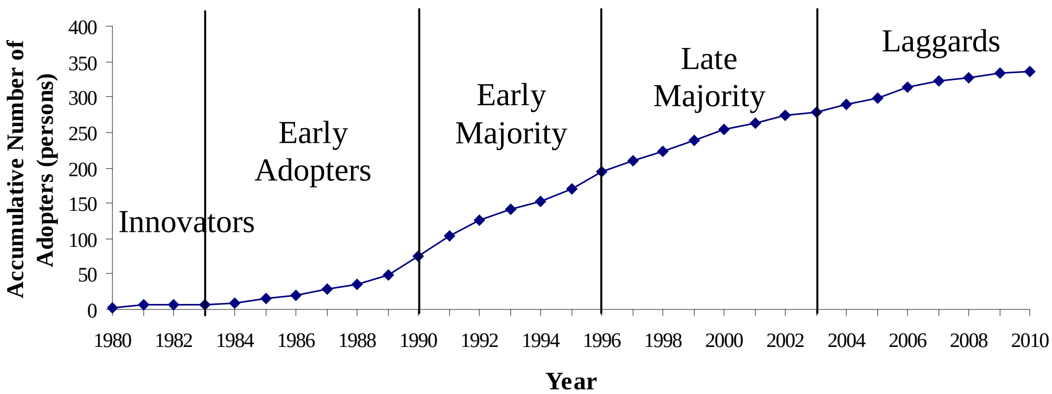

Figure 4.2 Cumulative adoption and aggregate diffusion of hybrid maize in Thailand 1980-2010

Source: Survey sample (2011)

Descriptive Statistics

The survey data were collected and edited in order to describe the general information on the demographic and farm characteristics of maize farmers in Thailand. In addition, the other variables related to public and private roles, the characteristics of hybrid maize varieties and the attitudes of farmers toward the advantages of hybrid maize over OPVs and local varieties are also described in the study.

Demographic Characteristics of Maize Farmers

The demographic characteristics of 335 sample maize farmers are summarized in Table 4.2. The surveyed male farmers accounted for 55.22% or 185 persons and 44.78% or 150 persons are female farmers. The average age of farmers in this survey is 51.15 years with the age of the youngest farmers at 22 years and the eldest at 86 years.

With respect to the years of formal education received, it was found that the average year of formal education is 5.31 years and the minimum years of education received is at zero or no education received. The highest level education of surveyed farmers is 16 years or can be defined as graduation with a bachelor degree or equal.

With respect to the size of maize farmers' households, the average number of persons in the households is 4.08 persons. The smallest farmers' households are only one person while the largest number of persons in maize farmers' households is 12 persons.

Risk perception or risk acceptance is identified as one significant factor in the technology adoption study. This study measures risk perception through the monthly money payment for the government lottery. From the surveyed data, the average amount of money that maize farmers paid for lottery was 448.83 baht per month with the highest amount of money spent being 20,000 baht. However, there are 100 farmers who do not spend their money for this lottery.

With respect to experience of maize cultivation, it was found that the average number of years of maize experience is 24.48 years and the experience distribution ranges between 2 and 62 years. In addition, the study also found that the average income of farmers' household is 550,408.7 baht per year while the average income from maize cultivation is 297,192.3 baht per year.

For communication through the measurement of annual meetings, the study found that maize farmers have the most formal meetings with public officers or public researchers at an average of 1.91 times per year, followed by meetings with input shops or input dealers at 0.95 times and private companies at 0.71 times per year.

Table 4.2 Summary of demographic characteristics of maize farmers, 2011

Demographic	Mean	Min	Max	Frequency	Percentage
No. of Observations	-	-	-	335	100.0
Gender					
Male	-	-	-	185	55.22
Female	-	-	-	150	44.78
Age (year)	51.15	22	86	-	-
Years of education	5.31	0	16	-	-
Household Size (person)	4.08	1	12	-	-
Money spends for Lottery (baht/month)	448.83	0	20000	-	-
Maize Cultivation Experience (year)	24.48	2	62	-	-
Household Income (baht/year)	550,408.7	33,600	4,300,000	-	-
Maize Income (baht/year)	297,192.3	3,225	3,748,080	-	-
Annual meeting with; (times per year)					
Public researchers	1.91	0	12	-	-
Private companies	0.71	0	8	-	-
Input shop or dealer	0.95	0	36	-	-

Farm Characteristics of Maize Farmers

The farm characteristics and production indicators of maize farmers are summarized in Table 4.3. The results reveal that the majority of maize farmers cultivate only one crop season of maize in a year, which accounted for 90.15% or 302 farmers while the percentage of maize farmers who cultivate two crops of maize per year was only 10.85% or 33 farmers. This study also found that the number of farmers who cultivate maize in monoculture practice was 168 farmers or 50.15% while 167 farmers or 49.85% cultivate in a polyculture practice. However, there were 93.13% or

312 maize farmers who cultivate maize as a main crop and only 6.87% or 23 farmers who cultivate maize as a second crop. In addition, the study also found that 317 farmers or 94.63% of maize farmers sold their products to local collectors, followed by wholesalers with nine farmers or 2.69% and eight farmers or 2.39% who sold to a manufacturer while there is only one farmer who sold maize products to the public sector.

With respect to the distance from the farm to the input market, input shop or input dealer where farmers buy maize seed for cultivation, it was found that the average distance is 9 km with the shortest distance at 0.01 km and the longest distance at 45 km.

Having a research center close to the farm is expected to be a significant factor on the speed of adoption. From the surveyed data, it was found that 36.72% or 123 farmers are located in a province where there is a public research center, 22.69% or 76 farmers have their farm located in a province where there is a private research center and 40.59% or 136 farmers have their farm located in a province with no public or private research center.

For the production indicators, the farm areas of maize cultivation are ranked between 0.08 hectares to 80 hectares and the average farm area from the survey is 6.28 hectares while the average productivity of survey farmers is 7.38 ton per hectare. With respect to the maize seed price, it was found that the price distribution ranges between 50 and 180 baht per kg and the average price of maize seed is 127.7 baht per kg. The average amount of maize seed used per hectare is 20.39 kg while the distribution ranges from 9.375 kg per hectare to 41.25 kg per hectare. In addition, the maize farmers could sell their maize grain at an average price of 5.65 baht. The lowest price of maize grain is 2.65 baht per kg and the highest price that farmers received is 12.36 baht per kg. The average maturity day of maize or the time period farmers waited from cultivation to harvest is 110.8 days and the distribution ranges between 90 and 150 days. Moreover, all maize farmers from the survey used hybrid maize that means there is no censored observation in this study.

Table 4.3 Summary of farm characteristics of maize farmers in Thailand, 2011

Farm characteristic	Mean	Min	Max	Frequency	Percentage
No. of Observations	-	-	-	335	100.0
Maize farming characteristics					
Cropping season per year					
1 season	-	-	-	302	90.15
2 seasons	-	-	-	33	10.85
Maize cultivation practice					
Monoculture	-	-	-	168	50.15
Polyculture	-	-	-	167	49.85
Importance of maize					
Main crop	-	-	-	312	93.13
Second crop	-	-	-	23	6.87
No. of farmers who cultivate maize as a commercial crop	-	-	-	335	100
Products are sold to;					
Local collector	-	-	-	317	94.62
Wholesaler	-	-	-	9	2.69
Manufacturer	-	-	-	8	2.39
Public sector	-	-	-	1	0.30
Distance from farm to input market (km)	9	0.01	45	-	-
Research center exists					
Public	-	-	-	123	36.72
Private	-	-	-	76	22.69
None	-	-	-	136	40.59

Table 4.3 (Continued)

Farm characteristic	Mean	Min	Max	Frequency	Percentage
Maize farming production indicators					
Maize farm size (hectare)	6.28	0.08	80	-	-
Yield (ton/hectare)	7.38	1.33	14.06	-	-
Seed price (baht/kg)	127.7	50	180	-	-
Seed rate (kg/hectare)	20.39	9.375	41.25	-	-
Farm price(baht/kg)	5.65	2.64	12.36	-	-
Maturity (day)	111.8	90	150	-	-
No. of farmer who use hybrid maize varieties	-	-	-	335	100

Farm Characteristics of Maize Farmers at the Time of First Adoption of Hybrid Maize

The farm characteristics of maize farmers since the first adoption from OPVs or local varieties to hybrid maize varieties are described in Table 4.4. The majority of maize farmers who started maize cultivation after 1980 are 57.31% or 192 farmers and the farmers who started maize cultivation before or in 1980 are 42.69%. Since the hybrid maize was first released in 1980, the number of farmers who started using hybrid seeds one year after it was released or started using hybrids in the first year of maize cultivation (duration of adoption equal to one) is 40.00% or 134 farmers. While 60.00% or 201 farmers waited and considered adopting hybrids more than one year after the release or after they started maize cultivation. The average years of duration or the length of time farmers waited before adopting the hybrid maize varieties is 7.90 years with the shortest period at one year and the longest period at 28 years. In addition, the age of farmers at the first adoption ranges between nine and 76 years and the average age of farmers at the first adoption is 37.05 years.

With respect to the farm area of maize at the first adoption of farmers, it was found that the average farm area at the first adoption is 7.19 hectares and ranges between 0.08 hectares and 184 hectares. The price of hybrid maize seed and the maize grain price at the first adoption are deflated in accordance with the consumer price index or CPI (Bureau of Trade and Economic Indices, 2012). The average price of hybrid maize seed is 119.81 baht per kg and ranges between zero and 220.30 baht per kg, which means some farmers could access this hybrid maize variety without any payment. The average price of maize grain is 5.20 baht per kg with the lowest price at 1.39 baht per kg and the highest price at 31.69 baht per kg.

Table 4.4 Hybrid maize varieties adoption by farmers in Thailand, 2011

Farm characteristic	Mean	Min	Max	Frequency	Percentage
No. of Observations	-	-	-	335	100.0
No. of farmers who start maize cultivation					
Up to and including 1980	-	-	-	143	42.69
After 1980	-	-	-	192	57.31
No. of hybrid maize Farmers					
In the first year after its release.	-	-	-	134	40.00
More than one year after its release.	-	-	-	201	60.00
Duration before adoption (years)	7.90	1	28	-	-
Age of farmers at adoption (year)	37.05	9	76	-	-
Farm size at adoption (hectares)	7.19	0.08	184	-	-
Seed price at adoption (baht/kg)	119.81	0	220.30	-	-
Grain price at adoption (baht/kg)	5.20	1.39	31.69	-	-

Source of Maize Seed

The sources of maize seed in the current year and the source of hybrid varieties at the first time of adoption are described in Table 4.5. It shows that input shops or input dealers played important roles as the main source of maize seed as 73.73% of survey maize farmers purchased seed from this sector followed by public research centers, private companies and local farmers at 18.51%, 3.58% and 3.28%, respectively. There was only one farmer who received free seed from an input shop or input dealer; only one who received free seed from private companies and one farmer who used self-saved seed.

When compared to the source of hybrid maize seed at the first time of adoption, it was found that input shops or input dealers also played an important role in hybrid maize seed distribution with 71.64% if farmers purchasing seed from this source. In addition, there were 19.70%, 4.78% and 1.19% who purchased hybrid maize seed from public research centers, private companies and local farmers, respectively. However, the study found that there were three farmers who received free hybrid maize seed from input shops, three farmers who received seed from a public research center and three farmers who received free seed from private companies.

Table 4.5 Proportion of the source of maize seed for cultivation currently and the source of hybrid varieties at the first time of adoption in Thailand, 2011

Source of seed for maize cultivation	At present		Hybrid varieties seed at the first adoption	
	Frequency	Percentage	Frequency	Percentage
Purchase from;				
Input shop/dealer	247	73.73	240	71.64
Public research centers	62	18.51	66	19.70
Private companies	12	3.58	16	4.78
Local farmers	11	3.28	4	1.19
Free distribute from;				
Input shop/dealer	1	0.30	3	0.90
Public research centers	-	-	3	0.90
Private companies	1	0.30	3	0.90
Local farmers	-	-	-	-
Self- saved seed	1	0.30	-	-
Total	335	100	335	100

Companies Supplying Hybrid Maize Varieties

Farmers were asked “Which brands or companies of maize seed do you use currently and at the first time of adoption of hybrids?” The majority of maize farmers currently use the varieties from Monsanto and Syngenta companies at 33.73% and 31.04%, respectively, followed by 14.33% who use the varieties from CP companies, 9.85% from Pacific, 7.76% from Pioneer, 0.6% from Cargill and 2.69% from other private companies. However, from the surveyed data, none of maize farmers currently use the hybrid varieties or other varieties from the public sector.

With respect to the hybrid seed companies that farmers used when they first adopted hybrid varieties, it was found that the majority of maize farmers used the seed varieties from CP at 40.00%, followed by Monsanto at 25.67%, Syngenta at 13.43%, Pacific, Pioneer and Cargill at 6.87%, 5.97% and 5.37%, respectively. In addition, there are some farmers who used the public hybrids at 2.69% when first adopting hybrid maize varieties.

Table 4.6 Proportion of hybrid maize varieties' companies currently and at the first time of adoption in Thailand, 2011

Companies of hybrid maize seed	**At present**		**At the first adoption**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
CP	48	14.33	134	40.00
Syngenta	104	31.04	45	13.43
Monsanto	115	34.33	86	25.67
Pacific	33	9.85	23	6.87
Pioneer	26	7.76	20	5.97
Cargill	-	-	18	5.37
Other private companies	9	2.69	-	-
Public varieties	-	-	9	2.69
Total	335	100	335	100

Source of Extension Service and Information of Hybrid Maize Varieties

Maize farmers were asked "Did you receive extension services or programs at the first adoption of hybrid maize varieties? And if you received any, what is the source of this extension?" It was found that the majority of farmers received extension services from private companies or a private research center when they decided to adopt hybrid varieties at 48.06%. The percentage of maize farmers who received extension services from public officers or a public research center was 30.75%. In addition, 28.96% received extension services from input shop or input dealer. However, there are 16.12% who did not receive extension services from public sector, private sector and input shop as shown in Table 4.7.

Table 4.7 Number of farmers who received seed extension services for maize cultivation at the first hybrid varieties adoption in Thailand

Item	Frequency	Percentage
No. of Observations	335	100.0
Extension Service		
Public officers	63	18.81
Private companies	96	28.66
Input dealer	50	14.93
Public officers and private companies	25	7.46
Public officers and input dealer	7	2.09
Private companies and input dealer	32	9.55
Public officers and private companies and input dealer	8	2.39
No received extension services	54	16.12
Total number of farmers who received extension service from		
Public officers	103	30.75
Private companies	161	48.06
Input dealer	97	28.96

Source of Credit for Input at the First Adoption of Hybrid Maize Varieties

With respect to credit for inputs, maize farmers were asked “Did you receive credit for inputs at the first adoption of hybrid maize varieties? And if you received credit, what is the source of this credit?” The surveyed data in Table 4.8 shows that the majority of maize farmers received credit for inputs from a public organization or a public research center at 45.97%, followed by credit from an input shop or input dealer at 12.84%, credit from private companies or a private research center at 3.88% while the percentage of farmers who did not receive any credit at the first adoption of hybrid maize varieties was 38.80%.

Table 4.8 Number of farmers who received credit for maize cultivation at the first hybrid varieties adoption in Thailand

Item	Frequency	Percentage
No. of Observations	335	100.0
Credit		
Public officers	149	44.48
Private companies	11	3.28
Input dealer	40	11.94
Public officers and private companies	2	0.60
Public officers and input dealer	3	0.90
Private companies and input dealer	0	0.00
Public officers and private companies and input dealer	0	0.00
No received extension services	130	38.80
Total number of farmers who received credit from		
Public officers	154	45.97
Private companies	13	3.88
Input dealer	43	12.84

Attitudes toward the Advantages of Hybrid Maize over OPVs and Local Varieties

The maize farmers were asked whether they strongly disagree, disagree, neutral, agree or strongly agree about eight attributes of hybrid maize over OPVs and local varieties, as presented in Table 4.9.

The attribute that farmers have the most agreement was the higher yielding of hybrid varieties over OPVs and local varieties with 84.78% while only 8.36% of farmers were uncertain and 6.78% disagreed. Followed by the attribute that hybrid varieties have better weight of grain and shape of kernel when compared to OPVs and local varieties with 81.79% agreed, 10.45% were uncertain and 7.76% disagreed.

For the third attribute, it was found that 69.56% of farmers agreed that hybrid varieties can tolerate drought more than OPVs and local varieties while 19.40% disagreed and 11.04% were uncertain. Easier to harvest is the fourth attribute that farmers have positive attitude. There were 67.76% of farmers who agreed that hybrid varieties could be harvested easier than OPVs and local varieties while 18.51% disagreed and 13.72% were uncertain about this attribute.

Rust or downy mildew resistant is the fifth attribute. There were 58.21% farmers who agreed that hybrid varieties could resist rust or downy mildew more than OPVs and local varieties while 27.76% were uncertain and 13.03% disagreed. The next two attributes are the pesticide and chemical resistant, and maturity with the agreement attitude at 50.15% and 49.25%, respectively.

The last attribute is that the price of hybrid maize grain is higher than the maize grain from OPVs and local varieties. There were only 37.61% who agreed with this statement while the majority of maize farmers disagreed at 49.45% and the percentage of farmers with an uncertain attitude was 11.94%.

Table 4.9 Attitudes toward the advantage of hybrid maize over OPVs and local varieties in Thailand, 2011

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Higher yielding	2 (0.60)	21 (6.27)	28 (8.36)	130 (38.81)	154 (45.97)
Earlier maturity	17 (5.07)	110 (32.84)	43 (12.84)	118 (35.22)	47 (14.03)
Better grain weight & Shape	4 (1.19)	22 (6.57)	35 (10.45)	124 (37.01)	150 (44.78)
More drought tolerant	7 (2.09)	58 (17.31)	37 (11.04)	123 (36.72)	110 (32.84)
More pesticide and chemical resistant	4 (1.19)	70 (20.90)	93 (27.76)	142 (42.39)	26 (7.76)
Easier to harvest	3 (0.90)	59 (17.61)	46 (13.73)	123 (36.72)	104 (31.04)
More rust or downy mildew resistant	5 (1.49)	42 (12.54)	93 (27.76)	122 (36.42)	73 (21.79)
Higher maize grain price	25 (7.46)	144 (42.99)	40 (11.94)	72 (21.49)	54 (16.12)

The attitudes toward the advantages of hybrid maize over OPVs and local varieties in Table 4.9 were measured using a 5-point Likert scale approach with 1 if strongly disagree, 2 if disagree, 3 if neutral, 4 if agree and 5 if strongly agree. Hence, the summed scores ranged from 8 – 40 points. The farmers who gave responses less than 24 points are allocated into unfavorable attitudes and the farmers who gave responses equal to or greater than 24 points are allocated to favorable attitudes. The number of farmers who were judged to have favorable and unfavorable attitudes is shown in Table 4.10.

Table 4.10 Numbers and percentage of favorable and unfavorable attitudes toward the advantage of hybrids over OPVs and local varieties for maize cultivation in Thailand, 2011

Item	Frequency	Percentage
No. of Observations	335	100.00
Attitudes		
Favorable attitude	309	92.24
Unfavorable attitude	26	7.76

Empirical Results

Before estimating the parametric models, the Kaplan-Meier non-parametric estimator is commonly used to investigate the duration data. Figure 4.3 presents the survival function which illustrates the relationship between the proportion of non-adopters and the adoption spell and it represents the time difference between the year of first maize cultivation and the year of hybrid varieties adoption.

The horizontal axis denotes the number of years farmers wait before deciding to adopt hybrid maize and the vertical axis presents the proportion of farmers who have not yet adopted at time t. Figure 4.3 illustrates that there are more than 40% of maize farmers who adopted hybrid maize since the first year after it was introduced included the farmers who used hybrids for the first time of cultivation. From the data collected in 2011, all of the sample maize farmers adopted hybrid varieties and the longest period that farmers waited before adopted is 28 years. Hence, the censored observations do not occur but duration model still used to indicate the factors that affected to the speed of adoption and the probability of surviving past a certain point in time may be of more interest than the expected time of the event.

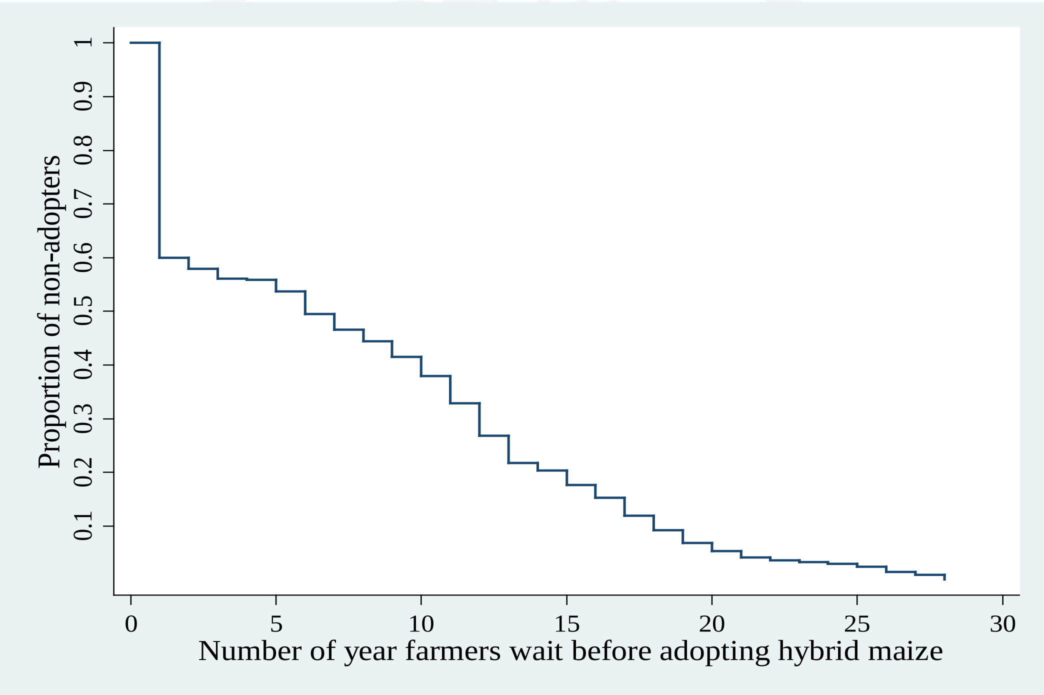

Figure 4.3 Kaplan-Meier estimator of the survival function

For the parametric estimation, the Akaike information criterion (*AIC*) is employed to choose the best fit model, and can be defined as $AIC = -2\ln L + 2(k+c)$, where k is the number of independent variables, c is the number of model-specific distribution parameters (=1 for exponential and =2 for Weibull and Gompertz distribution). Based on our samples, the *AIC* for the exponential distribution is 868.769, Weibull distribution is 801.003 and Gompertz distribution is 699.634. Therefore, the Gompertz distribution has the lowest *AIC* and fits the model better.

The results of the exponential, Weibull and Gompertz distribution hazard models are presented in Table 4.11. The coefficient estimates are reported as hazard ratios ($\exp(\beta, X)$). A value greater than one is interpreted as a positive impact on the hazard rate of adoption, implying a faster adoption process, and vice versa for a value less than one. For the demographic or personal characteristics of maize farmers, it was found that experience of maize cultivation (EXPE) has a significant impact on the speed of hybrid maize adoption on exponential, Weibull and Gompertz distributions, with a hazard ratio at 0.910, 0.879 and 0.857, respectively. This means that farmers with a one year increase in experience decrease the speed of adoption at 9.0% in cases of exponential, 12.1% for Weibull and 14.3% for Gompertz distributions. As a result, it does not support the hypotheses that more years of farming experience increases the probability of adoption. Since most of the less experienced farmers had started maize cultivation with hybrid varieties which are high yielding, along with the lack of accessibility to OPVs or local varieties, these are important factors affecting the speed of hybrid varieties adoption.

The age at the time of adoption (AGET) is one of the factors that influents the speed of adoption in case of exponential and Weibull distributions. Older farmers speed up the probability of adopting earlier as a one year increase in age increases the speed of adoption at 1.3% for exponential distribution and 1.6% for Weibull distributions. However, due to this study assumes Gompertz distribution, the age of farmers has no impact to the speed of hybrid maize adoption.

In addition, public communication through meetings has a significant effect on the speed of adoption. The result shows that farmers with a one time increase in meetings with public officers or researchers decreases the speed of adoption at 4.1% for exponential, 6.1% for Weibull and 6.5% for Gompertz distributions. Therefore, less frequent meetings with the public officers may actually increase the speed of hybrid maize adoption. As a result, it does not support the hypotheses but it may be possible because the public sector still produced and developed OPVs maize in the early stage after the release of hybrid varieties. The access to OPVs by farmers and the lower price of OPVs relative to hybrid varieties may slow down the speed of the adoption.

In contrast, meetings with private researchers (PRIM) or input dealers (SHOPM) had no significant impact on the speed of adoption while they also represent a negative impact in common with meetings with the public sector. This may imply that meetings with private sector or input dealers do not affect the adoption decision of maize farmers to use hybrid varieties.

However, the formal education of farmers (EDU), the size of households (HHS) and risk perceptions (RISK) are also demographic variables that have no significant impact on the speed of adoption in this study.

Distance from the farm to the input market or input dealer (INDIST) also plays an important role in the speed of adoption. It is suggested that an increase in distance by 1 km decreases the speed of adoption by 1.8% in case of Weibull and 2.2% for the Gompertz distribution. It implies that farmers who have farms closer to input markets or input dealers tend to adopt earlier. However, farm size at adoption time (FARMT) which was expected to positively shift the probability of adoption has no effect on the rate of adoption. However, the attitude towards the advantages of hybrid varieties over OPVs and local varieties (ATTI) was not found to have a significant on the speed of adoption.

With respect to the extension services, it was found that the extension services from an input shop or input dealer (SHOPEXTT) have a positive impact on the speed of hybrid maize adoption. For a unit increase in input shop extension service, the hazard rate of adoption is increased at 21.3% for the Gompertz distribution. On the other hand, the extension services from public researchers or a public research center (PUBEXTT) and private officers or a private research center (PRIEXTT) do not play an important role on the speed of adoption. As a result, it could be explained that extension services for hybrid maize varieties from an input shop or input dealer is more influential on the adoption decision from farmers than an extension service from any other sector.

However, credit from private companies or a private research center (PRICDTT) has become a significant factor on the speed of adoption. It implies that a unit increase in credit received will increase the speed of adoption 2.5 times for Weibull and 2.73 times for Gompertz distributions. However, the credit received from a public organization or a public research center (PUBCDTT) and an input shop or input dealer (SHOPCDTT) does not show the significant impact to the speed of adoption.

From the regression results above, it can be concluded that innovation or technology should be transferred to less experienced farmers or the new generation farmers to increase the speed of adoption. In terms of the public, private and input dealer roles in the adoption process, the results imply that while public communication may inversely influence the speed of hybrid maize varieties adoption, communication with private companies and input dealers was successful in increasing the adoption rate through the extension services of input dealers and the provision of credit for maize cultivation from the private sector. One possible reason is that farmers pay more attention to input dealers because they are more closely compared to the public or private sector. In addition, the credit for inputs from private companies has to be one important reason affecting the adoption decision as some private companies used the contract-farming approach and farmers can have more opportunity to access the new varieties.

There are two main reasons to explain the analysis that the public sector has a significant role but has lowered the speed of adoption: one is that the public sector still produced and developed OPVs maize in the early stage when hybrid varieties were released, and the lower price of OPVs relative to hybrid varieties may have decelerated adoption. Another reason is from the ineffectiveness of the knowledge-transfer of new crop varieties from public officers, which leads to less acceptance and adoption of the new varieties.

Moreover, one possible explanation is that the hybrid maize varieties are well-accepted among farmers because of significant yield improvement, compared to

OPVs. Even without public extension services or private companies' promotion, the speed of hybrid maize adoption most likely depends on the availability of seeds in the seed market. This also can be seen from the impact of accessibility to inputs (located near input dealers) on the speed of adoption discussed above. The privatization of hybrid varieties in 1991 allows greater access to hybrid seeds, and significantly increases the number of adopters (Fig 4.1). In this case, the attributes of technology (the trialability and observability of relative benefits) could be an important factor along with social communication.

Table 4.11 Coefficient estimates of exponential, Weibull and Gompertz distribution hazard model for the adoption of hybrid maize varieties (N=335)

Variable	**Distribution**					
	Exponential		**Weibull**		**Gompertz**	
	Hr. ratio	**P-value**	**Hr. ratio**	**P-value**	**Hr. ratio**	**P-value**
EDU	1.021	0.295	1.030	0.148	1.023	0.263
HHS	1.008	0.834	1.009	0.829	1.043	0.307
EXPE	0.910	0.000***	0.879	0.000***	0.857	0.000***
RISK	1.000	0.715	1.000	0.580	1.000	0.489
AGET	1.013	0.029**	1.016	0.006***	1.007	0.237
PUBM	0.959	0.055*	0.939	0.006***	0.935	0.004***
PRIM	0.986	0.768	0.991	0.858	0.998	0.961
SHOPM	0.979	0.342	0.969	0.188	0.964	0.149
INDIST	0.988	0.118	0.982	0.018**	0.978	0.006***
FARMT	1.001	0.904	1.002	0.772	1.001	0.832
ATTI	0.934	0.747	0.896	0.605	0.799	0.293
PUBEXTT	0.991	0.946	1.038	0.782	1.097	0.495
PRIEXTT	0.845	0.184	0.816	0.110	0.889	0.355
SHOPEXTT	0.991	0.945	1.022	0.867	1.213	0.044**
PUBCRDTT	0.948	0.667	0.909	0.448	0.894	0.372
PRICRDTT	1.877	0.037	2.509	0.003***	2.731	0.001***
SHOPCRDTT	1.045	0.814	1.065	0.741	0.922	0.672
p			1.445			
λ			0.692			
γ					0.169	
Log-likelihood	-416.384		-381.502		-330.817	
Chi2	262.81		331.32		430.16	
AIC	868.769		801.003		699.634	

Note: *, **, *** Estimates are significant at the 10%, 5%, and 1% level, respectively

Source: Estimated based on farmer survey data

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Hybrid maize varieties were released in Thailand in 1980 as one of the earliest hybrid crops in the agricultural market. The first hybrid varieties were released by the public sector; nonetheless, farmers' adoption of the public varieties was limited and slow partly due to the lack of information and experience of the new varieties. However, in the early 1990s, there was a substantial change in the maize seed industry, marked by an increasing role of private seed companies in production practice. Even though several studies showed that private hybrid maize varieties are more productive than open-pollinated varieties and public hybrids, the impacts of productivity as well as other factors on the adoption decision and the overall adoption rate are not yet clearly understood. Therefore, this study indicates the diffusion pattern of hybrid maize varieties in Thailand and determines the factors affecting the duration of adoption decisions by using the surveyed data from 335 maize farmers across five provinces of Thailand; Nakhon Ratchasima, Lopburi, Petchabun, Nakhon Sawan and Kampangphet.

The research revealed that hybrid maize diffusion pattern in Thailand approaches similar patterns suggested by Rogers. There were only 2.09% of maize farmers who adopted hybrid varieties during 1980-1983 and tended to be the innovators. The 20.60% of farmers who adopted next, were classified as early adopters and 35.22% were classified as early majorities. During these two categories, the adoption process increased dramatically because of the incoming of several private companies in seed industry. In addition, there were 25.07% of farmers who represents the late majorities and 17.02% who were the laggards.

In Thailand, the majority of maize farmers used the hybrid maize varieties from CP company after their first adoption, followed by Monsanto and Syngenta while only a few farmers who adopted the public hybrids. Currently, the varieties of Monsanto are the most popular among maize growers following by the varieties from Syngenta. The varieties from CP accounted for the third place in the market while none of the public hybrids are used by farmers. It can be concluded that public sector has seldom played the role in hybrid maize seed market and the competition from private companies was very concentrate.

With respect to extension services and credit for inputs at the first adoption, it was found that the majority of maize farmers received an extension service for hybrid maize from private companies or private research centers, followed by public sector and input dealer, respectively. On the other hand, the result shown that public organizations play the most important roles in providing credit for inputs, followed by input dealer and only a few farmers who received credit from private sector.

With respect to the attitudes toward the advantages of hybrid maize over OPVs and local varieties, the results indicated that the majority of farmers have a positive attitude to the hybrid maize varieties. The most favorable attitude is that hybrid varieties have higher yield when compared to OPVs and local varieties, followed by better weight and shape of maize grains, more drought tolerance, easier to harvest, more rust and downy mildew resistance, more pesticide resistance, faster mature and the receipt of higher price for maize grain, respectively.

In the empirical estimation, due to all of the sample maize farmers adopted hybrid varieties therefore the censored observations do not occur. However duration model is still used to indicate the factors that affected to the speed of adoption and the probability of surviving past a certain point in time may be of more interest than the expected time of the event. For parametric estimation, the Akaike information criterion (*AIC*) is employed to choose the best fit model and it is found that Gompertz distribution fits model better than exponential and Weibull distributions.

The empirical results from the farm survey reveal that farmers with a fewer number of years on maize cultivation or less experienced tend to adopt the hybrid maize varieties earlier. The study also suggests that farm location being closer to the input dealers will speed up the adoption of the hybrid varieties. When considering the role of public organizations, private companies and input dealers on the speed of hybrid maize adoption, It was found that less communication with public extension officers increased the adoption of hybrid maize varieties. On the other hand, more extension services from an input dealer and a higher level of credit loans from private companies were positively correlated to the speed of the adoption.

Recommendations

The empirical findings are a useful guide to policy makers or seed producers to increase the speed of adoption and to identify their policies and strategies. The first recommendation is that new crop varieties should be promoted to new generation farmers and those who are less experienced in maize cultivation. The reason is that the new generation farmers tend to be more educated and have more capability to consider the use of new technology. Thus, providing knowledge or information about technology to these farmers will speed up adoption and diffusion. The next recommendation is that increasing input accessibility would also increase the adoption rate because farmers with less distance from farm to input market tend to adopt earlier.

In addition, more effective communication by the public sector is needed, such as the transfer of knowledge and information about new crop varieties, to increase the speed of adoption. In addition, a sufficient extension service through input shops or input dealers and credit loans for inputs from the private sector could enhance the adoption decision to use new technology. Moreover, the availability of technology may be important to the speed of adoption in cases of prominent perceived benefits (significant yield improvement) like hybrid maize varieties.

Further Study

This study is an initial step for applying duration analysis to investigate the speed of adoption based on Thai agricultural commodity. This can serve as a guideline for analyze not only the adoption of other agricultural commodities but also in the adoption of new farming system, agricultural practices, new technology in agriculture and so on. In addition, some variables related to the physiographic characteristics such as highland, upland and lowland include the community characteristics such as the information from neighbors or head of community might be added to the model for further study because this might effect to the speed of adoption in other commodity.

REFERENCES

Abdulai, A. and W. E. Huffman. 2005. "The Diffusion of New Agricultural Technologies: The Case of Cross-bred Cow Technology in Tanzania." **American Journal of Agricultural Economics** 87(3): 645-659.

Akaike, H. 1974. "A New Look at the Statistical Model Identification." **IEEE Transactions on Automatic Control** 19(6): 716-723.

Bureau of Trade and Economic Indices. 2012. **Consumer Price Index and Core Consumer Price Index Report** (Online). http://www.price.moc.go.th/en/content1.aspx?cid=1, April 20, 2012.

Burton, M., D. Rigby, and T. Young. 2003. "Modelling the Adoption of Organic Horticultural Technology in the UK using Duration Analysis." **The Australian Journal of Agriculture and Resource Economics** 47(1): 29-54.

Cavane, E. 2011. "Farmers' Attitude and Adoption of Improved Maize Varieties and Chemical Fertilizers in Mozambique." **Indian Research Journal of Extension Education** 11(1): 1-6.

Chirwa, E. A. 2005. "Adoption of Fertiliser and Hybrid Seeds by Smallholder Maize Farmers in Southern Malawi." **Development Southern Africa** 22(1): 1-12.

Cleves, M. A., W. W. Gould, and R. G. Gutierrez. 2004. **An Introduction to Survival Analysis using Stata.** College Station, TX: Stata Press.

Cooper, D., W. D. McCausland, and I. Theodossiou. 2008. "Unemployed, Uneducated and Sick: The Effects of Socio-economic Status on Health Duration in the European Union." **Journal of the Royal Statistical Society: Series A (Statistics in Society)** 171(4): 939-952.

Cox, D. R. 1972. "Regression Models and Life-tables." **Journal of the Royal Statistical Society: Series B (Methodological)** 34(2): 187-220.

D'Emden, F. H., R. S. Llewellyn, and M. P. Burton. 2006. "Adoption of Conservation Tillage in Australian Cropping Regions: An Application of Duration Analysis." **Technological Forecasting & Social Change** 73(6): 630-647.

Dadi, L., M. Burton, and A. Ozanne. 2004. "Duration Analysis of Technological Adoption in Ethiopian Agriculture." **Journal of Agricultural Economics** 55(3): 613-631.

Department of Agricultural Extension. 2011. **Registration project farmers** (Online). http://www.farmer.doae.go.th, February 8, 2011.

De Una-Alvarez, J., M. S. Otero-Giraldez, and G. Alvarez-Llorente. 2003. "Estimation under Length-Bias and Right-Censoring: An Application to Unemployment Duration Analysis for Married Women." **Journal of Applied Statistics** 30(3): 283-291.

Ekasingh, B., P. Gypmantasiri, K. Thong-ngam, and P. Grudloyma. 2004. **Maize in Thailand: Production Systems, Constraints, and Research Priorities.** Mexico, D. F.: International Maize and Wheat Improvement Center (CIMMYT).

Feder, G. and G. T. O'Mara. 1981. "Farm Size and the Diffusion of Green Revolution Technology." **Economic Development and Cultural Change** 30(1): 59-76.

Fuglie, K. O. and C. A Kascak. 2001. "Adoption and Diffusion of Natural-Resource-Conserving Agricultural Technology." **Review of Agricultural Economics** 23(2): 386-403.

Gamba, P., C. Ngugi, H. Verkuijl, W. Mwangi, and F. Kiriswa. 2002. **Wheat Farmers' Seed Management and Varietal Adoption in Kenya.** Mexico, D. F.: International Maize and Wheat Improvement Center (CIMMYT), Egerton University, Njoro, Kenya, and KARI, Nairobi.

Gerpacio, R. V. (ed.). 2001. **Impact of Public- and Private-Sector Maize Breeding Research in Asia, 1966 – 1997/98.** Mexico, D. F.: International Maize and Wheat Improvement Center (CIMMYT).

Griliches, Z. 1957. "Hybrid Corn: An Exploration in the Economics of Technological Change." **Econometrica** 25(4): 501-522.

Hannan, T. H., and J. M. MacDowell. 1984. "The Determinants of Technology Adoption: The Case of the Banking Firm." **Rand Journal of Economics** 15(3): 328-335.

Hannan, T. H.,and J. M. MacDowell. 1987. "Rival Precedence and the Dynamics of Technology Adoption: An Empirical Analysis." **Econometrica** 54(214): 155-171.

Hintze, L. H., M. Renkow, and G. Sain. 2003. "Variety Characteristics and Maize Adoption in Honduras." **Agricultural Economics** 29(3): 307-317.

IICRD (Inseechandrastitya Institute for Crops Research and Development). 2012. **Research and Development of Field Corn Variety for Animal Feed Industry** (Online). http://www.iicrd.ku.ac.th/output/ncsrc_corn.htm, April 18, 2012.

Iqbal, M., A. Bashir, and U. Farooq. 1999. "Factors Affecting the Adoption of Hybrid Maize Varieties in the Irragated Punjab." **International Journal of Agriculture&Biology** 1(3): 149-151.

Iwai, N., O. Napasintuwong, and R. E. Emerson. 2005. **Immigration Policy and the Agricultural Labor Market: The Effect on Job Duration.** Paper Presented at the American Agricultural Economics Association, Annual Meeting, Providence, Rhode Island, July 24-27.

Kasetsart University Research and Development Institute. 2009. **Plant Development by Kasetsart University**. Bangkok, Thailand: KURDI.

Klein, J. and M. Moeschberger. 1997. **Survival Analysis: Techniques for Censored and Truncated Data.** New York: Springer-Verlag.

Krejcie, R. V., and D. W. Morgan. 1970. "Determining Sample Size for Research Activities." **Educational and Psychological Measurement** 30(3): 607-610.

Lancaster, T. 1978. "Econometric Methods for the Duration of Unemployment." **Econometrica** 47(4): 939-956.

Limsombunchai, V., and S. Kao-ian. 2010. **Corn Seed Utilization and Return to Farmers: A Case study of Tak Fa District.** Paper presented at the 4th Workshop of Corn and Sorghum Research Project of Kasetsart University, Lop Buri Province, Thailand, June 17-19.

Matuschke, I. and M. Qaim. 2008. "Seed Market Privatisation and Farmers' Access to Crop Technologies: The Case of Hybrid Pearl Millet Adoption in India." **Journal of Agricultural Economics** 59(3): 498-515.

Mugisha, J. and G. Diiro. 2010. "Explaining the Adoption of Improved Maize Varieties and Its Effects on Yields among Smallholder Maize Farmers in Eastern and Central Uganda." **Middle-East Journal of Scientific Research** 5(1): 06-13.

Office of Agricultural Economics. 2011. **Thailand Agricultural Statistics 2010/2011 Annual Report.**

Pornpratansombat, P., B. Bauer, and H. Boland. 2011. "The Adoption of Organic Rice Farming in Northeastern Thailand." **Journal of Organic Systems** 6(3): 4-12.

Rogers, E. M. 1962. **Diffusion of Innovations**. New york: Free Press.

Rogers, E. M. 2003. **Diffusion of Innovations**. 5th ed. New York: Free Press.

Ruttanapracha, W. 1993. **Modern Technology Adoption and Production Efficiency of Maize Farmers in Northeast of Thailand.** Master of Science Thesis in Agricultural Economics, Kasetsart University (in Thai).

Ryan, B. and N. C. Gross. 1943. "The Diffusion of Hybrid Corn in Two Iowa Communities." **Rural Sociology** 8(1): 15–24.

Sain, G. and J. Martinez. 1999. "Adoption and Use of Improved Maize by Small-Scale Farmers in Southeast Guatemala." **CIMMYT Economics Paper 99-04.** Mexico, D. F.: International Maize and Wheat Improvement Center CIMMYT.

Salasya, B., W. Mwangi, D. Mwabu, and A. Diallo. 2007. "Factors Influencing Adoption of Stress-Telorance maie hybrid (WH 502) in Western Kenya." **African Journal of Agricultural Research** 2(10): 544-551.

Simtowe, F., M. Zeller, and A. Diagne. 2009. "The Impact of Credit Constraints on the Adoption of Hybrid Maize in Malawi." **Review of Agricultural and Environmental Studies** 90 (1): 5-22.

Srinivasan, V. and H. C. Mason. 1986. "Nonlinear Least Square Estimation of New Product Diffusion Models." **Marketing Science** 5(2): 169-178.

Sunding, D. and D. Zilberman. 2001. The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector. In B.L. Gardner and G. C. Rausser (eds.). **Handbook of Agricultural Economics.** Amsterdam: Elsevier, 207-261.

Suwantaradol, K. 2001. **Two Decades of Hybrid Maize Seed Business in Thailand.** Paper presented at the 30th National Corn and Sorghum Research Conference, Ubon Ratchathani Province, Thailand, August 19-23.

Thailand Development Research Institute. 1990. **Enhancing Private Sector Research and Development in Thailand.** Bangkok, Thailand. March 1990.

Thai Feed Mill Association. 2011. **Estimation of Livestock and Demand for Livestock Feed in Thailand 2000 – 2011** (Online). http://www. thaifeedmill.com/tabid/56/Default.aspx, September 22, 2011.

Woolridge, J. M. 2002. **Econometric Analysis of Cross Section and Panel Data.** Cambridge, Massachusetts: The MIT Press.

APPENDICES

Appendix A

Table for determining the sample size from a given population

Table for determining the sample size from a given population

N	S	N	S	N	S	N	S
10	10	150	108	460	210	2200	327
15	14	160	113	480	214	2400	331
20	19	180	118	500	217	2600	335
25	24	190	123	550	225	2800	338
30	28	200	127	600	234	3000	341
35	32	210	132	650	242	3500	346
40	36	220	136	700	248	4000	351
45	40	230	140	750	256	4500	351
50	44	240	144	800	260	5000	357
55	48	250	148	850	265	6000	361
60	52	260	152	900	269	7000	364
65	56	270	155	950	274	8000	367
70	59	270	159	1000	278	9000	368
75	63	280	162	1100	285	10000	373
80	66	290	165	1200	291	15000	375
85	70	300	169	1300	297	20000	377
90	73	320	175	1400	302	30000	379
95	76	340	181	1500	306	40000	380
100	80	360	186	1600	310	50000	381
110	86	380	181	1700	313	75000	382
120	92	400	196	1800	317	100000	384
130	97	420	201	1900	320		
140	103	440	205	2000	322		

Source: Krejcie and Morgan (1970)

N represents the population size.

S represents the sample size.

Appendix B

Questionaire

แบบสอบถามเรื่องการปลูกข้าวโพดพันธุ์ลูกผสมและความคิดเห็นทั่วไปที่มีต่อพันธุ์ข้าวโพด

การสำรวจในครั้งนี้เป็นส่วนหนึ่งของงานวิจัยและการทำวิทยานิพนธ์ในหัวข้อ "การวิเคราะห์ระยะเวลาของการยอมรับข้าวโพดพันธุ์ลูกผสมในประเทศไทย" โดย นาย สุทธิพร พูลสวัสดิ์ นิสิตปริญญาโท ภาควิชาเศรษฐศาสตร์เกษตรและทรัพยากร คณะเศรษฐศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ โดยมีวัตถุประสงค์เพื่อศึกษาการยอมรับพันธุ์พืชและเสนอแนะนโยบายสำหรับ การพัฒนาอุตสาหกรรมเมล็ดพันธุ์ในประเทศไทย โดยงานวิจัยนี้มิได้หวังผลทางการค้า หรือผลประโยชน์ต่อองค์กรใด ดังนั้นทุกคำตอบของท่านจักเป็นประโยชน์ต่องานศึกษา วิจัยในครั้งนี้ และขอขอบพระคุณสำหรับความร่วมมือเป็นอย่างสูงมา ณ โอกาสนี้

สุทธิพร พูลสวัสดิ์

<u>ส่วนที่ 1</u>

กรุณาตอบคำถามต่อไปนี้ให้ตรงกับความเป็นจริงมากที่สุด

1. ท่านปลูกข้าวโพดเพื่อเป็นการค้าใช่หรือไม่

☐ ใช่ ☐ ไม่ใช่

2. ลักษณะของการปลูกข้าวโพดในไร่ของท่าน

☐ ปลูกข้าวโพดเพียงอย่างเดียว

☐ ปลูกร่วมกับพืชอื่นๆ (โปรดระบุ) ____________________________

3. ในกรณีที่ท่านปลูกข้าวโพดร่วมกับพืชอื่นๆ ข้าวโพดเป็นพืชหลักหรือไม่

☐ พืชหลัก ☐ พืชรอง

4. จำนวนรอบของการปลูกข้าวโพดในแต่ละปี

☐ 1 รอบ ☐ 2 รอบ ☐ อื่นๆ ________

5. ปัจจุบันท่านปลูกข้าวโพดพันธุ์อะไร และกรุณาระบุพันธุ์ที่ท่านทราบ

☐ พันธุ์ลูกผสมของเอกชน (โปรดระบุพันธุ์) ____________________________

☐ พันธุ์ลูกผสมของภาครัฐ (โปรดระบุพันธุ์) ____________________________

☐ พันธุ์ผสมเปิด (โปรดระบุพันธุ์) ____________________________

☐ อื่นๆ (โปรดระบุพันธุ์) ____________________________

☐ ไม่ทราบว่าเป็นพันธุ์อะไร

6. พันธุ์ข้าวโพดที่ท่านปลูกในปัจจุบัน ท่านได้รับเมล็ดพันธุ์มาจากที่ใด

- ☐ เก็บหรือคัดเองจากรุ่นก่อนหน้า
- ☐ ซื้อจากร้านค้าเมล็ดพันธุ์ในท้องถิ่น
- ☐ ซื้อจากพนักงานขายจากบริษัทเอกชน
- ☐ ซื้อจากหน่วยงานรัฐบาล / ศูนย์วิจัย
- ☐ ได้รับแจกฟรีจากร้านค้าเมล็ดพันธุ์ในท้องถิ่น
- ☐ ได้รับแจกฟรีจากบริษัทเอกชน
- ☐ ได้รับแจกฟรีจากรัฐบาล / ศูนย์วิจัย
- ☐ ได้รับแจกฟรีจากเพื่อนบ้าน
- ☐ อื่นๆ (โปรดระบุ) ____________________

7. ระยะทางจากฟาร์มถึงร้านค้าเมล็ดพันธุ์ คิดเป็นระยะทางโดยประมาณ

____________ กม.

8. จำนวนเมล็ดพันธุ์ที่ใช้ปลูกต่อไร่ ____________ กก./ไร่

9. ต้นทุนค่าเมล็ดพันธุ์ ____________ บาท/ไร่

10. ระยะเวลาที่ใช้ในการปลูกข้าวโพด นับตั้งแต่วันปลูกจนถึงวันเก็บเกี่ยว ____________ วัน

11. พื้นที่ปลูกข้าวโพดในปัจจุบัน ____________ ไร่

12. ผลผลิตข้าวโพดที่ได้ ____________ ตัน

13. ผลผลิตต่อไร่ ____________ กก./ ไร่

14. ท่านขายข้าวโพดให้กับใคร

☐ ผู้รวบรวม	☐ โรงงานแปรรูป
☐ ขายเอง	☐ ภาครัฐและศูนย์วิจัย
☐ พ่อค้าส่ง	☐ อื่นๆ ____________

15. ราคาข้าวโพดที่ขายได้ ____________ บาท/กก.

16. การปลูกข้าวโพดเป็นรายได้หลักของท่านหรือไม่

☐ ใช่	☐ ไม่ใช่

ส่วนที่ 2

กรุณาตอบคำถามในเรื่องของ พันธุ์ข้าวโพดลูกผสม ให้ตรงกับความเป็นจริงมากที่สุด

17. ท่านรู้จักข้าวโพดพันธุ์ลูกผสมหรือไม่

☐ รู้จัก ☐ ไม่รู้จัก (ข้ามไปตอบ ส่วนที่ 4)

18. ท่านเคยปลูกข้าวโพดพันธุ์ลูกผสมหรือไม่

☐ เคยปลูก และปัจจุบันยังปลูกอยู่

☐ เคยปลูก แต่ปัจจุบันไม่ได้ปลูกแล้ว

☐ ยังไม่เคยปลูก (ข้ามไปทำส่วนที่ 3)

☐ อื่นๆ ________________________________

19. ถ้าท่านเคยปลูกข้าวโพดพันธุ์ลูกผสม ท่านปลูกครั้งแรกเมื่อปี พ.ศ. ____________________ หรือ __________________ ปี มาแล้ว

20. ในขณะที่ท่านปลูกข้าวโพดพันธุ์ลูกผสมครั้งแรก ท่านมีพื้นที่สำหรับทำการเกษตร ________ ไร่

21. ในขณะนั้นท่านซื้อเมล็ดพันธุ์ข้าวโพดลูกผสมในราคา __________________ บาท/กก.

22. ในการที่ท่านตัดสินใจทำการปลูกข้าวโพดพันธุ์ลูกผสมเป็นครั้งแรก ท่านรู้จักข้าวโพดพันธุ์นี้ได้อย่างไร (ตอบได้มากกว่า 1 ข้อ)

☐ คำแนะนำจากเพื่อนบ้าน (1)

☐ เอกสาร/แผ่นพับ/ใบปลิว ของหน่วยงานภาครัฐ (2)

☐ เอกสาร/แผ่นพับ/ใบปลิว ของหน่วยงานภาคเอกชน (3)

☐ วารสารหรือหนังสือทางการเกษตร (4)

☐ วิทยุ / หนังสือพิมพ์ / โทรทัศน์ (ระบุ____________________) (5)

☐ คำแนะนำจากร้านค้าเมล็ดพันธุ์ (6)

☐ คำแนะนำจากเจ้าหน้าที่ของรัฐ (7)

☐ คำแนะนำจากบริษัทเอกชน (8)

☐ อื่นๆ ____ (9)

23. ในขณะที่ท่านตัดสินใจปลูกข้าวโพดพันธุ์ลูกผสม ท่านได้รับการส่งเสริมหรือการถ่ายทอดข้อมูลข่าวสารจากหน่วยงานใด

☐ ได้รับการส่งเสริมและการถ่ายทอดข้อมูลข่าวสารจากร้านค้า

☐ ได้รับการส่งเสริมและการถ่ายทอดข้อมูลข่าวสารจากบริษัทเอกชน

☐ ได้รับการส่งเสริมและการถ่ายทอดข้อมูลข่าวสารจากหน่วยงานของรัฐ

☐ ไม่ได้รับการส่งเสริมหรือและการถ่ายทอดข้อมูลข่าวสาร

☐ อื่นๆ ________________________________

24. ในขณะที่ท่านตัดสินใจปลูกข้าวโพดพันธุ์ลูกผสมครั้งแรก ท่านได้รับสินเชื่อจากหน่วยงานใด

☐ ได้รับสินเชื่อ จากหน่วยงานภาครัฐ

☐ ได้รับสินเชื่อ จากบริษัทเอกชน

☐ ได้รับสินเชื่อ จากร้านค้าเมล็ดพันธุ์

☐ ไม่ได้รับสินเชื่อ

☐ อื่นๆ ________________________________

25. ข้าวโพดพันธุ์ลูกผสมพันธุ์แรกที่ท่านปลูกมาจาก

☐ ได้รับแจกจากภาครัฐ พันธุ์ ________________________________

☐ ได้รับแจกจากภาคเอกชน พันธุ์ ________________________________

☐ ได้รับแจกจากร้านค้าเมล็ดพันธุ์ พันธุ์ ________________________________

☐ ได้รับแจกจากเพื่อนบ้าน พันธุ์ ________________________________

☐ ซื้อจากภาครัฐ พันธุ์ ________________________________

☐ ซื้อจากภาคเอกชน พันธุ์ ________________________________

☐ ซื้อจากร้านค้าเมล็ดพันธุ์ พันธุ์ ________________________________

☐ ซื้อจากเพื่อนบ้าน พันธุ์ ________________________________

☐ อื่นๆ (โปรดระบุ) ________________________________

26. ในกรณีที่ท่านซื้อข้าวโพดพันธุ์ลูกผสม ในครั้งแรกท่านซื้อมาในราคา __________ บาท/กก.

27. ท่านขายผลผลิตข้าวโพดพันธุ์ลูกผสมที่ท่านปลูกครั้งแรกได้ในราคา __________ บาท/กก.

28. หากท่านเคยปลูก และเลิกปลูกไปแล้ว อะไรเป็นสาเหตุที่ทำให้ท่านเลิกปลูกข้าวโพดพันธุ์ลูกผสม

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ส่วนที่ 3

กรุณาแสดงความคิดเห็นเกี่ยวกับข้าวโพดพันธุ์ลูกผสม ข้าวโพดพันธุ์ผสมเปิด และข้าวโพดพันธุ์อื่นๆ ในประเด็นต่อไปนี้

ประเด็น	ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วย	ไม่แน่ใจ/ไม่มีความคิดเห็น	เห็นด้วย	เห็นด้วยอย่างยิ่ง
ข้าวโพดพันธุ์ลูกผสมให้ผลผลิตต่อไร่ดีกว่าข้าวโพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมใช้เวลานับตั้งแต่ปลูกจนกระทั่งเก็บเกี่ยวสั้นกว่าพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมให้ผลผลิตที่มีรูปทรงและน้ำหนักดีกว่าข้าวโพดพันธุ์ผสมเปิด และพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมสามารถทนต่ออากาศแล้งได้ดีกว่าข้าวโพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมสามารถต้านทานยาฆ่าแมลงและยากำจัดศัตรูพืชได้ดีกว่าข้าวโพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมสามารถปลูกและเก็บเกี่ยวได้ง่ายกว่าข้าว โพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดพันธุ์ลูกผสมสามารถต้านทานโรคราน้ำค้างและราสนิมได้ดีกว่าข้าวโพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					
ข้าวโพดลูกผสมให้ผลผลิตที่มีราคาดีกว่าข้าวโพดพันธุ์ผสมเปิดและพันธุ์อื่นๆ					

<u>ส่วนที่ 4</u>

ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

ชื่อ-นามสกุล ____

ที่อยู่ ______________________________ ตำบล ______________________

อำเภอ ____________________________ จังหวัด ______________________

อายุ ____________ ปี

ระดับการศึกษาของท่าน

☐ ไม่ได้เรียนหนังสือ

☐ ประถมศึกษา 4 ☐ ประถมศึกษา 6

☐ มัธยมศึกษา 3 ☐ มัธยมศึกษา 6

☐ ปวช. หรือ ปวส. ☐ มหาวิทยาลัย

จำนวนสมาชิกในครัวเรือน _______________ คน

การเข้าร่วมกิจกรรมทางการเกษตรในแต่ละปี

☐ การเข้าร่วมกิจกรรมนัดพบกับเกษตรอำเภอ/เกษตรตำบล _____ ครั้ง/ปี

☐ การเข้าร่วมกิจกรรมนัดพบกับศูนย์วิจัยข้าวโพด _____ ครั้ง/ปี

☐ การเข้าร่วมกิจกรรมนัดพบกับร้านค้า/ตัวแทนจำหน่ายเมล็ดพันธุ์ _____ ครั้ง/ปี

☐ การเข้าร่วมกิจกรรมนัดพบกับบริษัทเอกชนผู้จำหน่ายเมล็ดพันธุ์ _____ ครั้ง/ปี

จำนวนค่าใช้จ่ายในการซื้อล็อตเตอรี หรือซื้อหวยในแต่ละเดือน _____________ บาท/เดือน

ท่านเคยปลูกข้าวโพดมาแล้ว ___________ ปี

รายได้โดยเฉลี่ยของครัวเรือนต่อปี ____________________ บาท

สัดส่วนรายได้ที่มาจากการปลูกข้าวโพด _________________%

สัดส่วนรายได้ที่มาจากการเกษตรประเภทอื่น ______________%

สัดส่วนรายได้ที่มาจากนอกภาคการเกษตร _______________%

Appendix C

Command for Duration Analysis on STATA Program

Command for duration analysis on STATA program

1. The data for timing and adoption of an individual would be set for duration analysis (survival analysis)

   [stset duration, failure(adoption)]

2. Create Kaplan-Meier survival curve to identify the proportion of adopters and non-adopters overtime

   [sts graph, survival]

3. Tests of equality across strata to explore whether or not to include the covariates in the final model.

   3.1. For categorical variables, the log-rank test will be used to test equality which is non-parametric test.

   [sts test (categorical variables), log rank]

   3.2. For the continuous variables, a univariate Cox proportional hazard regression which is a semi-parametric model will be used.

   [stcox (continuous variables)]

   The covariates with represent the p-value of 0.2-0.25 or less will be considered and included in the final model.

4. In the final model, the command for regress in Exponential distribution is [streg EDU HHS EXPE RISK AGET PUBM PRIM SHOPM INDIST FARMT ATTI PUBEXTT PRIEXTT SHOPEXTT PUBCDTT PRICDTT SHOPCDTT, dist(exponential)]

   And the command for regress in Weibull distribution is [streg EDU HHS EXPE RISK AGET PUBM PRIM SHOPM INDIST FARMT ATTI PUBEXTT PRIEXTT SHOPEXTT PUBCDTT PRICDTT SHOPCDTT, dist(Weibull)]

The command for regress in Gompertz distribution is
[streg EDU HHS EXPE RISK AGET PUBM PRIM SHOPM INDIST FARMT ATTI PUBEXTT PRIEXTT SHOPEXTT PUBCDTT PRICDTT SHOPCDTT, dist(Gompertz)]

5. After regress each model, Akaike Information Criterion (AIC) will be applied to select the best model fit the study follow the command;

[estat ic)

The model with lower AIC will fit model better.

BIOGRAPHICAL DATA

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