General Information on Taiwanese Crop Insurance

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Abstract

With technology constantly evolving in agriculture and producers adapting these methods to conduct business, it is important for the Taiwanese academia and Taiwanese Crop Insurance Corporation (TCIC) to meet the growing demands of farmers and ranchers, we study and design agricultural profit insurance as risk management tool in this paper. We identify the key issues and concerns that arise in the design and rating of agricultural yield insurance plans, with a particular emphasis on yield risk modeling. We show how the availability of data shapes the insurance scheme and the ratemaking procedures. Relying on the Taiwan experience and recent developments in statistics and econometrics, we review some risk modeling concepts and provide technical guidelines in the development of agricultural insurance plans. Yield randomness varies regionally. Price randomness differs among commodities and changes over time. Yields and prices tend to move in opposite directions. Finally, we show how these risk modeling techniques can be extended to price risk in order to develop agricultural profit insurance schemes.

Keywords: agricultural profit insurance, profit risk, yields risk, bull call spread.

Introduction

Crop Insurance policy provides you with insurance if your crops experience a loss in yield, whether it is due to an insurable cause of loss in the quality or quantity of the insured crop. Your insurance policy covers you in case the crop fails to grow (establish) or excess moisture prevents you from being able to seed. You select your coverage level (50 to 80 per cent) and your production guarantee is based upon your growing experience with the selected crop. TCIC realizes that one insurance policy package does not suit everyone. For this reason there is many options to choose from, allowing you to tailor your insurance policy to your farm. With growing concerns about climate change on agricultural yields and prices, farming is a financially risky occupation. On a daily basis, farmers are confronted with an ever-changing landscape of possible price, yield, and other outcomes that affect their financial returns and overall welfare. The consequences of decisions or events are often not known with certainty until long after those decisions or events occur, so outcomes may be better or worse than expected. When aggregate crop output or export demand changes sharply, for example, farm prices can fluctuate substantially and farmers may realize returns that differ greatly from their expectations. Understanding risk is a key element in helping producers make better decisions in risky situations, and also provides useful information to policymakers in assessing the effectiveness of different types of risk protection tools.

Risk is an important aspect of the farming business. The uncertainties of weather, yields, prices, government policies, global markets, and other factors can cause wide swings in farm income. Risk management involves choosing among alternatives that reduce the financial effects of such uncertainties.

Five general types of risk are described here: production risk, price or market risk, institutional risk, human or personal risk, and financial risk.

- Production risk derives from the uncertain natural growth processes of crops and livestock. Weather, disease, pests, and other factors affect both the quantity and quality of commodities produced.

- Price or market risk refers to uncertainty about the prices producers will receive for commodities or the prices they must pay for inputs. The nature of price risk varies significantly from commodity to commodity.
- Financial risk results when the farm business borrows money and creates an obligation to repay debt. Rising interest rates, the prospect of loans being called by lenders, and restricted credit availability are also aspects of financial risk.
- Institutional risk results from uncertainties surrounding government actions. Tax laws, regulations for chemical use, rules for animal waste disposal, and the level of price or income support payments are examples of government decisions that can have a major impact on the farm business.
- Human or personal risk refers to factors such as problems with human health or personal relationships that can affect the farm business. Accidents, illness, death, and divorce are examples of personal crises that can threaten a farm business.

The management of crop production risks is an issue of fundamental importance to agricultural economies. Because of the random nature of production conditions (e.g., weather, pests, diseases), agricultural producers face an array of risks that may influence their level of output per acre from year to year. Management of such yield risks has long been an important issue for producers as well as for policy makers.

Crop insurance is one mechanism for the management of the risks associated with random yield shocks. Wide swings in farm income can result from variances of weather, yields, prices, government policies, global markets, and other factors. Managing risk is an important aspect of the farming business, and crop yield and revenue insurance is one of the tools used to manage risk. Producers of specific crops can purchase insurance policies at a subsidized rate, under Federal crop insurance programs. These insurance policies make indemnity payments to producers based on current losses related to either below-average yields (crop yield insurance) or below-average revenue (revenue insurance). Farmers sign up for insurance before planting, but usually pay premiums after harvest.

What Does X% Coverage Mean?

A crop insurance policy essentially guarantees a certain percentage of the expected outcome, whether that outcome is the yield or the revenue. Policies have a variety of farmer-selectable characteristics—including the share of the expected outcome guaranteed. For example, if a producer had an expected yield of 100 bushels per acre and wanted to guarantee 75 bushels per acre, the producer could obtain a 75-percent yield insurance policy that would ensure that, at the end of the crop year, no matter what happened in terms of actual yields (whether yields were good or if bad weather or pests, etc., caused yields to be low), the producer would receive compensation for at least 75 bushels per acre. If a producer preferred to insure against revenue loss, he or she could take out an appropriate revenue insurance policy.

Note that yield and revenue policies do not cover the same thing and, for a given coverage level, do not provide the insurance policyholder the same amount of insurance policy (and hence, would not cost the same amount in terms of the premium paid for the insurance policy). For example, suppose we have identical producers A and B, each with 100 acres of corn, each facing an expected future price of $6/bushel—and $6/bushel was also the average price received over the past several years—and both A and B each have an expected yield of 100 bushels per acre. This means that the expected revenue for A and B comes to 100 acres*100 bushels per acre*$6 per bushel = $60,000. Let A obtain a yield insurance policy at a coverage level of 65 percent (priced at 100 percent of the futures price which, in this case, is $6 per bushel) while B obtains a revenue insurance policy at a coverage level of 65 percent. Finally, suppose that while nationally, yields turn out to be very high and cause actual prices to drop to $5 per bushel at harvest time, A and B each suffer crop losses amounting to 50 bushels per acre (i.e., each lose half the expected crop).

Before insurance policy, A and B each generate revenue equaling: 100 acres*50 bushels per acre*$5 per bushel = $25,000. Because A took out a yield insurance policy, A is guaranteed to receive compensation on 65 percent of the total expected yield (100 bushels per acre), so A is guaranteed payment on 65 bushels per acre. Because A only generated 50 bushels per acre, A receives indemnities for the remaining 15 bushels per acre (the shortfall) at 100 percent of the expected price. With 100 acres, this amounts to an indemnity payment of 100 acres*15 bushels per acre*$6 per bushel = $9,000. Total revenues for A then equal $34,000.

With a revenue insurance policy, B is guaranteed to receive 65 percent of the expected revenue of $60,000, or $39,000. Therefore, the indemnity payment B receives equals $39,000 – $25,000 = $14,000. While A and B each took out 65-percent coverage policies, these policies work differently and, as a result, would be priced differently. 65-percent yield insurance policy will cost less than a 65-percent revenue insurance policy, and policies for marginal land will command higher prices than those for highly productive land.

Your Coverage

Production Guarantee and Quality Coverage

Production Guarantee

A TCIC contract guarantees a yield based on what you have grown over the long term and the coverage option you selected. This guarantee appears on your Statement of Insurance in kilograms and bushels for most crops, and kilograms and pounds for those crops typically marketed in pounds.

Yield-loss payments are based on the shortfall between the production guarantee and the total net harvested production for all acres of the insured crop.
You have 70% coverage on 100 acres of HRSW
and the long-term individual yield is 708 kg/acre
(26 bushels/acre).
Your production guarantee is:
708 x 70% = 496 kg/acre (18.2 bushels/acre)
Your total production guarantee is:
496 x 100 acres = 49,600 kg (1,821 bushels)
In the fall, you harvest 29,937 kg (1,099 bushels).
To calculate your yield-loss:
49,600 kg (total production guarantee) - 29,937 kg (actual harvested production)=19,663 kg yield-loss
Your yield-loss claim payment is: 19,663 kg x $0.150 ($/kg)= $2,949.45

Quality Coverage

In addition to production, quality is also factored in when calculating yield-loss. A designated grade has been established for each crop based on a historical average grade. When the grade of your harvested production is lower than the designated grade due to an insurable peril, that production is reduced by a quality factor and is used in calculating your claim.

Continuing with the previous yield-loss example, the standard grade for HRSW is #2 CW. You harvest CW Feed.
The quality factor is calculated as:
Price for CW Feed ÷ market price of #2 CW = $100.00/ton ÷ $200.00/ ton=0.5
Harvested production after quality factors is: 29,937 kg x 0.50=14,969 kg
To calculate your yield-loss after the quality factor is applied:
49,600 kg (production guarantee)
- 14,969 kg (actual harvested production after quality adjustment)
34,631 kg yield-loss
The incremental payment is:
34,631 kg loss after quality
- 19,663 kg loss before quality (as calculated in previous example)
14,968 kg additional loss due to quality
You would be eligible for a further payment of: 14,968 kg x $0.150/kg = $2,245.20
Total payment = $2,949.45 + $2,245.20= $5,194.65

What Is The Supplemental Coverage Option? The Supplemental Coverage Option (SCO) is a new crop insurance policy option that provides additional coverage for a portion of your underlying crop insurance policy deductible. You must buy it as an endorsement to the Yield Protection, Revenue Protection, or Revenue Protection with the Harvest Price Exclusion policies. The Taiwan Government pays 65 percent of the premium cost for SCO.

SCO is available, starting with the 2015 crop year, in select counties for spring barley, corn, soybeans, wheat, sorghum, cotton, and rice.

How Do I Buy SCO?

First, you must choose;

- • Yield Protection;
- • Revenue Protection; or
- • Revenue Protection with the Harvest Price Exclusion.

This is your 'underlying insurance policy'. Next, you choose SCO as an endorsement to the underlying insurance policy. You must make this choice by the sales closing date for your underlying insurance policy, and with the same insurance policy company. Any crop on a farm that you elect to participate in the Taiwan Agriculture Risk Coverage (TARC) program (a new program started in the 2014 Taiwan Farm Bill, administered by the Taiwan Farm Service Agency) is not eligible for SCO coverage. How Does SCO Work? SCO follows the coverage of your underlying insurance policy. If you choose Yield Protection, then SCO covers yield loss. If you choose Revenue Protection, then SCO covers revenue loss. The amount of SCO coverage depends on the liability, coverage level, and approved yield for your underlying insurance policy. However, SCO differs from the underlying insurance policy in how a loss payment is triggered. The underlying insurance policy pays a loss on an individual basis and an indemnity is triggered when you have an individual loss in yield or revenue. SCO pays a loss on an area basis, and an indemnity is triggered when there is a county level loss in yield or revenue.

It is easiest to explain how coverage is determined through an example. Suppose a grower's corn crop has an expected value of $100 per acre (50 bushels at $2 per bushel). Assume the grower buys a Revenue Protection insurance policy with a 75-percent coverage level (this is the 'underlying insurance policy'). The underlying insurance policy covers 75 percent (or $75) of the expected crop value and leaves 25 percent (or $25) uncovered as a deductible.

At this point, the grower has the option to buy SCO coverage. Since the underlying insurance policy is Revenue Protection, SCO will also provide revenue protection, except that payments will be determined at a county level. SCO revenue coverage is described in the following table.

Step	SCO Coverage Calculation	
A	SCO Endorsement begins to pay when county revenue falls below this percent of its expected level (the per- cent is the same for all SCO policies – set by law)	86%
B	SCO Endorsement pays out its full amount when county revenue falls to the coverage level percent of its expected level (always equal to the coverage level of the underlying insurance policy)	75%
C	Percent of expected crop value covered by SCO (A–B,or86% –75%)	11%
D	Amount of SCO Protection (C *Expected Crop Value, or 11% * $100)	$11

The SCO Endorsement begins to pay when county average revenue falls below 86 percent of its expected level. The full amount of the SCO coverage is paid out when Taiwan average revenue falls to the coverage level of the underlying insurance policy - in this example, it is 75 percent (shown on line B in the table).

SCO payments are determined only by county average revenue or yield, and are not affected by whether you receive a payment from your underlying insurance policy. So it is possible for you to experience an individual loss but to not receive an SCO payment, or vice-versa.

The dollar amount of SCO coverage is based on the percent of crop value covered. In this example there are 11 percentage points of coverage (from 86 percent to 75 percent). Eleven percent of the expected crop value is $11 (or 11 percent $100). The SCO insurance policy can cover up to $11 of the $25 deductible amount not covered by your underlying insurance policy.

How Much Does SCO Cost?

The Taiwan Government pays 65 percent of the premium. The exact premium cost depends on the crop, county, coverage level you choose, and the type of coverage you choose, such as Yield Protection or Revenue Protection. You should talk to your crop insurance policy agent for more information.

How Do I Decide If I Should Buy SCO?

When considering SCO, you must first consider whether to elect to participate in the TARC program. Crops for which TARC is elected on a farm are not eligible for SCO coverage.

For those crops and farms eligible for SCO coverage, the type and coverage level you choose for the underlying insurance policy determines the type and amount of SCO coverage. You should talk to your crop insurance policy agent to determine what best meets your individual risk management needs.

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Where Is SCO Available?

SCO is available, starting with the 2015 crop year, in select counties for spring barley, corn, soybeans, wheat, sorghum, cotton, and rice.

The choice of counties selected for 2015 is based on the availability of county yield data from Taiwanese National Agricultural Statistics Service (TNASS), subject to the following criteria designed to maximize the availability of SCO while maintaining actuarial soundness and program integrity. These criteria are similar to what is used for area- based, insurance policy programs administered by the Taiwan Risk Management Agency (TRMA). In general, the criteria are:

□□□□NASS county yield estimates are available for at least 20 of the last 30 years. This provides a minimum amount of data needed to establish expected yields similar to the existing yield trend approaches used for related area-based insurance policy programs;
□□□TNASS county yield estimates are available for at least 8 of the last 10 years, with an average of at least 10,000-planted acres over those years. This limits SCO to counties where county yield data has been consistently available, so that there is a reasonable expectation that a county yield will be available at the end of the growing season to determine losses; and
□□□There are at least 50 or more farming entities for the crop in Taiwan according to the most recent Census of Agriculture. This limits the possibility for a single producer (or small group) to skew or influence Taiwan estimate for a given year and limits SCO to counties where TNASS is likely to receive adequate reports to publish a county estimate.

Will SCO Be Available for More Crops?

Starting with the 2016 crop year, TRMA will be making greater use of crop insurance policy data to expand SCO coverage into more areas, more crops, and to make SCO coverage more practice-specific, (for example, irrigated in comparison to non-irrigated). TRMA will expand the program to more crops (and counties) as the program continues.

What Happens If I Choose SCO and Sign Up for TARC? SCO will first be available for the 2015 crop year's winter wheat, where you must make your crop insurance policy coverage decisions for fall-planted crops (including SCO) by the sales closing date (generally September 30). If you have applied for SCO for your winter wheat for 2015 you may choose to withdraw coverage on any farm where you intend to choose TARC for winter wheat by the earlier of your acreage reporting date or December 15 without penalty or being charged a premium. This allows you additional time to make an informed decision related to whether to choose to participate in either the TARC or Price Loss Coverage (PLC) programs for your winter wheat, which will happen later this winter.
To withdraw coverage, you must notify your agent of your intended election for TARC by the earlier of your winter wheat acreage reporting date or December 15. This is a one -time exemption that is only allowed for the 2015 crop year's winter wheat to coordinate with TARC program sign- up rules.

After this one-time exemption for 2015 crop year fall- planted winter wheat, if you choose SCO and TARC on the same crop on a farm, your SCO coverage for that crop on that farm will be cancelled and you will forfeit 20 percent of your SCO premium on that crop and farm to cover administrative expenses. However, your underlying insurance policy will still be in effect.

Where to Buy Crop Insurance?

All multi-peril crop insurance policies, including Catastrophic Risk Protection and SCO policies, are available from crop insurance policy agents. A list of crop insurance policy agents is available at all TWCA(TW Council of Agriculture) service centers and on the TRMA website at: http://eng.coa.gov.tw/.
http://eng.coa.gov.tw/

Taiwan's local climate is greatly influenced by the East Asian monsoon. Massive Rainfall and strong wind are mostly from tropical cyclones (typhoons) in summer and cause serious losses in the agricultural sector. Although the Council of Agriculture has provided natural disaster loss subsidies to the farmers, the subsidies are hardly enough to satisfy the farmers. In its most fundamental form, a crop insurance plan will pay producers an indemnity in the event that their yields fall below a pre-determined level. Construction of such a seemingly simple contract requires representation of a number of important parameters.

Accurate measurement of such parameters may be quite complex, especially in cases where limited knowledge of the risks or levels of protection being provided are available. The challenges associated with accurately measuring the parameters that determine liability, premiums, indemnities and other components of a crop insurance plan are often complicated and may require the application of rather complex actuarial methods, models, and assumptions in order to design and rate viable insurance contracts. The purpose of this paper is to provide Bank staff and policy makers involved in crop insurance programs in developing countries with an overview of the latest developments in the modeling of crop yield risk and, to some extent, crop revenue risk, and to discuss how these modeling concepts affect the design and the rating of crop insurance. This study used the data of rice yield from the Council of Agriculture in Taiwan, this paper will focus on the yield loss from typhoon in Taiwan. Meanwhile, we also considered the correlation of transaction price and yield in our models.

In contrast to traditional insurance, agricultural profit insurance seeks to protect the expected income. On the application of Bull call spread; this paper utilized Monte Carlo method to simulate premiums of agricultural profit insurance on different limit levels of claims. The results of our study indicate that the estimated premiums decrease with higher lower limit and increase with higher upper limit. The increase of relationship between price and cost will lead to a decrease of premiums.

Moreover, one factor in determining the amount of the disaster payment is the level at which the producer is participating in crop insurance; the higher the crop insurance coverage level, the greater the disaster payment. Whether potential disaster program payments create sufficient incentives to purchase higher, and more expensive, crop insurance coverage will depend on producers' individual situations. Based on the latest developments in agricultural risk modeling and on the U.S. experience, this paper reviews each of these concerns and identifies possible solutions and recommendations that may be commonly used to address each issue.

This paper is organized as follows. Crop insurance References are presented in Section 2. Section 3 examines the research data and methodology. Section 4 examines the empirical analysis. Finally, the key issues are summarized in the conclusions.

2. Prior Studies

A considerable amount of past work has examined demand for crop insurance, with emphasis on understanding how differences in farmer characteristics and risk positions impact the use of, and willingness to pay for, specific forms of crop insurance (e.g., Goodwin, Wang et al.) Goodwin and Smith (1995) review the history and operation of the U.S. crop insurance program. The European Commission (2001) provides a description of crop insurance programs in European countries, Canada and Japan. FAO (1991) describes several crop insurance programs in developing countries (e.g., Chile, Cyprus, Mauritius, Philippines).Stokes et al., (1997) makes use of a fundamental paradigm of asset valuation and stochastic calculus to develop a theoretical model to value crop insurance.

Duncan and Myers (2000) develop a new insurance model that shows how catastrophic risk affects the nature and existence of agricultural insurance market equilibrium. Catastrophic risk is shown to increase premiums, reduce farmer coverage levels and, under some conditions, lead to a complete breakdown of the agricultural insurance market. Optimal protection is not provided by available U.S. agricultural insurance contracts and may include combinations of profit insurance, yield insurance, futures, and options contracts (Mahul and Wtight, 2003). Sherrick et al. (2004) analyzed farmers' decisions to purchase agricultural insurance and their choices among alternative products. The influences of risk perceptions, competing risk management options, as well structural and demographic differences are evaluated. Chambers (2007) proposed a method for estimating a farmer's stochastic discount factor that is independent of his or her risk preferences, and shows that that stochastic discount factor is appropriate for calculating a farmer's willingness to pay for an agricultural insurance product. Agricultural insurance is important for most commercial scale agricultural producers to protect against the consequences of poor agricultural performance or price declines. There is no complete program and implementation of agricultural insurance in Taiwan yet. Many countries in the world have implemented agricultural insurance to a considerable degree. Protection against climate changes has been an important issue in agriculture. Traditionally, the commercial insurance market provides protection against insurable risk. However, the agricultural risks may not be completely insurable (Ozaki, Goodwin and Shirota, 2008). Turvey (2009) presented an option model to estimate livestock insurance premium.

On the behavioral side, moral hazard and adverse selection have also been incorporated into explanations of the performance of insurance products and into empirical and theoretical studies of crop insurance demand (Goodwin and Smith, 1996). These studies have mainly addressed the impacts of farmer risks on participation and coverage election decisions, and have identified implications of asymmetric information on participations and performance of Federal Crop Insurance Corporation (FCIC) programs. Makki and Somwaru (2001) examined factors that influence product selection, but still focus on measures of farmer-level risk characteristics as the variables to explain choices among competing products. Farmers' preferences for insurance product attributes remain largely unaddressed.

3. Research data and Methodology

3.1 Research Data

Data sources of are divided into two parts, one for the farm price per kilogram and cost per hundred kilograms of rice yield from 1987 to 2011 and the other for the typhoon related yield loss. There are two types of yield costs, which are the direct yield costs plus indirect costs and the above costs with farmland rent and capital cost. Direct costs include seed, fertilizer, chemicals, energy, and labor (human and animal labor charges or mechanic fees). Indirect costs comprise farm facilities, machines and taxes. The second data source is for agricultural disaster (typhoon) loss from 2003 to 2011. The authors collect data from Agricultural Statistics Yearbook and Investigation report of Taiwan agricultural yield cost, which are published by the Taiwan Council of Agriculture.

3.2 Methodology

In this paper we use financial model to design agricultural profit insurance as a risk management tool against price and yield risk for the sake of domestic agricultural producer.

3.2.1 Price risk

It is first assumed that the farm level operations involve the yield of pomelo. The net profits of per kilogram grape fruit are given by

$R = p - c$(1)

where p is farm price and c is the yield cost per kilogram pomelo. Assume the change of p and c follows geometric Brownian motion as shown in equation (2) and (3).

$dp = \alpha_p p dt + \sigma_p p dw_p$ (2)

$dc = \alpha_c c dt + \sigma_c c dw_c$(3)

α_p and α_c are the drift rate andσ_p and$\sigma_c$are volatilities of price and cost. The terms dw_p and $dw_c$are Wiener processes. According to Ito's lemma the total possible change in net profits from price risk is shown in equation (4).

$dR = (\alpha_p p - \alpha_c c)dt + \sigma_p p dw_p - \sigma_c c dw_c$ (4)

$E(dR) = (\alpha_p p - \alpha_c c)dt$,

$Var(dR) = (p^2\sigma_p^2 + c^2\sigma_c^2 - 2pc\rho\sigma_p\sigma_c)dt$

3.2.2 Price risk and yield risk

- Insurance coverage should be offered at the whole farm level in order to stabilize the farmer's overall agricultural revenue. This global coverage focuses on losses that cannot be mitigated through diversification and avoids fraudulent claims

The yield loss caused by typhoon is

$L = (p - c) \times q$ (5)

Where q represents annual yield loss from typhoon. The change of yield loss can be written as

$dL = [(\alpha_p p - \alpha_c c)dt + \sigma_p p dw_p - \sigma_c c dw_c] \times dq$ (6)

$E(dL) = dq(\alpha_p p - \alpha_c c)dt$

$Var(dL) = dq(p^2\sigma_p^2 + c^2\sigma_c^2 - 2pc\rho\sigma_p\sigma_c)dt$

We use aggregate loss model (collective loss model) to estimate the change of typhoon caused yield loss (dq).The frequency model is based ^based on poisson process and the severity model is based on selecting appropriate distribution to describe the size of loss.

The aggregate loss, S, is defined by the sum of these losses:

S = L1 + L2 + ...+ Ln

If n, L1, L2, ... are the individual claims.L1, L2, ... are i.i.d., then S has a compound distribution.
n: frequency of claims; L: the severity of claims

3.2.3 Monte Carlo Approaches

This paper use Monte Carlo approaches to examine a number of net profit options. Themodel was simulated for 5000 runs.

3.2.4 Option models

On the application of European call option and Bull call spread, this study utilized Monte Carlo method to simulate premiums of agricultural profit insurance on different limit levels of claims.

European options
An European option is an option which can only be exercised at its maturity.

$$I^P \cdot \max(K - R, 0)$$

$$I^P = \begin{cases} 1 \text{Claims, the probability } p \\ 0 \text{No claims, the probability } 1 - p \end{cases}$$

Where K is a lower point (attachment point) and R is the actual simulated profit. The insurance premium will be the expected discounted value of an European option at maturity (T):

$$\text{Premium} = E[I^P \cdot \max(R - K, 0)] \cdot e^{-rT}$$

Bull Call spread

When we use an European option to model insurance ^contrat, the insurer may face huge claims. In order to avoid this disadvantage, the application of bull call spread strategy is better approach to model profit insurance under limited claims. A bull call spread defines:

$$I^P \cdot \max\,[\min(K_2, R) - K_1, 0]$$

$$I^P = \begin{cases} 1 \text{Claims, the probability } p \\ 0 \text{No claims, the probability } 1 - p \end{cases}$$

Where K1 is lower limit and K2 the upper limit.

The insurance premium will be the expected discounted value of a bull call spread at maturity (T):

$$\text{Premium} = E\{I^P \cdot \max\,[\min(K_2, R) - K_1, 0]\} \cdot e^{-rT}$$

4. Empirical Analysis

4.1 Descriptive statistical analysis

Table 4-1 shows the statistics of collected data about price, cost and yield loss under typhoon.
Table 4-1 sample data statistics

Sample Data	The first part			The second part
Statistics	Price	Cost of yielda	Cost of yield b	Typhoon yield loss
Unit	Yuan / kg	Yuan / kg	Yuan / kg	Kg / ha
Mean	30.245	15.289	17.420	3659.410
Standard deviation	7.920	3.561	4.121	1989.499
Full distance	34.210	12.910	14.350	8286.005
Max	50.860	23.430	26.050	9241.561
Min	16.650	10.520	11.700	955.556
Skewness	0.516	0.822	0.571	1.181
Kurtosis	0.856	0.111	-0.539	2.179

Sample Data	The first part			The second part
Statistics	Price	Cost of yield a	Cost of yield b	Typhoon yield loss
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Skewness	0.516	0.822	0.571	1.181
Kurtosis	0.856	0.111	-0.539	2.179

Figure 4-1 provides the movement of pomelo farm price and yield cost from year 1986 to 2011.

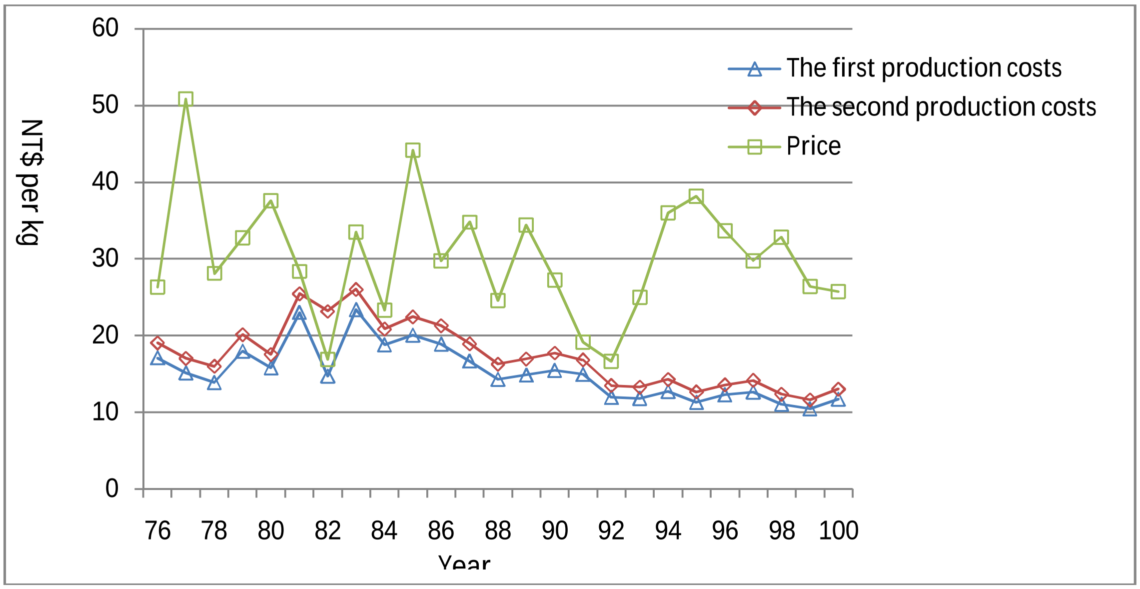

Figure 4-1 Pomelo farm price and yield cost per kg

Table 4-2 highlights the average typhoon caused loss of pomelo yield from year 2003 to 2011.
Table 4-2 Average typhoon loss situation from 2003 to 2011

Damage Area	Yield losses		Loss per hectare
Hectare	Tonne	Kilogram	Kg / ha
575.3	2894.9	2894921.0	3659.4

In Table 4-3 we test the relationships among main variables and find there exist no significant correlation except two yield costs.

Table 4-3 sample correlation coefficient

The correlation coefficient	price	costs a	costs b	yield loss
price	1			
costs a	0.1593	1		
costs b	0.0387	0.9463***	1	
yield loss	0.5821	0.1641	0.1626	1

*** The significance level of 0.01 (two-tailed)

4.2 Estimation

Under different risk scenarios, we establish 4 models to estimate agricultural profit insurance premiums. The statistics of simulated pomelo yield yield are provided in table 4-4.

Model I: profit insurance against price risk with first yield cost
Model II: profit insurance against price risk with second yield cost
Model III: profit insurance against price and yield risk and with first yield cost
Model IV: profit insurance against price and yield risk and with second yield cost

The results of premiums assessment using the above models are presented in Appendix 1 and 2.

Table 4-4 statistics of simulated pomelo yield yield under different correlation coefficients

Unit: dollar/kg

Statistics	Model I				Model II				Model III				Model IV			
The correlation coefficient	0	0.159	0.5	0.8	0	0.0387	0.5	0.8	0	0.159	0.5	0.8	0	0.0387	0.5	0.8
Mean	-1.766	-1.768	-1.766	-1.768	-1.880	-1.881	-1.881	-1.879	40552.158	38597.139	36878.169	33752.990	39924.121	40619.466	38586.795	37048.149
Standard deviation	11.286	10.761	9.969	9.125	11.094	11.074	10.433	9.777	82085.248	74125.330	72343.347	62750.096	76596.028	78251.766	74006.994	72404.221
Full distance	83.999	85.594	72.016	71.264	86.963	77.537	78.330	76.651	1863967.019	1030970.761	1043772.769	821770.186	792530.281	1505142.523	951738.951	1394039.682
Max	41.588	39.626	33.349	31.249	40.984	36.355	34.805	37.044	1863967.019	1030970.761	1043772.769	821770.186	792530.281	1505142.523	951738.951	1394039.682
Min	-42.41	-45.968	-38.667	-40.014	-45.978	-41.182	-43.525	-39.607	0	0	0	0	0	0	0	0
Skewness	0.004	-0.013	0.003	-0.013	0.001	-0.007	-0.003	0.005	5.584	3.789	4.087	3.606	3.636	4.693	4.082	4.343
Kurtosis	-0.007	0.004	0.038	0.031	0.003	-0.011	0.008	0.015	69.101	22.344	26.527	19.995	19.182	45.072	27.329	37.584
95%quantile	-16.95	-16.055	-14.557	-13.062	-16.487	-16.284	-15.681	-14.287	192502.500	177836.400	168074.600	154922.300	189750.600	182792.400	177194.100	176369.600
5%quantile	20.506	19.552	18.215	16.959	20.094	20.178	18.813	18.135	0	0	0	0	0	0	0	0
95%VaR	16.951	16.055	14.557	13.062	16.487	16.284	15.681	14.287	192655.071	177914.739	168348.105	155202.513	190540.465	183330.565	168348.105	176712.825
95%ES	21.495	20.378	18.914	16.951	20.986	20.889	19.654	18.349	305368.408	286267.071	278857.767	243078.427	296967.540	296273.622	278857.767	279530.472

European option

Figure 4-2 provides the trend of estimated insurance premiums of model I by European option approach under different correlation coefficients. The figure shows that the premiums decrease with higher correlation coefficient and with higher lower limit.

Figure 4-3 shows that model II has the same movement like model I.

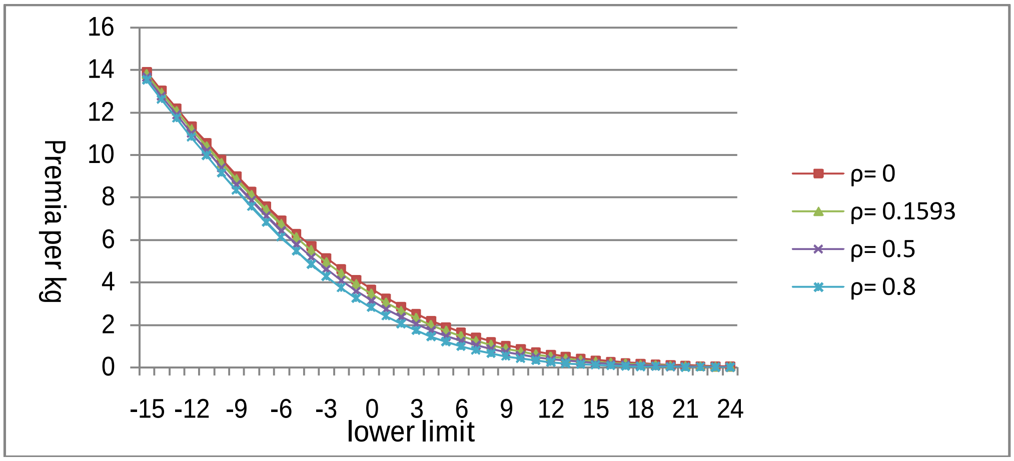

Figure 4-2 Premiums of Model I by European option approach under different correlation coefficients

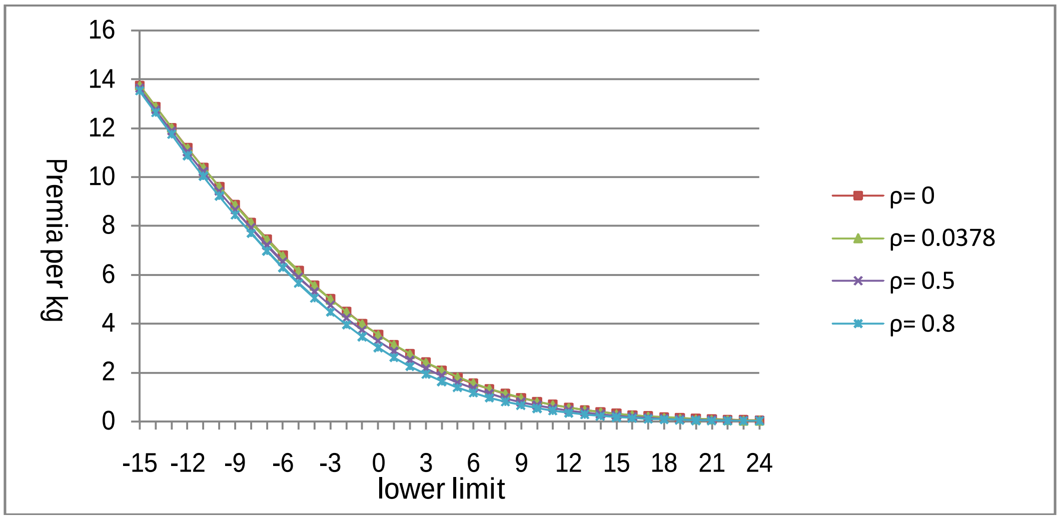

Figure 4-3 Premiums of Model II by European option approach under different correlation coefficients

In the Figure 4-4 and 4-5 we see that insurance premiums per hectaredecrease with higher correlation coefficients and higher lower limit.

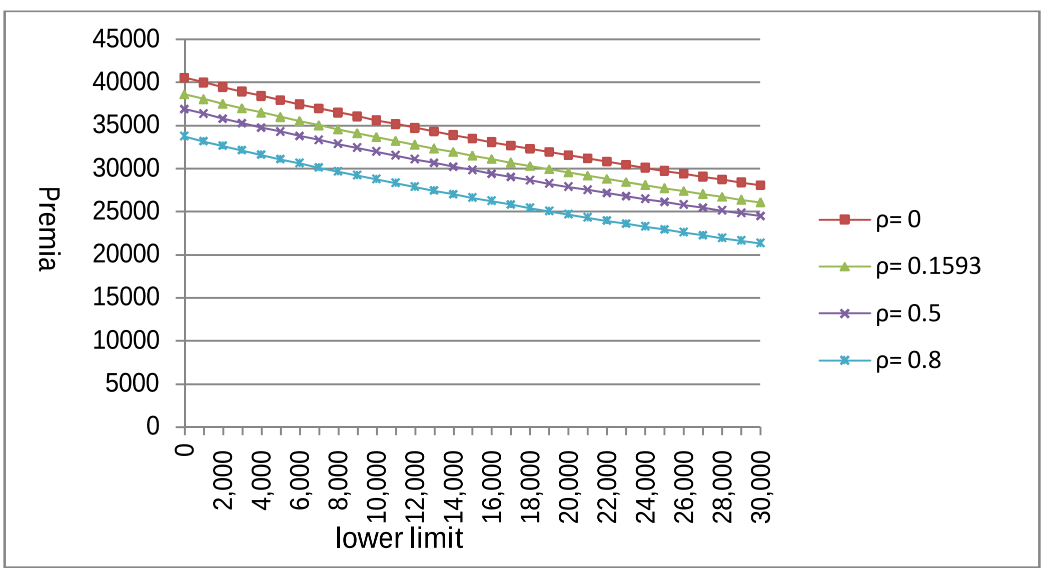

Figure 4-4 Premiums of Model III by European option approach under different correlation coefficients

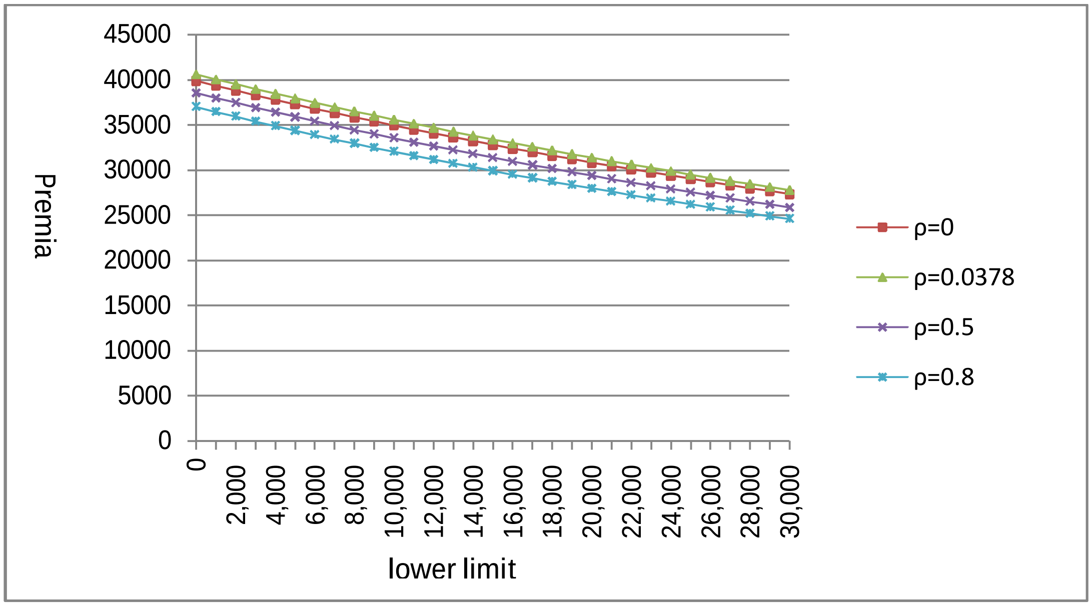

Figure 4-5 Premiums of Model IV by European option approach under different correlation coefficients

Bull call spread strategy

Figure 4-7 provides the trend of estimated insurance premiums of model I by bull call spread approach under different correlation coefficients. The figure shows that the premiums decrease with higher correlation coefficient and with lower claim amounts.

Figure 4-8 provides that model II has the same movement like model I.

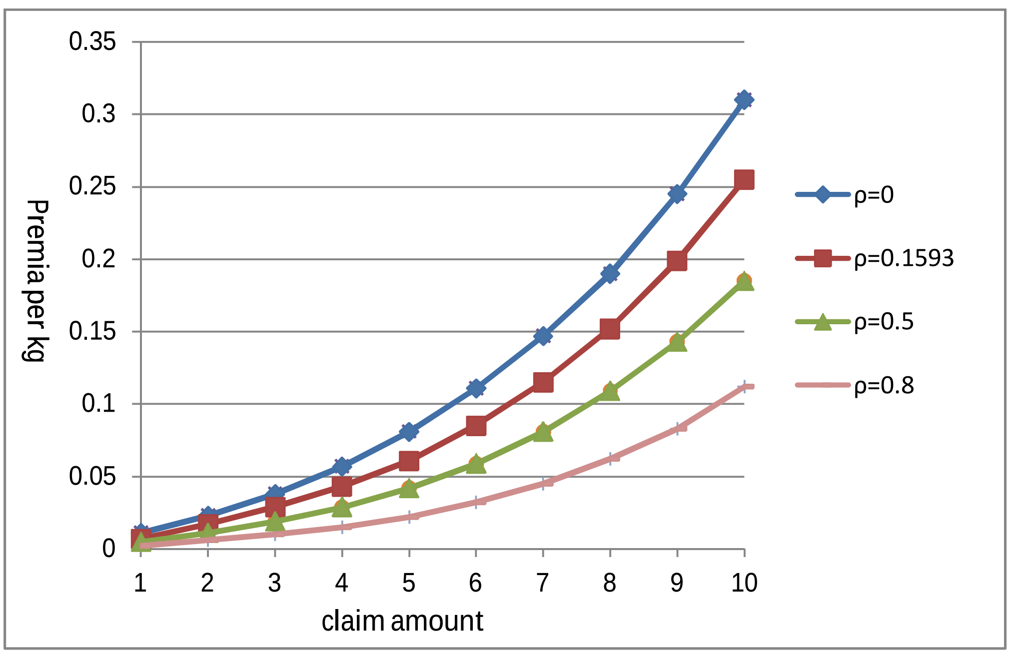

Figure 4-7 Premiums of Model I by call spread approach with upper limit of 25

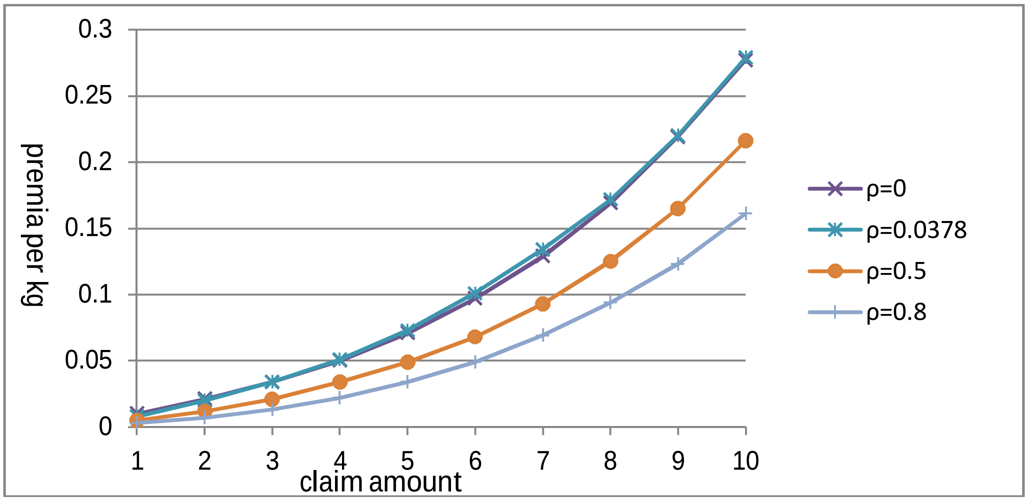

Figure 4-8Premiums of Model II by call spread approach with upper limit of 25

Figure 4-9 provides the trend of estimated insurance premiums per hectare of model III by bull call spread approach under different correlation coefficients. The figure shows that the premiums decrease with higher correlation coefficient and with lower claim amounts. Figure 4-10 provides that model IV has the same movement like model III.

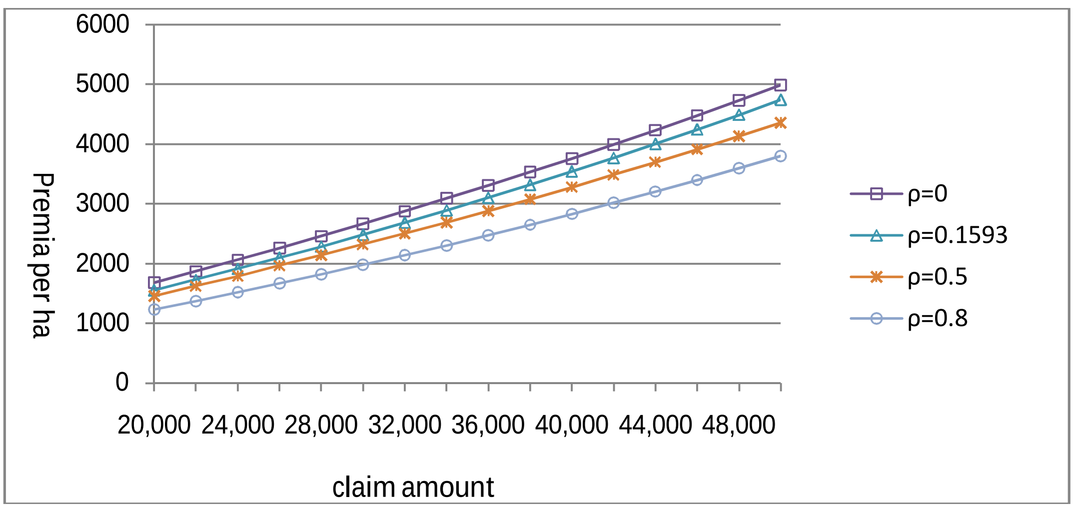

Figure 4-9 Premiums of Model III by call spread approach with upper limit of 150000

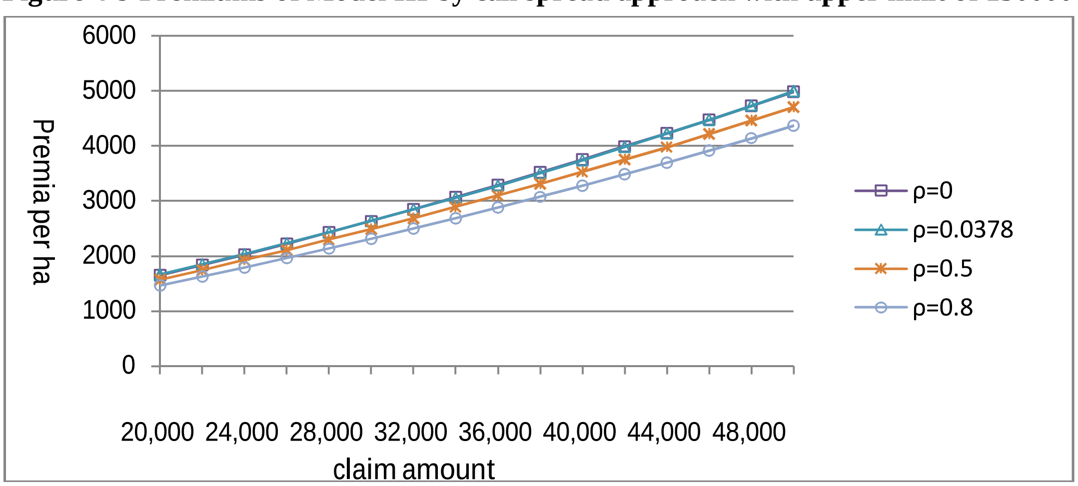

Figure 4-10 Premiums of Model IV by call spread approach with upper limit of 150000

5. Conclusion

In this paper, we try to establish agricultural profit insurance models as risk management tool against agricultural price risk and yield risk. Using available data from the Council of Agriculture, the models have been designed by European option pricing and bull call spread strategy to simulate profit insurance premiums with different claims limit.

The results of our study indicate that the estimated premiums decrease with higher lower limit and increase with higher upper limit. The increase of correlation coefficients will lead to a decrease of premiums.
In addition of these results, we find that the application of bull call spread approach to model insurance premiums are better than European option for claims limit settlement.

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