



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Effects of Subsidized Crop Insurance on Crop Choices

Jisang Yu
Department of Agricultural and Resource Economics
University of California, Davis
jiyu@primal.ucdavis.edu

Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28

Copyright 2015 by Yu. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Effects of Subsidized Crop Insurance on Crop Choices

Jisang Yu

July 21, 2015

Abstract

This study focuses on how subsidized crop insurance affects crop choices. Crop insurance programs may change the investment decision of farmers due to risk reduction or premium subsidies. First, actuarially fair insurance reduces the risk of farmers, holding expected return constant. Second, premium subsidies encourage farmers to purchase crop insurance and increases the expected return to the risky crop. Yet, outside of crop insurance, farmers have self-insurance mechanisms available, such as crop diversification. I derive conditions for when actuarially fair insurance and premium subsidies lead to more investment in the risky higher-return crop, while allowing for self-insurance. The effect of premium subsidies are decomposed into an encouragement (indirect) effect and a relative profitability (direct) effect. These effects are explained by the interaction between market insurance and self-insurance, and the interaction between a risky crop and a safe crop. I discuss each effect as a combination of a wealth effect and a substitution effect. The framework provides a novel view of the evaluation of subsidized crop insurance programs.

1 Introduction

Farmers are often exposed to production and price uncertainty. Uncertainty implies unanticipated variability in output quantity or price that is caused by exogenous shocks such as weather, crop pest or diseases, or unexpected changes in demand. Farmers make production or investment decisions before the realization of shocks. Their behaviors would be different if they could accurately predict output quantities and prices. Portfolio diversification, such as diversifying marketing channels or

crop mix, or utilizing financial devices such as futures, options, or insurance are often discussed as risk management schemes for farmers.

Moving from traditional to modern agriculture with higher returns needs investments in material and human capital (Schultz (1964)). In the context of economic growth and development, this transformation is crucial especially in developing countries. However, when the returns from investments are considered to be uncertain, farmers may face constraints caused by their risk-averse behavior or a high cost of credit. If these constraints are binding to a majority of agents in the developing world, relaxing these constraints through policies that facilitate risk management would promote investments and thus, economic development.

Crop insurance has been developed in many countries. Studies related to demand for crop insurance, optimal insurance contract design, and information asymmetry problems have contributed to the development of more attractive crop insurance programs. Others have focused on evaluating the effects of existing crop insurance schemes by investigating changes in production or investment decisions of farmers or in the market supply of crops. However, there have been relatively few studies on the role of premium subsidies in crop insurance programs (Goodwin, Vandemeer, and Deal (2004), and Goodwin and Smith (2013)).

Ehrlich and Becker (1972) discuss the interaction between market insurance, self-insurance, and self-protection. The substitutability between market insurance and self-insurance, which refers to the action to reduce the size of loss in the bad state, and the complementarity between market insurance and self-protection, which refers to the action to reduce the probability of the bad state, are discussed under the expected utility and state preference framework. In the context of this paper, the analogue to the relationship between market insurance and self-insurance is that of crop insurance and farm portfolio choice, which is asset allocation decision among a risky crop and a safe crop. Farmers with different self-insurance options behave differently as response to the provision of crop insurance and premium subsidy.

Except for few empirical studies in the context of the U.S. crop insurance program, there has been no explicit discussion on the role of premium subsidies. This paper utilizes the expected utility maximization model in the portfolio theory and examines the changes in farm portfolio

as actuarially fair and subsidized crop insurance become available. By separating the investment change due to subsidized crop insurance into a) change due to the provision of actuarially fair crop insurance and b) additional change due to the premium subsidy, the role of premium subsidy can be clarified. Another focus of this paper is the heterogeneity across farms. When farmers have their own means to mitigate the portfolio risk, for example crop diversification, and the cost of self-insurance is different across farms, the effect of subsidized crop insurance is heterogeneous.

I discuss the optimal farm portfolio in the absence of crop insurance markets, with actuarially fair crop insurance, and with subsidized crop insurance. The paper discusses the investment effect of subsidized crop insurance and the role of premium subsidy. Expected utility maximization models with simultaneous decisions on portfolio and insurance choices provide some general propositions on the interaction between the demand for insurance and the demand for a risky asset (Eeckhoudt, Meyer, and Ormiston (1997), and Hennessy (1998)). The comparative statics from these studies provide implications on the investment effects of insurance. I later revisit their propositions.

2 Effects of Crop Insurance on Farm Portfolio

As discussed above, since the role of uncertainty on agricultural investment decisions has gained attention, researchers have focused on risk management designed to facilitate allocation of profit across different states of nature or reduction of the probability of loss. In the context of crop insurance and production, studies like Ramaswami (1993), Chambers and Quiggin (2002), and Cheng, Carter and Sarris (2014) provide conceptual frameworks to describe agricultural investment decisions when crop insurance is available.

Ramaswami presents the decomposition of the effect of insurance on supply response with a single input production function and a multiple input production function under the expected utility framework. The effect of insurance is decomposed into two channels: risk reduction and moral hazard. The study suggests that the direction of the effect of insurance on supply response may be ambiguous. Chambers and Quiggin investigate the linkage between the producer's insurance choice and the production decisions when area-yield insurance is available, by utilizing the Arrow-Debreu state-contingent approach. They provide the sufficient condition that the provision of area-yield

insurance induces a change toward riskier production patterns.

The magnitude of the impact of crop insurance varies across different financial and risk environments. Cheng, Carter and Sarris investigate the different outcome of agricultural index insurance across different financial and risk environments. The effective index insurance contract to boost farm investment and technology adoption is contingent on financial and risk environments.

There have been many studies investigating empirical evidence of the production effect of crop insurance. Empirical studies focusing on acreage response to the U.S. crop insurance program, such as Wu (1999) and Goodwin, Vandemeer, and Deal (2004), suggest a positive effect of crop insurance on crop acreage. It is difficult to identify which factors of crop insurance drive the positive effect since the U.S. crop insurance program is heavily subsidized. Sumner, Alston, and Glauber (2010) point out the role of subsidy in the U.S. crop insurance program and the political demand for crop insurance as modes of subsidy. Thus, identifying the subsidy effect in supply response to crop insurance is important. Goodwin and Smith (2013) present preliminary empirical estimates indicating potential positive effect of premium subsidy.

In developing countries, recent studies such as Cai et al. (2012), Mobarak and Rosenzweig (2012), Cole, Giné, and Vickery (2013), Karlan et al. (2014), and Elabed and Carter (2014) find that the provision of insurance changes farmers' behavior toward productions of crops with higher risk and higher returns. These studies utilize randomized field experiments. These studies all indicate that the provision of insurance programs induces investment changes toward crops with higher risk and higher return. Note that these programs also have premium subsidies. Therefore, similar to the U.S. crop insurance program, the positive effects from these insurance programs may be a mixture of risk reduction and premium subsidies by insurance provision.

Yet, there is no explicit discussion on the role of premium subsidies on the investment effect of crop insurance. The interaction between crop insurance and self-insurance and its relationship with the investment effect also have not been studied much.

3 A Conceptual Framework

This section presents a conceptual framework to discuss the channels of the effect of subsidized crop insurance on their crop choices or farm investments. The model describes the optimal farm portfolios under different crop insurance market environments. I assume that farmers have two crops they can produce and the crop production is the only investment they can make. They can produce a crop with stable return, which is denoted as the “safe” crop, and they can also produce a crop with variable return with higher expected return than the safe crop, which is denoted as the “risky” crop. This section illustrates their choice across the “safe” and the “risky” crops.

The framework illustrates the effects of subsidized crop insurance by modifying the portfolio choice models and revisiting several propositions of Eeckhoudt, Meyer, and Ormiston (1997), and Hennessy (1998) in the context of subsidized crop insurance.

3.1 Preference and Agricultural Environment

Farmers allocate their initial capital asset, K_0 , into the investment on the safe crop, K_s , with linear return s , and the investment on the risky crop production, K_r . The return from the risky crop production is represented by rK_r where r is a positive random variable. The expected value of r is greater than s , since the risky crop has a higher rate of return than that of the safe crop. I assume there is no credit market available for farmers so that they cannot borrow nor lend their initial capital assets.

Risk-averse farmers maximize their expected utility, $U = E(u(.))$ where $u(.)$ is increasing and strictly concave function. Therefore, the optimization problem is

$$\text{Max}_{K_r} U(K_r) = Eu(x(K_r))$$

$$\text{subject to } K_r - K_0 \leq 0$$

where $x(K_r) = s(K_0 - K_r) + rK_r$.

The first order conditions are

$$U_{K_r} = Eu'(x)(r - s) = \lambda,$$

$$\lambda(K_r - K_0) \leq 0.$$

where λ is the Lagrangian multiplier.

As long as $E(r) > s$, it is clear that any agent with $u' > 0$ would invest at least some of the risky crop (Fishburn and Porter 1976). Therefore, the only relevant corner solution is $K_r^* = K_0$. From the Kuhn-Tucker condition, $K_r^* < K_0$ if and only if

$$Eu'(rK_0)(r - s) < 0 \quad (1).$$

The condition (1) indicates the farmers only allocate some of their initial capital asset into the safe crop if and only if the marginal benefit of investing in the safe crop exceeds that of the risky crop at $K_r = K_0$. Obviously, as the rate of return of the safe crop increases, this condition is more likely to be satisfied.

The investment on the safe crop is self-insurance described in Ehrlich and Becker (1972). The price of self-insurance becomes cheaper as s increases, and thus the demand for self-insurance, which is the investment on the safe crop, increases. This is straight from condition (1). In this paper, I focus on the effects of subsidized crop insurance when (1) is satisfied.¹

In the following two sections, effects of subsidized crop insurance are separated into a) actuarially fair insurance effect, and b) premium subsidy effect. More specifically, actuarially fair insurance effect is the difference between farm portfolios without crop insurance availability and that with actuarially fair insurance market, and premium subsidy effect is the difference between farm portfolios with actuarially fair insurance market and that with premium subsidy.²

¹When $Eu'(rK_0)(r - s) \leq 0$, the investment effects of actuarially fair crop insurance and premium subsidy are non-positive since $K_r^* = K_0$ without crop insurance availability.

²The optimal K_r and θ with the absence of crop insurance markets, with actuarially fair crop insurance availability, and with premium subsidies are denoted with subscripts zero, one and two, respectively.

3.2 Actuarially Fair Crop Insurance

The actuarially fair insurance for the risky crop is introduced. Farmers can purchase actuarially fair insurance θ , per unit of K_r and obtain indemnity, $I(r)$. The actuarially fair premium is $\pi = E(I(r))$. The indemnity $I(r)$ is non-increasing in r and decreasing in some r .

Under the availability of crop insurance, the farmers face the following optimization problem:

$$\text{Max}_{K_r, \theta} U(K_r, \theta) = Eu(x(K_r, \theta))$$

$$\text{subject to } (1 + \theta\pi)K_r - K_0 \leq 0$$

$$-\theta \leq 0$$

where $x(K_r, \theta) = s(K_0 - (1 + \theta\pi)K_r) + (r + \theta I(r))K_r$.

The first order conditions are

$$U_{K_r} = Eu'(x)(r - s + \theta(I(r) - s\pi)) = \lambda(1 + \theta\pi),$$

$$U_\theta = Eu'(x)(I(r) - s\pi)K_r = \lambda K_r \pi - \mu,$$

$$\lambda((1 + \theta\pi)K_r - K_0) \leq 0,$$

$$-\mu\theta \leq 0,$$

where λ and μ are the Lagrangian multipliers. The interior solution is characterized with $U_{K_r} = 0$ and $U_\theta = 0$.

For the following analysis, the sign of $U_{K_r\theta}$ is useful for comparative statics.

Proposition 1 Constant absolute risk aversion (CARA) or decreasing absolute risk aversion (DARA) preferences are sufficient for $U_{K_r\theta} > 0$ (Eeckhoudt, Meyer, and Ormiston 1997).

The proof is in the appendix. Eeckhoudt, Meyer, and Ormiston (1997) show that the sufficient condition for $U_{K_r\theta} \geq 0$ is DARA preference in a similar framework, whereas in this case CARA

is also sufficient. This condition determines other comparative statics on insurance demand and investment effect of subsidized crop insurance.

3.2.1 Insurance Demand

The demand for actuarially fair crop insurance is positive if and only if

$$s\pi Eu'(x|_{\theta=0}) < Eu'(x|_{\theta=0})(I(r)) \quad (2).$$

The condition (2) indicates that farmers purchase insurance if and only if the marginal benefit of indemnity payment, $Eu'(x|_{\theta=0})I(r)$, exceeds the marginal cost of crop insurance, $Eu'(x|_{\theta=0})s\pi$. The marginal cost of crop insurance is the marginal benefit from self-insurance, which is through the investment of the safe crop, times the fair premium. Also note that at $\theta = 0$ the marginal cost of self-insurance is equal to the marginal benefit from the risky crop investment.

The substitutability between crop insurance and self-insurance can be examined by investigating changes of the demand for crop insurance with respect to changes in the rate of return from the safe crop, s .

Proposition 2 The demand for actuarially fair insurance decreases with an increase in s if farmers have CARA preference or DARA preference with $R_r(x) \leq 1$ where $R_r(x) = -\frac{u''(x)x}{u'(x)}$.

Proof Using implicit function theorem,

$$\frac{\partial \theta^*}{\partial s} = \frac{1}{J}(U_{sK_r}U_{K_r\theta} - U_{s\theta}U_{K_rK_r}),$$

where $J = U_{\theta\theta}U_{K_rK_r} - (U_{K_r\theta})^2$ and $U_{s\theta}$ and U_{sK_r} are negative under CARA or DARA with $R_r(x) \leq 1$. And by proposition 1, $U_{K_r\theta}$ is positive for CARA or DARA preferences. Therefore under CARA or DARA with $R_r(x) \leq 1$, $\frac{\partial \theta^*}{\partial s} < 0$.

The substitutability between the crop insurance and the self-insurance holds if farmers with CARA or DARA with $R_r(x) \leq 1$. Similar to demand theory, the change in the demand for crop insurance is a composition of a wealth effect and a substitution effect. As the rate of return from

the safe crop investment increases, the expected return from the given portfolio allocation increases and this increase leads to the wealth effect on the demand for insurance. For CARA or DARA with $R_r(x) \leq 1$, the farmers become less risk-averse as the expected return increases and thus, the demand for insurance decreases. The substitution effect clearly leads to a decrease in the demand for insurance. For other preferences, the wealth effect may increase the demand for insurance as the rate of return from the safe crop investment increases and the magnitude may or may not be greater than the substitution effect.

3.2.2 Actuarially Fair Crop Insurance Effect on the Investment

For farmers who satisfy condition (2) and satisfy the interior solution condition, i.e. $K_{r1}(1 + \theta_1\pi) < K_0$, their portfolios are characterized with $U_{K_r} = 0$ and $U_\theta = 0$.³ The actuarially fair crop insurance effect on the risky crop investment is defined as $K_{r1} - K_{r0}$. Note that for the farmers with zero demand of actuarially fair crop insurance, $K_{r1} = K_{r0}$, and thus there is zero investment effect on the risky crop investment.

Proposition 3 CARA preference or DARA preference is sufficient for the positive actuarially fair crop insurance effect on the risky crop investment (Hennessy 1998).

Proof The investment of actuarially fair crop insurance is positive, i.e. $K_{r1} - K_{r0} > 0$. This can be shown by treating θ as exogenous parameter and showing $\frac{\partial K_r}{\partial \theta} > 0$. Using the implicit function theorem,

$$\frac{\partial K_r}{\partial \theta} = -\frac{U_{K_r\theta}}{U_{K_rK_r}}$$

and Proposition 1 show that CARA or DARA is sufficient for $U_{K_r\theta} > 0$.

Hennessy shows this result under a similar setting. The difference between proposition 3 and Hennessy is the existence of self-insurance. Due to the credit constraint and the self-insurance

³The condition for the interior solution is

$$Eu'(\frac{r + \theta^*I}{1 + \theta^*\pi}K_0)(r - s + \theta^*(I(r) - s\pi)) < 0.$$

for θ^* satisfies

$$Eu'(\frac{r + \theta^*I}{1 + \theta^*\pi}K_0)(r\pi - I) = 0.$$

through the safe crop investment, Proposition 2 holds only with condition (2) while under the framework of Hennessy any risk-averse agents with the indemnity $I(r)$ non-increasing in r and decreasing in some r purchase the actuarially fair insurance and increase the investment in the risky crop. The cost of self-insurance affects the magnitude of the actuarially fair crop insurance effect on the risky crop investment.

Proposition 4 The increase in the rate of return from the safe crop investment reduces the actuarially fair crop insurance effect on the risky crop investment if the farmers have CARA preference or DARA preference with $R_r(x) \leq 1$.

Proof This can be shown by checking the sign of $\frac{\partial^2 K_r}{\partial \theta \partial s}$.

The condition (2) and proposition 4 indicate that the rate of return from the safe crop investment affects the actuarially fair crop insurance effect on the risky crop investment. For CARA or DARA with $R_r(x) \leq 1$, the provision of the actuarially fair crop insurance affects farm portfolio heterogeneously according to their rate of return from the safe crop.

By Hennessy and Proposition 3, an increase in the insurance purchase increases the risky crop investment. And by Proposition 2, the substitutability reduces the demand for insurance and thus, the investment effect becomes smaller as the rate of return from the safe crop decreases. Also note that condition (2) depends on the rate of return from the safe crop investment. The farmers with zero demand for the actuarially fair crop insurance, i.e. who do not satisfy condition (2), are not affected by the actuarially fair crop insurance. Therefore, the investment effect of actuarially fair insurance is contingent on the cost of self-insurance.

3.3 Premium Subsidy

As described above, this section focuses on changes from the portfolio with the availability of actuarially fair crop insurance to the portfolio with the availability of subsidized crop insurance. Consider the premium subsidy, $0 < \gamma < 1$, which makes the premium equal to $\pi(1 - \gamma)$.

3.3.1 Insurance Demand

By substituting π with $\pi(1 - \gamma)$, the condition for positive insurance demand is

$$s\pi(1 - \gamma)Eu'(x|_{\theta=0}) < Eu'(x|_{\theta=0})I(r) \quad (4).$$

From (2) and (4), the farmers who satisfy

$$s\pi(1 - \gamma)Eu'(x|_{\theta=0}) < Eu'(x|_{\theta=0})I(r) < s\pi Eu'(x|_{\theta=0}) \quad (5)$$

purchase the insurance only with the premium subsidy γ . Note that the premium subsidy γ does not affect the distribution of indemnity payment.

For the farmers who satisfy condition (4) and satisfy the interior solution condition, i.e. $K_{r2}(1 + \theta_2\pi(1 - \gamma)) < K_0$, their portfolios are characterized with $U_{K_r} = 0$ and $U_\theta = 0$.⁴

For the farmers who do not satisfy condition (2), the premium subsidy γ is effective if it is great enough to satisfy condition (5). From (5), the effective premium subsidy is

$$\gamma > \gamma_T = s\pi - \frac{Eu'(x|_{\theta=0})I(r)}{Eu'(x|_{\theta=0})} \quad (6).$$

Any premium subsidy γ that does not satisfy (6) has zero effect on the farm portfolio. The threshold γ_T is increasing in s for CARA or DARA. This indicates that in the environments where it is cheap to self-insure against the farm portfolio risk, the minimum level of effective premium subsidy is greater than the environments with expensive self-insurance.

⁴The condition for the interior solution is

$$Eu'(\frac{r + \theta^*I}{1 + \theta^*\pi(1 - \gamma)}K_0)(r - s + \theta^*(I(r) - s\pi(1 - \gamma))) < 0.$$

for θ^* satisfies

$$Eu'(\frac{r + \theta^*I}{1 + \theta^*\pi(1 - \gamma)}K_0)(r\pi(1 - \gamma) - I) = 0.$$

3.3.2 Premium Subsidy Effects

The farmers with a positive demand for subsidized crop insurance, i.e. satisfying condition (4), increase their crop insurance demand with a positive premium subsidy if $\frac{\partial \theta^*}{\partial \gamma} > 0$.

Proposition 5 CARA preference or DARA preference with $R_r(x) \leq 1$ is sufficient for $\frac{\partial \theta^*}{\partial \gamma} > 0$ and $\frac{\partial K_r^*}{\partial \gamma} > 0$ (Eeckhoudt, Meyer, and Ormiston (1997), Hennessy (1998)).

Eeckhoudt, Meyer, and Ormiston, and Hennessy show that the optimal insurance purchase and the optimal investment on the risky asset decreases as the price of insurance increases. Therefore, the premium subsidy, which decreases the price of insurance, leads to opposite results. The premium subsidy effect on the risky crop investment is positive under CARA or DARA with $R_r(x) \leq 1$ for the farmers with condition (4). CARA or DARA farmers with $R_r(x) \leq 1$ who have positive demands of actuarially fair crop insurance increase their risky crop investment as the premium subsidies are provided. Also, by Proposition 3, CARA or DARA farmers with zero demand for actuarially fair crop insurance, but positive demands with positive premium subsidy γ , increase their risky crop investment as the premium subsidies are provided.

From Propositions 3 and 5, the part of the positive premium subsidy effect on the risky crop investment is from the increase in insurance purchase (encouragement effect). However, the premium subsidy may increase the risky crop investment not only by encouraging the insurance purchase and reducing the riskiness of the investment, but also inducing the relative profitability effect on the risky crop investment for the given insurance purchase. In other words, the premium subsidy can be represented as

$$\frac{\partial K_r}{\partial \gamma} = \left(1 - \frac{\partial K_r}{\partial \theta} \frac{\partial \theta}{\partial K_r}\right)^{-1} \left(\frac{\partial K_r}{\partial \theta} \frac{\partial \theta}{\partial \gamma}_{K_r \text{ constant}} + \frac{\partial K_r}{\partial \gamma}_{\theta \text{ constant}} \right) \quad (7),$$

and the term $\frac{\partial K_r}{\partial \theta} \frac{\partial \theta}{\partial \gamma}_{K_r \text{ constant}}$ represents the effect of premium subsidy on the risky crop investment through increased insurance purchase, and the term $\frac{\partial K_r}{\partial \gamma}_{\theta \text{ constant}}$ represents the relative profitability effect of premium subsidy on the risky crop investment. This type of decomposition is parallel to the decomposition of Eeckhoudt, Meyer, and Ormiston, which defines the direct and indirect effects of a parameter shift. According to their definition, the encouragement effect is the indirect effect

and the relative profitability effect is the direct effect.

Proposition 6 CARA preference or DARA preference with $R_r(x) \leq 1$ is sufficient for $\frac{\partial \theta}{\partial \gamma} \theta \text{ constant} > 0$ and CARA or DARA is sufficient for $\frac{\partial K_r}{\partial \gamma} \theta \text{ constant} > 0$.

Proof By treating K_r as an exogenous parameter, using the implicit function theorem,

$$\frac{\partial \theta}{\partial \gamma} \theta \text{ constant} = -\frac{U_{\theta\gamma}}{U_{\theta\theta}}$$

and

$$U_{\theta\gamma} = s\pi K_r E u'(x) - s\theta \pi K_r E u'(x) R_a(x) (I(r) - s\pi).$$

The second term is zero for CARA and positive for DARA with $R_r(x) \leq 1$ including the minus sign. Similarly, by treating θ as an exogenous parameter, using the implicit function theorem,

$$\frac{\partial K_r}{\partial \gamma} \theta \text{ constant} = -\frac{U_{K_r\gamma}}{U_{K_r K_r}}$$

and

$$U_{K_r\gamma} = s\theta \pi E u'(x) - s\theta \pi K_r E u'(x) R_a(x) (r - s + \theta(I(r) - s\pi)).$$

The second term is zero for CARA and positive for DARA including the minus sign.

The encouragement effect is from an increase of insurance purchase due to an increase of premium subsidies. The demand for insurance increases as the price of insurance becomes cheaper when insurance and self-insurance are substitutes and the discussion is similar to that of Proposition 2.⁵ The first term, $s\pi K_r E u'(x)$, represents the substitution effect and the second term, $-s\theta \pi K_r E u'(x) R_a(x) (I(r) - s\pi)$, represents the wealth effect. CARA has zero wealth effect and DARA with $R_r(x) \leq 1$ has a positive wealth effect, which are sufficient for crop insurance and self-insurance to be substitutes.. With Proposition 3, the encouragement effect is positive if crop insurance and self-insurance are substitutes.

The relative profitability effect, which is a change in the risky crop investment holding the

⁵Hennessy has similar discussions in the context of Proposition 5, but only decomposed the entire effect into a wealth and a substitution effects without separating the encouragement effect and the relative price effect.

insurance purchase constant, is also a composition of a wealth and a substitution effect. Similarly, the first term, $s\theta\pi Eu'(x)$, is the substitution effect and the second term, $-s\theta\pi K_r Eu'(x)R_a(x)(r - s + \theta(I(r) - s\pi))$, is the wealth effect. The substitution effect is positive regardless of preferences since the risky crop becomes more profitable without changing the riskiness of the investment. The wealth effect, from the increase in the expected return from the given portfolio due to premium subsidy, encourages more investment in the risky crop if the farmers are DARA. CARA has zero wealth effect.

The encouragement effect is from the substitutability between crop insurance and self-insurance, and the relative profitability effect is from the substitutability between the safe and the risky crop. The premium subsidy induces the risky crop investment through two different types of substitutability. For the farmers are DARA with $R_r(x) \geq 1$, crop insurance and self-insurance may not be substitutes. The encouragement effect becomes ambiguous since the wealth effect between insurance and self-insurance is negative. The relative profitability effect is still positive. Note that in the extreme case the overall effect of the premium subsidy may be negative. Therefore, the weight of the encouragement effect and the relative profitability effect is contingent on preferences. In some extreme cases, it is possible that premium subsidies function as direct subsidies such as output price or input subsidies.

Another interesting outcome from the decomposition of (7) is that the share of the relative profitability effect becomes larger as the subsidy increases if there is a maximum limit for the insurance purchase. The farmers purchase the maximum amount of insurance as the subsidy increases and after they reach the limit, the only effect of premium subsidy would be the relative profitability effect. Figure 1 and 2 describes this phenomenon. The effect on the risky crop investment is lower with a limit for maximum insurance purchase. Also, in Figure 2, the premium subsidies still increase the risky crop investment even after the farmers purchase crop insurance up to the maximum limit.

Figure 1: The effects of premium subsidies

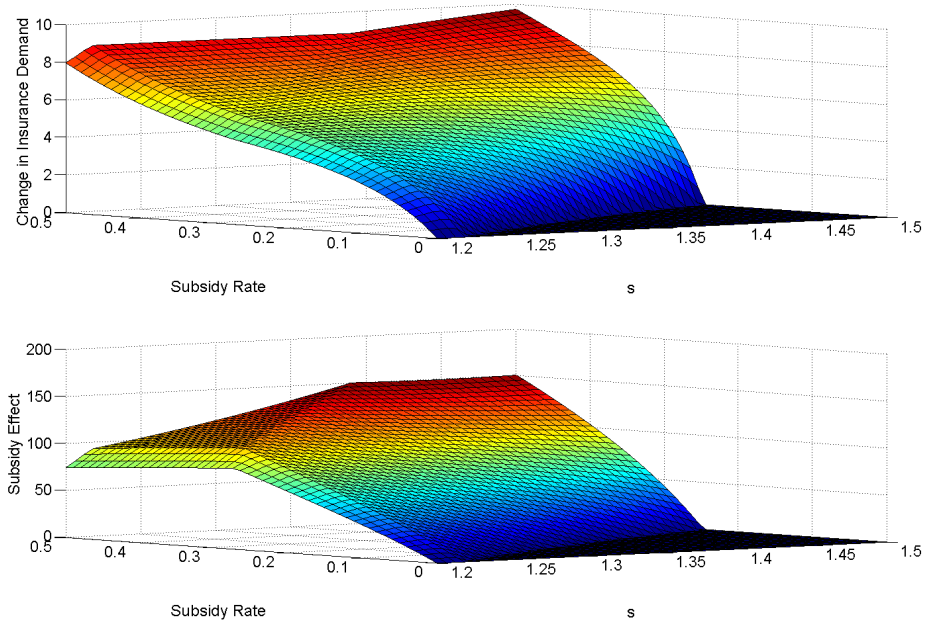
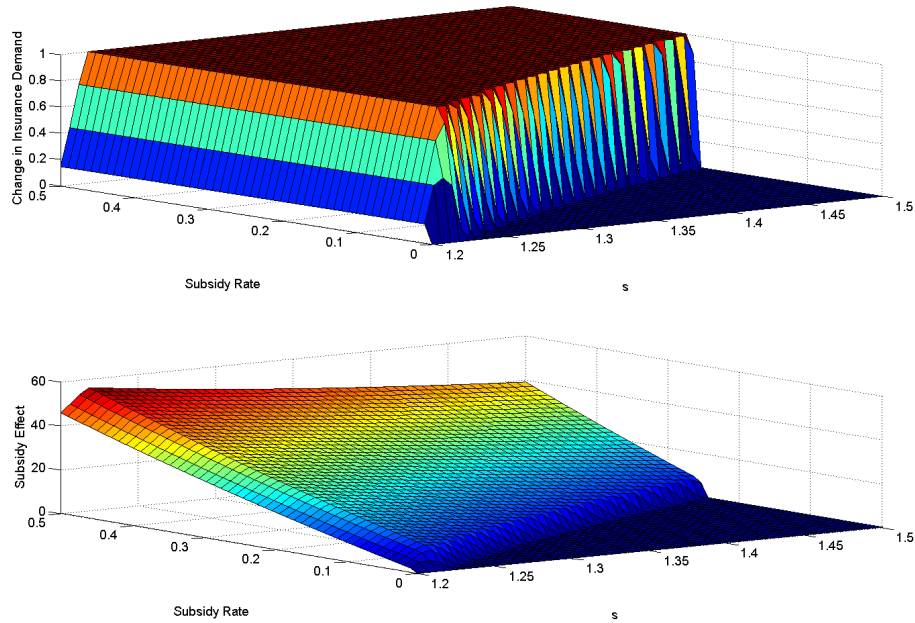


Figure 2: The effects of premium subsidies with a limit for maximum insurance purchase



Also, two figures show that there are heterogeneous effects of premium subsidies across farmers with different rate of returns from the safe crop investment. The rate of return from the safe

crop investment affects the encouragement effect and the relative profitability effect. The degree of substitutability between crop insurance and self-insurance, and between the risky crop and the safe crop depends on the rate of return from the safe crop investment.

4 Conclusions

In this paper, I show that the cost of self-insurance is crucial on the crop insurance purchase. If the cost of self-insurance is cheap enough, the farmers do not have incentive to participate in crop insurance programs. The cheaper the cost of self-insurance, the higher the subsidy rate that is required to encourage farmers to participate in crop insurance programs.

Several portfolio theories are revisited and applied to the context of subsidized crop insurance. I discuss the conditions for the positive insurance demand and the positive investment effect of actuarially fair crop insurance and premium subsidy. Portfolio literature and my discussion indicate that there are a certain set of preferences that are sufficient for the positive investment effect from actuarially fair and subsidized crop insurance.

The premium subsidy effect on the risky investment is separated into two effects: the encouragement effect and the relative profitability effect. Each effect is explained by a composition of a wealth effect and a substitution effect. The degree of substitutability between crop insurance and self-insurance, and between the risky crop and the safe crop determine the weight of the encouragement effect and the relative profitability effect. If the substitutability between crop insurance and self-insurance is smaller than the substitutability between the risky crop and the safe crop, the dominant driver of the investment effect is the relative profitability effect and premium subsidies function as output price or input subsidies.

Therefore, for the efficiency of policy implementation, it is important to examine the self-insurance environments, which can be agricultural or financial environments of farmers, and the risk preferences. The premium subsidy may promote the risky crop investment by encouraging the insurance purchase but for some preferences it may function as direct subsidies. Implementation of crop insurance programs should consider these possibilities. Also, further investigations on different

credit market environments and different insurance contracts, especially for index insurances are required. It is necessary to examine how different credit markets and different insurance contracts affect two types of substitutability, and thus the investment decision.

References

- Cai, H., Y. Chen, H. Fang, and L. Zhou. 2009. Microinsurance, trust and economic development: Evidence from a randomized natural field experiment. *NBER Working Paper* No. w15396
- Cai, J. 2013. The Impact of Insurance Provision on Households' Production and Financial Decisions. *MPRA Working Paper*
- Carter, M. R., L. Cheng, and A. Sarris. 2014. Where and How Can Index Insurance Boost the Adoption of Improved Agricultural Technologies? *Working Paper*
- Cole, S., X. Giné, and J. Vickery. 2013. How Does Risk Management Influence Production Decisions? Evidence from a Field Experiment. *Harvard Business School Working Paper*, No.13080
- Eeckhoudt, L., J. Meyer, and M. B. Ormiston. 1997. The Interaction Between the Demands for Insurance and Insurable Assets. *Journal of Risk and Uncertainty* 14
- Ehrlich, I., and G. S. Becker. 1972. Market Insurance, Self-Insurance, and Self-Protection. *Journal of Political Economy* 80(4)
- Elabed, G., and M. R. Carter. 2014. *Ex-ante* Impacts of Agricultural Insurance: Evidence from a Field Experiment in Mali. *Working Paper*
- Fishburn, P. C., and R. B. Porter. 1976. Optimal Portfolios with One Safe and One Risky Asset: Effects of Changes in Rate of Return and Risk. *Management Science* 22(10)
- Giné, X., and D. Yang. 2009. Insurance, Credit and Technology Adoption: Field Experimental Evidence from Malawi. *Journal of Development Economics* 89(1)
- Goodwin, B. K., and V. H. Smith. 2013. What Harm Is Done By Subsidizing Crop Insurance? *American Journal of Agricultural Economics* 95(2)
- Goodwin, B. K., M. L. Vandemeer, and J. L. Deal. 2004. An Empirical Analysis of Acreage Effects of Participation in the Federal Crop Insurance Program. *American Journal of Agricultural Economics* 86(4)
- Hennessy, D. A. 1998. Risk Market Innovation and Choice. *International Review of Economics*

and Finance 7(3)

Karlan, D. R.D. Osei, I. Osei-Akoto, and C. Udry. 2014. Agricultural Decisions after Relaxing Credit and Risk Constraints. *The Quarterly Journal of Economics* 129(2)

Kirwan, B. 2014. The Crowd-out Effect of Crop Insurance on Farm Survival and Profitability. *Selected Paper for presentation at the Agricultural and Applied Economic Associations Annual Meeting*

Miranda, M. J., and K. Farrin. 2012. Index insurance for developing countries. *Applied Economic Perspectives and Policy* 34(3)

Mobarak, A. M., and M. Rosenzweig. 2012. Selling formal insurance to the informally insured. *Discussion Paper* Economic Growth Center, No. 1007

Ramaswami, B. 1993. Supply Response to Agricultural Insurance: Risk Reduction and Moral Hazard Effects. *American Journal of Agricultural Economics* 75(4)

Sandmo, A. 1971. On the theory of the competitive firm under price uncertainty. *American Economic Review* 61

Schultz, T. W. 1964. *Transforming traditional agriculture*. New Haven, CT: Yale University Press.

Smith, V. H., and B. K. Goodwin. 2006. Crop insurance, moral hazard, and agricultural chemical use. *American Journal of Agricultural Economics* 78(2)

Sumner, D. A., J. M. Alston, and J. W. Glauber. 2010. Evolution of the economics of agricultural policy. *American Journal of Agricultural Economics* 92(2)

Wu, J. 1999. Crop insurance, acreage decisions, and nonpoint-source pollution. *American Journal of Agricultural Economics* 81(2)

Appendix

Proof of Proposition 1

Proof Using Arrow-Pratt absolute risk aversion coefficient representation, $U_{K_r\theta}$ can be rewritten as

$$U_{K_r\theta} = -E[R_a(x)u'(x)(I - s\pi)(r - s)]$$

where $R_a(x) = -\frac{u''(x)}{u'(x)}$, which is the Arrow-Pratt absolute risk aversion coefficient. This can be rewritten as

$$U_{K_r\theta} = \int_0^{s\pi} u'(x)(I - s\pi)R_a(x)(s - r)dF(I(r)) + \int_{s\pi}^{I_h} u'(x)(I - s\pi)R_a(x)(s - r)dF(I(r))$$

with $I_h = I(0)$ and from the first order condition,

$$\int_0^{s\pi} u'(x)(I - s\pi)dF(I(r)) + \int_{s\pi}^{I_h} u'(x)(I - s\pi)dF(I(r)) = 0 \quad (*)$$

For CARA and DARA preferences,

$$R_a(x|_{r_1})(s - r_1) < R_a(x|_{r_2})(s - r_2) \quad \text{for } \forall r_1 \text{ and } r_2$$

where r_1 is any r with $I(r) \in [0, s\pi]$, and r_2 is any r with $I(r) \in [s\pi, I_h]$. With (*) implies $U_{K_r\theta} > 0$. And IARA is necessary for

$$R_a(x|_{r_1})(s - r_1) > R_a(x|_{r_2})(s - r_2) \quad \text{for } \forall r_1 \text{ and } r_2$$

but not sufficient.