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Premium subsidy for crop insurance as an incentive device in China: In which respects might it work wrongly?

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ABSTRACT

Direct subsidy for crop insurance premiums paid by producers is widely adopted by policy-makers in many countries. It is generally believed to be a good device for income transfer to rural producers. In the recently launched crop insurance program in China, it is also employed as an incentive tool to encourage per-producer output and discourage rural-to-urban migration besides its traditional role. This research develops a dual-economy model to check three essential hypotheses that may support the Chinese government's decision. The model incorporates subsistence constraint in consuming agricultural products, which essentially changes the yield-revenue relationship of agricultural products. The analytical results from the model do not support these plausible hypotheses. When rural producers insure their crops with partial coverage, output at the individual level drops rather than increases. Meanwhile, the provision of insurance plus premium subsidy crowds the agriculture sector with too many laborers engaged in agricultural production. In this sense, government subsidy for crop insurance premiums induces efficiency loss rather than gain. The authors suggest that a comprehensive cost-benefit analysis should be carried out comparing premium subsidy and other types of risk-reduction and income-transfer programs, for the better use of government budget.

Keyword: premium subsidy; crop insurance; output decision-making; economic efficiency

I. INTRODUCTION

In the face of uncertainty in agricultural production and fluctuation in market price (s), an increasing number of Chinese farmers are choosing to access off-farm income sources to gain higher, more stable income, by working in the non-farming sectors either locally or in distant large cities seasonally. The large labor flow in China started in the mid-1980s after the relaxation of long-standing controls over rural-urban migration [1,2]. In 2008, the number of rural laborers migrating to urban areas reached 16.4 million, accounting for 22.6% of the total rural population (population with the status of "rural resident" or *nongcun* *hukou* in the household registration system) [3]. In 2008, the annual average income of the urban household reached slightly more than three times that of the rural household [4], which creates a strong incentive for rural-to-urban migration. Meanwhile, according to the authors' survey, many rural farming households are reducing their rice plantation plans so that more labor-hours can be allocated to off-farm jobs provided locally. The impact of the rational choices of farming households is revealed macroscopically. In 2003, the aggregate output of grain was 431 million tons, a drop of more than 100 million tons from that of 1998 [5]. Moreover, the drop mentioned above is in accordance with strict institutional control of migration under the *hukou* system. If the *hukou* system were removed, massive migration to cities would be expected to occur [6].

In the face of this issue, the Chinese government must deal with a certain trade-off: migration and off-farm income sources can definitely help rural households increase annual income and reduce rural-urban disparity, but it simultaneously reduces agricultural productivity and undermines the foodstuff self-sufficiency of the country. In this sense, the Chinese government is carrying out a series of policies to increase the incomes of rural households on the one hand and to keep them in their place on the other. These policy instruments include: 1) giving direct lump-sum subsidy to rural producers who continue agricultural production, particularly grain plantation; 2) imposing penalties on rural households whose crop lands are left uncultivated; 3) launching an agricultural disaster insurance program and simultaneously giving direct subsidy for insurance premiums; 4) giving direct lump-sum subsidies to producers who purchase farming machinery in order to encourage technical progress; and 5) as an experiment, allowing free transfer of land use rights in some regions since 2008.

Amongst all the mechanisms mentioned above, direct subsidy for crop insurance premiums has been widely adopted as both an income-transfer and an incentive tool [7]. According to some popular wisdom [8~10], government subsidy is necessary for the emergence of a crop insurance market. Output of agricultural production is likely to rise if producers are provided with insurance, and an abundance of agricultural products drives prices down and then promotes social welfare. Urban consumers, however, would take all these benefits away, since producers' labor income comes from the sales revenue of crops. In this sense, the government should carry out further redistribution policy to compensate producers. If it is again in the form of premium subsidy, then a virtuous circle could probably be established.

There are three pieces of essential logic in this hypothesis: premium subsidy will attract more resources, including labor, capital, and land, to be engaged in agricultural production so 1) per-farm output increases; 2) the number of farms is likely to grow; and 3) the abundance of agriculture products brings about a higher level of social welfare. Though policy instruments based on this hypothesis have been widely carried out, it is quite controversial. A study carried out by Nelson and Loeham [11], with a similar approach to [9], distinguishes between risk-increasing factors and risk-decreasing ones. It has been found that the provision of crop insurance will induce producers to increase the use of risk-increasing factors while reducing the use of risk-decreasing ones, revealing a typical moral-hazard structure. This analytical result has been supported by empirical studies carried out in the US [12~14]. They have paid attention mainly to producers' decision-making regarding specific factors of input rather than the overall output level, e.g., how many kilograms/bushels of grain will be produced per acre. In this sense, the three key statements in the hypothesis have not been verified by the existing literature.

This paper addresses whether these three essential logics are valid. In the model, we consider a general equilibrium economy in which social welfare is measured by the aggregate of the individual welfare level. First, in such an economy, the total natural endowment available for production will be controlled. Only when resources are allocated efficiently can the social optimum be achieved. Second, in the equilibrium, prices are endogenously decided by the market per se. In particular, subsistence consumption of agricultural products will be incorporated. It allows us to grasp whether there is a gain in social welfare if the price of agricultural products drops rapidly in response to a slow increase in supply.

The plan of this paper is as follows. In the next section, we introduce the basic structure of the model, including the key assumptions, essential features of the ex-post equilibrium, as well as the insurance system that we are going to discuss. On this basis, producers' ex-ante decision-making will be discussed. We will verify these three logics one by one: 1) Do producers increase their output level if premium subsidy is provided and the effective premium rate drops? 2) Does the number of laborers engaged in rural production increase correspondingly? And 3) is social welfare promoted because of the subsidy? In the final part of this paper, discussion will be presented identifying the gap between the model findings and the reality, and will provide clues for further study.

II. The context of the economy

A.The dual economy

We consider a simple closed dual economy with two sectors and two regions, both rural and urban. There is a population of homogeneous laborers in this economy and initially, all of them stay in rural areas. As a complete dual economy, it is generally assumed that there is a part of the population staying in the urban sector. Urban residents, however, as observed in reality, do not have any incentive to move to find work in rural areas as the rural sector does, either because of the income gap or because of the special techniques required in rural production, particularly in China and some other countries. On the other hand, it is only rural residents who seasonally or permanently migrate to urban areas. It is actually the mobility of rural residents that determines the labor allocation structure. Since the focus of the model is on the allocation of resources (labor) and risk-bearing, immobile urban residents make neither contribution nor a difference to the result of the model. We assume that rural residents who work in the rural sector ("rural producers" in this model) account for a fraction of n and that the rest, $1-n$ fraction of rural residents, work in the urban sector ("urban workers"). Be aware that in the model when we talk about "urban workers," this actually refers to individuals who come from rural areas while working in the urban sector. Without loss of generality, we normalize the population to 1. The rural sector produces agricultural products used for private consumption, while the urban sector produces urban goods for both private consumption and capital stock investment.

The labor market between regions/sectors is open without any friction, so n is endogenously determined. The assumption of free migration implicitly leads to an equilibrium of equalized labor income in some sense, which may be questioned because China has been well known for its rural-to-urban income gap for years. Nevertheless, if we look at the reasons for the income gap, many of them, e.g., costs of transportation and obtaining a working permit, are neutral in the decision-making of seasonal migrants, and will not change the pattern of allocation of labor and risk-bearing. For more information on the structure of neutrality of urban residents as well as lump-sum transaction costs in migration, please refer to the more complete dual-economy model developed by Ye et al. [15]. The model is a static one. Coupled with the assumption of free migration, this model is equivalent to a labor allocation problem. At the beginning of each period, each laborer first considers in which sector they are going to work in the following period. If they choose the rural sector, they are then "rural producer," and have to further choose a planned output level of production, X , which they believe can maximize their expected welfare state. On the other hand, if a laborer chooses to work in the urban sector, they are called "urban worker" and simply follow the mandatory working time without ex-ante planning. The production process then starts and the state of the world is to be determined. There are only two states of nature assumed for the sake of simplicity, state $t=0$ in which no disasters occur and state $t=0$ in which disasters occur and damages are claimed. The probability of falling under each state is $\pi(0)$ and $\pi(1)$, respectively. In this model, only the rural sector will be affected by natural disasters and the output of agricultural products could probably be damaged. Once a disaster occurs, the yield of all producers in this small economy is assumed to be damaged by the disaster simultaneously to the same degree. So all rural producers will get $\delta(t)X$ of an agricultural product (e.g., grain) in any state t, $0<\delta(1)<\delta(0)=1$. In order to avoid regressive results, it is strongly assumed that $\delta(1)>0$. Otherwise, in state 1, there will be no harvest in the agricultural sector and further discussion is meaningless. This seemingly strong assumption is actually innocuous to some extent. It is equivalent to the case where homogeneous producers under collective risks exchange full-cover mutual insurance. In this sense, their labor incomes will be the same for any arbitrary collective state of nature [15~17].

Urban workers' labor income is, consequently, risk free.

We further assume that there is some insurance option available for producers, either the package directly offered by insurance companies or that offered with government intervention. The package follows the general form of the yield insurance in FCIP (Federal Crop Insurance Program) in the United States and cost insurance in China. Indemnity per acre is calculated by σ . $\left[0, \bar{\xi} - \tilde{\delta} \cdot \xi\right]$ σ here denotes the indemnity coefficient, which is the price guarantee if it is yield insurance or cost reimbursement if it is cost insurance. $\bar{\xi}$ is the trigger yield put in the contract. $\tilde{\delta} \cdot \xi$ denotes the realized yield, with ξ representing the planned per-acre yield and $\tilde{\delta} \in \{\delta(0), \delta(1)\}$ representing the state-contingent discounting factor.

In order to simplify the formulation of the insurance contract so that it can be put into the context of our model, we made two important assumptions. On the one hand, it is assumed that land is homogeneous in terms of fertility as well as risk. So given the same level of input, the possible outcomes of output from all land will be the same. On the other hand, we assume that insurers can observe producers' behavior perfectly. In real situations, e.g., in the current crop insurance program in China, it has been observed that some producers may put less effort into planting correctly, increasing the risk of poor harvest after the insurance contract is underwritten. We make this assumption to prevent our discussion from diversifying to a moral hazards issue. The actual loss induced by a disaster can be simplified to

$$\max\left[0, \bar{\xi} - \tilde{\delta} \cdot \xi\right] = \left(1 - \tilde{\delta}\right) \xi .$$

Provided the assumptions above are correct, it is equivalent for a producer to specify the proportion of acres (l / L) and the proportion of output ρ it wants to insure, since per-acre output ξ times land cultivated L is exactly planned output level X, $\rho \cdot X, = \xi \cdot 1$. In this sense, total indemnity can be calculated equivalently by

$$m = \sigma \cdot \Delta \cdot X \cdot \rho, \tag{1}$$

with $\Delta = \delta(0) - \delta(1)$ denoting the actual damage ratio induced by a disaster and $\rho = \ell / L \leq 1$denoting the ratio of insured acres to total acres cultivated.

B. Ex-post equilibrium

After the production process is finished, the ex-post economy reaches equilibrium through exchange and trade. The budget constraint for an individual in the ex-post exchange economy is

$$p(t) x_i(t) + y_i(t) = e_i(t), \tag{2}$$

in which $p(t)$ is the state-contingent relative price of agricultural products to urban goods. $x(t)$ and $y(t)$ are the state-contingent consumption of agricultural products and urban goods, respectively. $e(t)$ is the state-contingent labor income of an individual, which equals product revenue if the individual works in the rural sector or wages paid by a firm if the individual works in the urban sector. Subscript i = 1,2 is used to denote the rural producer and the urban worker, respectively. Social aggregate budget constraint follows

$$\begin{aligned} &n x_1(t) + (1-n) x_2(t) = n\delta(t) X \\ &n y_1(t) + (1-n) y_2(t) = (1-n) e_2 - nC(X) = Y \end{aligned} \tag{3}$$

We assume that technology in the urban sector follows a constant return to scale with respect to labor. In this static framework, the aggregate urban goods available for consumption must equal the total wages paid to urban workers $(1-n)e_2$, which is certain, minus the total costs involved in agricultural production, $nC(X)$.

Individuals choose their best consumption bundles according to their preference. The ex-post utility level is measured by a quasi-linear utility function $u(x, y) = f(x) + y$ with

$$f(x) = \begin{cases} b\left(x^{1-1/\alpha} - 1\right)\left(1 - 1/\alpha\right)^{-1}, 0 < \alpha < 1 \\ b \ln x \qquad , \alpha = 1 \end{cases},$$

yielding a demand system that is inelastic with respect to consumption of agricultural products. Compared to the popular Stone-Geary utility function [18] of the same feature, the demand system yielded by this quasi-linear utility function has zero income elasticity of demand and constant price elasticity of demand, which exactly equals parameter − α. With this assumption, the ex-post equilibrium can be determined as

$$p(t) = b \cdot \left[n\delta(t) X\right]^{-1/\alpha}, \tag{4}$$

by assuming interior solutions. This price system will exactly allocate each individual the per-capita amount of agricultural products to consume. Ex-post indirect utility follows

$$v_i\left(e_i\left(t\right),p\left(t\right)\right)=\arg\max u_i\left(x_i\left(t\right),y_i\left(t\right)\right) \\ =e_i\left(t\right)-\varphi\left(p\left(t\right)\right) \quad (5)$$

with $\varphi(p)=\begin{cases}\dfrac{b^{\alpha}p^{1-\alpha}-\alpha b}{1-\alpha},0<\alpha<1 \\ b\left(\ln b^{-1}p+1\right),\alpha=1\end{cases}$.

Another important feature of the quasi-linear utility function is that the ex-post utility function is a monotonic transfer of the planned output level, *X*. There are some important features of the equilibrium:

a) $p(0)\delta(0)-p(1)\delta(1)<0$.

Rural producers will gain higher product revenue if a disaster happens and destroys a part of the harvest. This feature creates an essential difference between this model and popular wisdom. In most of the literature, either analytical research or empirical estimation, a positive revenue-yield relationship is assumed, although in many cases, there is a negative price-yield relationship. This feature is determined by the assumption of subsistence constraint together with a closed economy. If either of the two assumptions is removed, the model will collapse into one that has been widely treated. The corresponding change in the implication of the model, however, does not mean that the model is not robust. Such a revenue-yield relationship widely exists in the market, particularly the fresh vegetables and fruits, for which distant shipping and long-term storage are not possible. As for cereal products, it is not widely seen because they can on the one hand be stored for years at acceptable cost and governments are always concerned about their prices, for the sake of food security, on the other hand.

b) $\mathrm{Var}\left[v_1\right]<\mathrm{Var}\left[v_2\right]$

This means that the cross-state variance of state-contingent welfare states of the rural producer is smaller than that of the urban worker. In other words, urban workers bear more risk than rural producers. This is a result of feature a), the negative revenue-yield relationship. If there is a domestic insurance market working for risk transfer, it must then be rural producers who provide insurance coverage. It reveals quite an important structure in this study: although rural producers suffer from yield loss (the direct risk-bearer), they are actually not the final victims. This is the critical point of what we may call the "inter-sectoral" structure of risk diversification: the flow of laborers and goods may alter the actual risk-bearing pattern from what it seems to be. Risk transfer from rural producers to urban consumers has been carried out by the goods market, before the financial/insurance market comes into the picture. Consequently, market allocation of catastrophic risk regarding subsistence goods is so inherent that we should not deal with it in the same manner in which we deal with risks in many other sectors/situations.

It is, however, unrealistic for rural producers to provide domestic disaster insurance to urban consumers since the transaction costs will be significantly high. In this sense, when we come to the sub-model with insurance contracts, it must be provided by some foreign insurer and the model collapses into a partial one in terms of the insurance market. Insurance can be provided both to rural producers, against crop failure (although there is no "income failure"), and to urban consumers, against a drop in purchasing power and reduced consumption. Both types of insurance will result in welfare promotion as they cope with different types of risks in the economy. In the preceding part, however, we focus on the insurance provided to rural producers because the objective of this study is to discuss rural producers' decision-making under subsidized insurance premiums.

III. Ex-ante decision-making and equilibrium

1) Criteria for ex-ante decision-making

Individuals' ex-ante decision-making is a two-stage process. Provided with all state-contingent outcomes (ex-post welfare states) and their corresponding probability, an individual will choose the sector that can bring the highest ex-ante expected utility to work in.

As a rational expected utility maximizer, a producer is then to choose planned output level *X* and insurance coverage level ρ, taking the market prices for agricultural products and insurance coverage as parameters:

$$\max_{X,\rho}\mathrm{E}\,W_1=\sum\nolimits_t\pi(t)W\left(v_1\left(e_1(t),p(t)\right)\right),$$

which is subject to

$$\begin{array}{l} e_1\left(t\right)=p\left(t\right)\delta\left(t\right)X-C\left(X\right)+\left(t-\nu\right)\cdot m \\ m=\sigma\cdot\Delta\cdot X\cdot\rho \\ 0\le\rho\le1\end{array}$$, for *t*=0, 1. (6).

The expected ex-ante welfare level is measured by von Neumann-Morgenstern (VNM) utility function $W(\cdot)$ as a function of ex-post indirect utility $v_1\left(e_1\left(t\right),p\left(t\right)\right)$. $W\left(\cdot\right)$ is introduced to define the risk-averse preference of the producer. Ex-post income consists of three parts, product revenue $p\left(t\right)\delta\left(t\right)X$, production costs $-C(X)$, and the state-contingent insurance item $(t-\nu)\cdot m$. For ease of description, we allow producers to take out loans at the beginning of each period and repay them after yield and revenue are realized. If a disaster does not happen, the $t = 0$ and the insurance item is exactly the premium rate charged to the producer. The last inequality holds because a producer cannot insure cropland that is not actually cultivated. The introduction of insurance into the system changes the state-contingent incomes of rural producers, the ex-ante expected welfare level, and consequently the ex-ante equilibrium. It has no impact on the mechanism of determining the ex-post equilibrium, however.

This maximization problem is quite general but causes a lot of problems due to our general equilibrium structure. It becomes analytically intractable when we try to determine the population distribution. As indicated, risk-neutral producers in imperfect financial markets (e.g., under budget/liquidity/credit constraint) behave as if they were risk averse [19]. In this sense, we provide an alternative to the elegant structure as a compromise:

$$\max_{X,\rho} \mathrm{E}\,V_1 = \sum\nolimits_t \pi\left(t\right) v_1\left(e_1\left(t\right), p\left(t\right)\right),$$

which is subject to

$$\begin{aligned}
&\lambda_1\left(t\right): e_1\left(t\right) = p\left(t\right)\delta\left(t\right)X - C\left(X\right) + \left(t-\nu\right)\cdot m \\
&\lambda_2 : m = \sigma\cdot\Delta\cdot X\cdot\rho \\
&\lambda_3 : 0 \le \rho \le 1 \\
&\lambda_4 : C\left(X\right) + \nu m \le K
\end{aligned}\quad \text{, for } t=0,\,1, \tag{7}$$

with a Greek letter before each constraint as its corresponding Lagrangian multiplier. First-order conditions for maximization require the last budget constraint to bind at K. In other words, the rural producer tries to take out a loan of the maximal amount, K. We have three solutions.

a) If $\rho = 0$ *and* $m = 0$

This corresponds to the case in which no insurance is provided, or where the producer feels that it is not optimal to purchase insurance coverage. The first-order condition for this case is

$$\sum\nolimits_t \pi\left(t\right) \frac{\partial v_1\left(t\right)}{\partial e_1\left(t\right)} \frac{\partial e_1\left(t\right)}{\partial X}\bigg|_{\rho=0} = 0\,, \tag{8}$$

which yields optimal planned yield X_0.

b) If $0 < \rho < 1$

We call this type of insurance demand "partial coverage." The first-order conditions hold that

$$\left(1-\nu\right)p\left(0\right)\delta\left(0\right) + \nu p\left(1\right)\delta\left(1\right) - C'\left(X\right) = 0\,. \tag{9}$$

c) If $\rho = 1$

The first-order conditions for maximization can be updated to

$$\sum\nolimits_t \pi\left(t\right)\left[p\left(t\right)\delta\left(t\right) - C'\left(X\right) + \left(t-\nu\right)\sigma\Delta\right] = 0\,. \tag{10}$$

2) Ex-ante equilibria

In the model, the statistics imply

$$\frac{d\mathrm{E}\,W_1}{dn}, \frac{d\mathrm{E}\,V_1}{dn} < 0\,,\ \frac{d\mathrm{E}\,W_2}{dn}, \frac{d\mathrm{E}\,V_2}{dn} > 0\,. \tag{11}$$

The more individuals are engaged in agricultural production, the lower the expected utility they will receive. Sharp price drops can be induced by an abundance of agricultural products, and this correspondingly reduces the labor income of producers. The effect of the first half of the sentence is predicted by the literature, but the other half is not really mentioned. The effect of population distribution on individuals' welfare states is shown in Fig. 1.

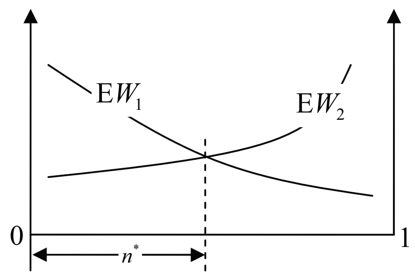

Figure 1. Determination of equilibrium population distribution

Recall that the criterion for choosing between sectors is simply to check which sector can provide higher expected ex-ante utility. In this sense, the population distribution reaches equilibrium if there is a marginal individual who is perfectly indifferent to working in either sector, holding that

$$\mathrm{E}\,W_1 = \mathrm{E}\,W_2\,, \text{ or } \mathrm{E}\,V_1 = \mathrm{E}\,V_2\,. \tag{12}$$

With constraint , static population distribution n will be endogenously determined. We specify $\alpha = 1/2$ and $C(X) = c \cdot X$ to derive explicit analytical results.

When risk neutrality is assumed, the expected ex-ante utility level coincides with the expected income level. Since we further assume that the cost function is linear in X, there is no concave set for maximization in the benchmark case. In this sense,

$$X_0 = K/c . \tag{13}$$

Together with constraint (12), it yields the equilibrium (X_0, n_0) .

When rural producers purchase partial coverage, the equilibrium (X_{pc}, n_{pc}) is determined by (9) together with constraint . When full coverage is purchased, the equilibrium (X_{pc}, n_{pc}) is determined by (10) together with .

3) Comparative statics

In the model, we measure economic efficiency by the social welfare function, which is a plain aggregate of all individual welfare functions:

$$U_i = n_i \mathrm{E} V_1 + (1 - n_i) \mathrm{E} V_2 \text{, for } i = 0, pc, fc . \tag{14}$$

The three subscripts in the equation represent the case with no insurance contract, partial insurance coverage, and full insurance coverage.

Performing basic comparative statics, we have

$$dX^*_{pc}/d\nu > 0, dX^*_{fc}/d\nu < 0 ,$$

$$dn_{pc}/d\nu < 0,\ dU_{pc}/d\nu > 0, U_{pc}\big|_{\nu=\nu_0'} = U_0 \text{ , and}$$

$$dU_{fc}/d\nu < 0, U_{fc}\big|_{\nu=0} > U_0{}^* .$$

The sign of $dn_{fc} / d\nu$ is not certain but it necessarily holds that $n_{fc} > n_0$. Production behavior at the individual producer's level as well as the social aggregate welfare state against changes in the effective premium rate is shown in Fig. 2.

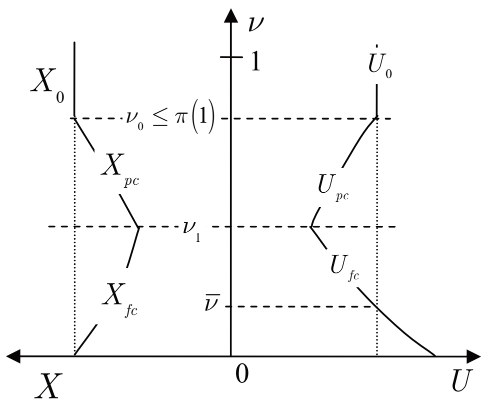

Figure 2. Production behavior of the risk-neutral rural producer under free migration

We may interpret Fig. 2 in the following way. At the beginning, there is no insurance market, or insurance is provided at an unacceptable price (generally, commercial insurance is offered with premium loading so the rate is definitely higher than is fair), and producers do not use the instrument to manage their risk.

The government then announces a premium subsidy program. Once the subsidy rate is high enough to allow insurance behavior to break even, $\nu \le \nu_0$, producers will purchase partial coverage and their output level decreases from X_0. This observation is quite different from popular wisdom. In the model, yield and producers' labor income shows a negative relationship, not a positive one as is generally assumed. Along with the decrease in individual output level, the social aggregate welfare level drops. There is excessive entry into the rural sector, while each producer produces less than the social optimal level.

Should the effective premium rate continue to drop as the government subsidy rate increases, producers will increase the coverage rate and it will finally bind at $\rho = 1$. The demand curve of producers as well as their supply curve of grain binds at this point, ν_1. So does the curve of social aggregate welfare level. Producers will turn to increase their output level because they saved budget to invest in production from cheaper insurance coverage. Social aggregate welfare begins to increase. Nevertheless, this increase is not because of the improvement in economic efficiency, but due to the extra resources that have been brought into this system by the government subsidy. It must be emphasized here that we did not take the government's budget for premium subsidy into account.

So we may summarize here that when factor mobility and intersectoral labor allocation is taken into account, premium subsidy is likely to result in rural sector overpopulation while each producer produces less than when no insurance is provided. Premium subsidy will probably result in a loss in economic efficiency rather than a gain. We have the interval $\left(\nu_0, \bar{\nu}\right)$ in which economic efficiency will definitely be undermined because of the premium subsidy.

IV. Government budget for premium subsidy

In the framework of perfect factor mobility, what will the necessary budget be for the government to achieve critical intervention effects? Suppose the inverse supply function of an international insurer is $v = v(M)$, the upsloping concave curve in Fig. 3, lying between π (1) and 1 for the existence of loading factors. $M(v) = n(v) \cdot m(v)$ is the aggregate demand for insurance coverage or producers.

As we know from Fig. 2, the break-even point of the insurance market is v_0. Consequently, a budget with the length of the thick-black-font segment in Fig. 3 will be necessary:

$$F_0 = \nu\left(M_{pc}\left(\nu_0\right)\right) - \nu_0 \tag{15}$$

The kink point between demand for partial coverage and full coverage is v_1. So, the critical government budget to reach this point equals the area of the dark-gray square:

$$F_1 = \left[\nu\left(M_{pc}\left(\nu_1\right)\right) - \nu_1\right] M_{pc}\left(\nu_1\right) \tag{16}$$

Finally, if the government wants to increase social aggregate welfare by investing substantial budget in premium subsidy, it has to prepare a budget with the size of the area of the light-gray square:

$$F_2 = \left[\nu\left(M_{fc}\left(\bar{\nu}\right)\right) - \bar{\nu}\right] M_{fc}\left(\bar{\nu}\right) \tag{17}$$

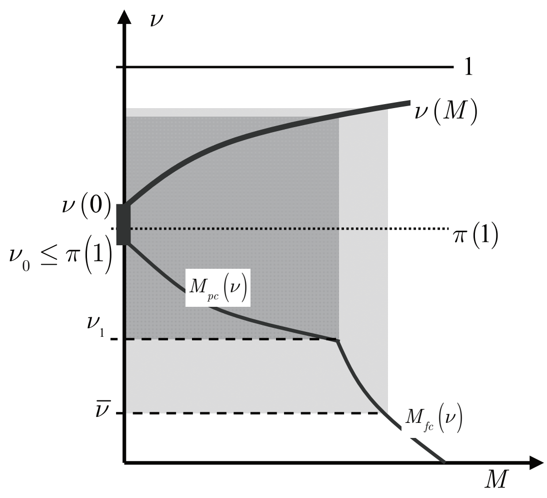

Figure 3. Required financial resources for premium subsidy to reach a critical effect

From Fig. 3, it is straightforward that the budget for premium subsidy increases dramatically when the subsidy rate goes up. Whether government expenditure on the premium subsidy mentioned above is cost-effective or economically efficient remains a question for further discussion, since we do not have a context for comparison among the investment choices of the government.

V. Conclusion and discussion

In this research, a simple model is developed to provide some alternative insights into producers' behavior under the subsidized insurance program. The major findings from our model include: 1) premium subsidy does not always induce producers to produce more output; 2) premium subsidy attracts more laborers to engage in agricultural production; and 3) premium subsidy could induce welfare loss because it undermines economic efficiency. Finding No. 2 is similar to popular wisdom but No. 1 and No. 3 diverges from it.

There are several critical structures in the model that provide the alternative findings listed above. Our assumption of a closed economy together with the inelastic demand system that determines the yield-revenue structure opposes common sense. This feature essentially changes the slope of the individual supply curve when partial coverage is purchased and yields a "V"-shaped curve. Second, in the structure of general equilibrium, the social optimum will be unique. The abundance of any product will be at the cost of the output of other products—obviously we must have a solution in this trade-off. Excessive entry into farm production and under-production by operating farmers results only in welfare loss.

Direct subsidy for crop disaster insurance premiums does not necessarily encourage producers to produce more output. A small amount of subsidy only leads to a smaller per-capita output level. Premium subsidy does lead to a larger population engaged in agricultural production. This result is very similar to that derived by Innes [20] that there is excessive entry into farm production and under-production by operating farmers, although in his model, it is the result of ex-post relief in the absence of ex-ante government policy.

Let us return to reality with our model findings. This research is basically theoretical, without any data or econometric estimation. In this sense, we cannot provide specific policy implications. Nevertheless, it is suggested that a government, like the Chinese government, should have taken the observations of this research into account before any kind of premium subsidy is provided. Premium subsidy requires large fiscal resources and it distorts the market as well as individuals' choice. Besides, there are still several alternatives for disaster reduction in the agriculture sector, which may increase producers' income level and consequently attract more laborers to engage in agricultural production. Cost-benefit analysis among investment in risk-mitigating infrastructures, post-disaster relief, direct income transfer, and premium subsidy should be carried out. Complicated models may be required to achieve this task, such as input-output econometric models (I-O), CGE models, sequential interindustry models (SIM), and dynamic stochastic general equilibrium models (DSGE) [21].

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References

[1] Zhao, Y, "Leaving the Countryside: Rural-to-Urban Migration Decisions in China," AEA Papers and Proceedings, 89 (2), 1999a, 281-286.

[2] Zhao, Y, "Labor Migration and Earnings Differences: The Case of Rural China," Economic Development and Cultural Change 47 (4), 1999b, 767-782.

[3] State Statistical Bureau of China, "China Statistical Year Book 2009" (online version). http://www.stats.gov.cn/tjsj/ndsj/2008/indexch.htm, accessed on May 20th, 2009.

[4] BBC News, "China Rural-Urban Wage Gap Widens," January 16, 2009, http://news.bbc.co.uk/2/hi/asia-pacific/7833779.stm, accessed on May 28th, 2009.

[5] Statistical Bureau of China, "China Statistical Yearbook 2008," Available at http://www.stats.gov.cn/tjsj/ndsj/2008/indexch.htm, accessed on July 16, 2009.

[6] Ito, J, "The Removal of Institutional Impediments to Migration and its Impact on Employment, Production And Income Distribution in China," Econ. Change Restruct. 41, 2008, 239-265. doi: 10.1007/ s10644-008-9051-7

[7] Goodwin, B.K., "Problems with Market Insurance in Agriculture," Amer. J. Agr. Econ. 83 (3), 2000, 643-649.

[8] Hazell, P, "Crop Insurance -- A Time for Reappraisal," IFPRI report 3, 1981, pp. 1–4.

[9] Ahsan, S.M., A.A.G Ali, and N. J. Kurian, "Toward a Theory of Agricultural Insurance," Amer. J. Agr. Econ. 64, 1982, pp. 520–29.

[10] Siamwalla, A. and A. Valdes, "Should Crop Insurance be Subsidized?" in Hazell, P. et al. eds., Crop Insurance for Agriculture Development: Issues and Experiences. Baltimore and London: Johns Hopkins University Press, 1986, pp. 117–125.

[11] Nelson, C.H. and E. T. Loehman, "Further Toward a Theory of Agriculture Insurance," Amer. J. Agr. Econ. 69, 1987, pp. 643–49.

[12] Smith, V.H. and B.K. Goodwin, "Crop Insurance, Moral Hazard and Agricultural Chemical Use," Amer. J. Agr. Econ. 78, 1996, pp. 428–38.

[13] Babcock, B.A., and D. Hennessy, "Input Demand Under Yield and Revenue Insurance," Amer. J. Agr. Econ. 78, 1996, pp. 416–27.

[14] Goodwin, B.K., M.L. Vanderveer, and J. L. Deal, "An Empirical Analysis of Acreage Effects of Participation in the Federal Crop Insurance Program," Amer. J. Agr.

Econ. 86, 2004, pp. 1058–77.

[15] Ye, T., M. Yokomatsu and N. Okada, "Labor Mobility, Goods Tradability, and Efficient Allocation of Disaster Risk," in the proceedings of 2009 IEEE International Conference on Systems, Man, and Cybernetics, San Antonio, Texas, USA, Oct 11–14, 2009, pp. 1992-1997.

[16] Cass, D., G. Chichilnisky, and H.M. Wu, "Individual Risk and Mutual Insurance," Econometrica 64, 1996, pp. 333–41.

[17] Yokomatsu, M. and K. Kobayashi, "Catastrophic Risks and Economic Valuation of Disaster Mitigation," paper presented at the Second Euro Conference on Global Change and Catastrophe Risk Management: Earthquake Risks in Europe, July 6–9, 2000, IIASA, Austria.

[18] Neary, J. P., "R.C. Geary's Contributions to Economic Theory," in D. Conniffe ed., R.C. Geary, 1893-1983: Irish Statistician (1997): Oak Tree Press, Dublin.

[19] Mahul, O, "The Output Decision of a Risk-Neutral Producer under Risk of Liquidation," Amer. J. Agr. Econ. 82, 2000, pp. 49-58.

[20] Innes, R., "Crop Insurance in a Political Economy: an Alternative Perspective on Agricultural Policy," Amer. J. Agr. Econ. 85, 2003, pp. 318–35.

[21] Greenberg, M. R., M. Lahr, and N. Mantell, "Understanding the Economic Costs and Benefits of Catastrophes and Their Aftermath: A Review and Suggestions for the U.S. Federal Government," Risk Analysis, 2007, vol. 27, no. 1, 83-96.

* Due to the bulkiness of equations of proof, they are not provided in this article. Please refer to Ye (2009) for more details.