京都大学防災研究所年報 第 52 号 B 平成 21 年 6 月
Annuals of Disas. Prev. Res. Inst., Kyoto Univ., No. 52 B, 2009

Inter-sectoral allocation of disaster risk: is inter-secotral fiscal transfer creating the right incentives?

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Synopsis

Given the fact that agriculture sector is more vulnerable in terms of disaster risks, direct monetary transfer are paid from tax-payers to agriculture producers in many countries. Such transfers are expected to not only provide higher and more stable income to producers but also create incentives to keep them continuing farming. Nevertheless, they have been doubted for inducing economic inefficiency because of the later effect which masks the market signal for resources and risk allocation. This research uses a dual-economy model with inter-sectoral flow of labor and commodity to discuss such government policies. It excursively aims at justifying government policies that discourages rural producers to work in urban sectors. The result of the model shows that if the price in the goods market is the only signal of allocating resources, migration behavior should be controlled. Disaster insurance market can achieve social optimal allocation if goods tradability is perfect. When goods tradability is imperfect, migration behavior in the insurance equilibrium should be controlled if the migration costs is low, or vice versa.

Keywords: inter-sectoral disaster risk allocation, labor mobility, goods tradability

1. Introduction

In many countries agriculture sector is taken special care of by governments. Various types of financial aids are widely provided to producers, e.g. direct product price intervention, lump-sum subsidy, disaster aid, as well as crop insurance programs with heavy premium subsidy. Although the motivation of doing so has been accepted by popular wisdom (e.g. Goodwin and Smith, 1995), government initiatives are doubted for undermining economic efficiency. Policy instruments which are not neutral to producers' decision-making are likely to hamper resources from flowing to the places where they can be efficiently used (Dixit and Longregan, 1995). For instance, the rural-urban disparity in China has reduced decade-long seasonal migration pattern in Mainland China. The strong signal from the labor market implies that the allocation of labor forces between rural and urban sectors should be adjusted. The household registration system (*Hukou*), however, has been inducing huge transaction costs for rural laborers to work in urban sectors (Ito, 2008). Recently, the Chinese government has carried out a series of policy instruments to increase rural producer's income and protect them from risks of natural disasters as well as market fluctuation (the State Council of China, 2006; Yang and Li, 2008). The Chinese government believes that besides helping rural producers enjoy higher and more stable income it is also important to keep enough labor in agriculture sector to ensure self-sufficiency. Consequently, policies with direct monetary transfer from tax-payers to rural producers are carried out, e.g. direct subsidy for farming and direct premium subsidy for crop disaster insurance. Nevertheless, it is worth noting that the removing of household registration system which can definitely increase the labor market efficiency is not among the policies carried out.

This research is carried out to verify such kind of “inefficient” inter-sectoral resources allocation and redistribution policies. It will excursively discuss whether the migration of farmers under purely market mechanism to the sectors paying higher and more stable salary should be encouraged or discouraged. The discussion uses the framework of inter-sectoral disaster risk diversification in a simple dual-economy model, following the most classic manner of discussion on inter-regional and inter-sectoral resources and risk allocation in the field of public economics. Beyond that, both labor mobility and goods tradability are taken into account, denoted by transaction costs in moving labors and shipping consumption goods between rural and urban areas, respectively. Besides the most general structure of discussion in this field, the model incorporates several issues to be more specified and focused. Firstly, the assumptions on factor mobility and goods tradability are abstracted from what is going on in China. Secondly, the concept of collective risk (Malinvaud, 1972 and 1973; Cass et al., 1996) is incorporated into this model so that the collectiveness of disaster risk is reflected.

The structure of this paper is arranged as follows: Section 2 introduces key assumptions of this model. In section 3, benchmark equilibrium is derived and comparative statics are employed to describe the basic mechanisms of labor and risk allocation in this model. In section 4, social optimal choice on redistributing wealth and allocating risk is derived as the criteria for evaluating efficiency performance of decentralized equilibira. In section 5, Malinvaud-Arrow (M.A.) insurance is introduced into the model, serving state-contingent *ex post* redistribution of wealth for consumption. Benchmark equilibria, social optima, and M.A. insurance equilibria are then compared in section 6 to answer the questions that the authors want to address. In the final section, the model is concluded and some discussion is put on policy implications as well as further research topics.

2. Model Assumptions

Consider a small closed economy with two regions and two sectors, both rural and urban. The rural sector locates in the rural area, producing the so-called rural goods (not necessarily agriculture product in current model) while the urban sector locates in the urban area and produces urban goods. Rural goods are only used for private consumption while urban goods are used for private consumption as well as capital stock investment. The production processes in both sectors are assumed to be exposed to natural disasters. There is a population of totally N labors in this economy, among which N_1 labors residing in the rural area and N_2 residing in the urban area. Labors are assumed to be homogeneous in terms of endowment and preference. A Labor’s welfare state is determined by his consumption on both kinds of goods. The time sequence follows the seasonal and “circular” migration pattern in China (Hare, 1999; Zhao, 1999a; Zhao, 1999b). Chinese farmers start to move to urban areas right after the Chinese New Year, which is ahead of the planting season. They work in large cities for a whole year and return to hometown when the festival comes again. In this sense, each period can be divided into four phases: 1) decision-making on seasonal move; 2) production; 3) disaster and the determination of the state of the world; 4) trade and consumption.

Decision-making on seasonal move

At the beginning of each period, rural residents consider whether to move to work in the urban area or not. If they decide not to move, they cultivate their land and are then called “rural workers”. If they decide to move, they shall work in the urban sector and then be called “seasonal workers”. Each rural resident is endowed with a piece of land homogeneous of size and fertility. The land of seasonal movers is assumed to remain uncultivated in this model. Before the seasonal move starts we have two groups of individuals: rural residents and urban residents. After that, we have three groups of individuals, rural workers, urban residents and seasonal workers, which are given subscripts of 1, 2 and 3 in the remainder of this paper, respectively.

Production process

In this phase, workers start to produce goods. Rural workers produce the so-called "rural goods" on household basis. Since they do not have any other investment or production alternatives, we assume that each rural worker contributes exactly a unit of labor in production, which is assumed to be an optimum amount. This assumption stands in this model as our focus is rural-urban migration rather than on-farm production decision. If no uncertainty is taken into consideration, rural workers will exactly produce the same amount of output, X. When disaster risk is taken into account, the final production becomes a random variable depending on the state of the crop land, $X(s)$.

In the urban sector, production is finished in an aggregate manner with a function of $Y=(K,L)$, in which K denotes the total social capital stock for production and L denotes the total labor force engaged. The wage rate is determined by the marginal productivity with respect to labor, $w = Y_L(K,L)$. It is assumed that the technology in the urban sector is constant-return-to-scale with respect to labor input, $Y_{LL} = 0$ and w is a constant. This assumption excludes the possibility of externality induced by technology and helps us to catch the essential impact from labor mobility and goods tradability. Here an urban worker's decision-making on his working hours is also skipped by assuming that there is mandatorily designated official working hours, e.g. 8 hours/day. This can be further simplified by unifying working hours to 1. Thus the labor income for an urban worker is exactly w.

As mentioned in the previous part, the move to urban area is costly. Rural residents who move to work in urban sector are supposed to pay a lump-sum cost, denoted by c, for the move. For the sake of simplicity, we allow seasonal workers to pay this cost after wages are paid. So the actual income for a seasonal worker is $w-c$.

Disaster and the state of the world

In this model the production of both sectors is exposed to natural disaster risk, which is framed with the collective risk theory. Firstly, the nature chooses the size, geographical location, and severity of the hazard, determining the collective state of the world $t \in \{0,1,\dots,T-1\}$. As for individual states, in accordance to our assumption on production functions, we assume that rural production activity could fall in different individual states and consequently rural workers may have different harvesting after some disaster events $X(s)$, $s \in \{0,1,\dots,S-1\}$. On the other hand, the entire urban sector falls into some same state as it is assumed to be a "big" company and all urban workers will have uniform *ex post* income $w(t)$. In other words, individual states of urban workers coincide with the collective states of the world.

The probability for a piece of land being in a joint state (s,t) is given by $\pi(s,t) > 0$, with $\sum_{s,t} \pi(s,t) = 1$. So the probability of the production of a specific plot of land with output of $X(s)$ could be derived as the conditional probability of $\pi(s \mid t) = \pi(s,t) \big/ \sum_{s'} \pi(s',t)$. Then exactly there would be $\pi(s \mid t) \cdot N_1$ pieces of land in individual state s when collective state t occurs. When seasonal move is taken into account, the total number of cultivated land reduces by n, the same as the number of seasonal workers. It is worth noting that the risk units here are not workers but plots of land. Therefore the theorem, although not perfectly appropriate, still applies if we assume that the land of seasonal workers is distributed uniformly in the space. In this sense, the number of cultivated but damaged land in the joint state of (s,t) is $\pi(s \mid t) \cdot N_1 \cdot (N_1 - n) / N_1 = \pi(s \mid t) \cdot (N_1 - n)$, while the social aggregate output of rural goods is $\sum_s \pi(s \mid t)(N_1 - n) X(s) = (N_1 - n)\mathrm{EX}(t)$.

Trade and consumption

Consumption of workers starts after the state of the world is known. The welfare state of an individual is measured by the utility of consuming both the rural and urban goods. As rural goods are produced labor by labor, rural workers firstly reserve a certain amount of rural goods x_1 for consumption, and then sell the surplus $X(s) - x_1$ to the market. This type of setting mainly refers to self-sufficiency agriculture. Transaction costs for delivering per unit of rural and urban goods are δ_i, $i = x, y$ respectively. If the relative price of rural goods to urban goods in an arbitrary collective state t is denoted by $p(t)$, the budget constraints for workers are:

$$\begin{aligned} &p(t)\left[X(s) - x_1(s,t)\right] = \left(1+\delta_y\right) y_1(s,t) \\ &\left[p(t)+\delta_x\right] x_2(t) + y_2(t) = w(t) \\ &\left[p(t)+\delta_x\right] x_3(t) + y_3(t) = w(t) - c \end{aligned} \quad , \quad (1.1)$$

for all *s, t*. In the budget constraints, seasonal workers are supposed to pay the shipping costs of the rural goods because seasonal workers stay in the urban area almost all the time in a year except a few days for holiday at their hometown. The social budget constraints follow:

$$\begin{aligned} &\sum\nolimits_{N_1-n}\left[X - x_1(s,t)\right] - N_2 x_2(t) - n x_3(t) \le 0 \\ &\sum\nolimits_{N_1-n} y_1(s,t) + N_2 y_2(t) + n y_3(t), \quad (1.2) \\ &\le Y\left(N_2+n\right) - C \end{aligned}$$

for all *s*, *t*. *C* is the social aggregate consumption on transportation to move seasonal workers and costs for shipping goods between rural and urban areas. Since the model is basically in a static manner, dynamic investment decision is skipped. If we assume the economy is running at its steady state where the return to capital stock is fixed, with the assumption of constant-return-to-scale with respect to labor, social consumable urban goods can actually be denoted by $Y(N_2+n) - C = (N_2+n)w(t) - C$, which is exactly the difference between social aggregate wage paid to urban workers and social aggregate transaction costs.

3. The benchmark case

Ex post equilibrium

After the state of the world is determined, an individual tries to maximize his/her *ex post* utility given his/her state-contingent wealth (or say "money" in terms of the urban good), $\omega_i(\cdot)$. In this benchmark case, it is equivalent to state-contingent labor income, $e_i(\cdot)$. As for the rural worker, the labor income equals the revenue of selling all products in hand. As for the urban worker, the labor income equals the labor wage. We assume that the *ex post* utility function shows the preference of constant-elasticity-of-substitution (CES) between the rural good and the urban good with elasticity of ϵ. It strictly holds that $u_x > 0 > u_{xx}$, $u_y > 0 > u_{yy}$, $u_{xy} > 0$. *Ex post* optimization requires that the marginal rate of substitution should be equal to the relative price. The social excessive demand function can be constructed as:

$$\begin{aligned} Z_x(t) = &\sum x_1^*(s,t) + N_2 x_2^*(t) \\ &+ n x_3^*(t) - \left(N_1-n\right)\mathrm{EX}(t) \end{aligned} , \quad (1.3)$$

for all *s*, *t*. According to Walras' Law, the necessary condition for an efficient *ex post* goods market is $p(t)Z(t) = 0$, for all *t*. Since we assume both rural and urban good are not free goods, it must hold that $p(t) > 0$ and $Z(t) = 0$. Therefore:

$$p(t) + \delta_x = \frac{\epsilon B(t)}{\left(N_1-n\right)\mathrm{EX}(t)}, \text{ for all } t, \quad (1.4)$$

with $B(t) = N_2 w(t) + n[w(t) - c]$ denoting social aggregate urban goods available for consumption. Note there that transaction costs for shipping goods are not excluded from $B(t)$. Equation (1.4) means that the subject effective relative price for the urban workers equals to the elasticity of substitution times the ratio of the social aggregate production for consumption (*ex post* consumption on shipping goods in included) to social aggregate urban goods available. In this sense, individuals' optimum choices are derived:

$$\begin{aligned} &x_1^*(s) = \frac{\epsilon X(s)}{1+\epsilon}, y_1^*(s,t) = \frac{\left[\epsilon B(t) - \delta_x\left(N_1-n\right)\mathrm{EX}(t)\right] X(s)}{(1+\epsilon)\left(1+\delta_y\right)\left(N_1-n\right)\mathrm{EX}(t)} \\ &x_2^*(t) = \frac{w(t)}{1+\epsilon}\frac{\left(N_1-n\right)\mathrm{EX}(t)}{B(t)}, y_2^*(t) = \frac{w(t)}{1+\epsilon} \\ &x_3^*(t) = \frac{w(t)-c}{1+\epsilon}\frac{\left(N_1-n\right)\mathrm{EX}(t)}{B(t)}, y_3^*(t) = \frac{w(t)-c}{1+\epsilon} \end{aligned} , (1.5)$$

for all *s*, *t*. It can be observed that only the consumption of rural workers is affected by goods tradability, given the fact that we are using urban goods as numeraire in this model. Due to the feature of CES utility function, *ex post* indirect utility is a linear function with state-contingent wealth. Coefficients are:

$$\begin{aligned} &A_1(t) = \left(1+\delta_y\right)^{-\frac{1}{\epsilon+1}} \left(p(t)\right)^{-\frac{\epsilon}{\epsilon+1}} \\ &A_{2,3}(t) = \left(p(t)+\delta_x\right)^{-\frac{\epsilon}{\epsilon+1}} \end{aligned} , \quad (1.6)$$

for all *s*, *t*. Social aggregate economic value of goods can be denoted as

$$\Omega(t)=(1+\epsilon)B(t)-\delta_x\left(N_1-n\right)\mathrm{EX}(t) \quad (1.7)$$

Ex ante equilibrium and comparative statics

We further assume that individuals' *ex ante* utility is a function $W(v_i(\cdot))$ showing Constant Relative Risk Aversion (CRRA) preference:

$$W\left(v_i(\cdot)\right)=\begin{cases}\dfrac{v_i(\cdot)^{1-\theta}-1}{1-\theta}, & \theta\neq 1\\ \ln v_i(\cdot) & \theta=1\end{cases}$$

Expected *ex ante* utility then takes the form of $\mathrm{E}W_i=\sum_{s,t}\pi(\cdot)W\left(v_i(\cdot)\right)$ .Comparative statics show that $d\mathrm{E}W_1/dn>0$ while $d\mathrm{E}W_2/dn$, $d\mathrm{E}W_3/dn<0$. When there are more seasonal workers, namely less rural workers, the total productivity of the rural sector decreases due to the outflow of labor forces. The relative price of the rural good consequently increases and rural workers' state-contingent wealth gets larger, given the fact that they are producing exactly the same amount of the rural good. We then see an increase in the expected utility of rural workers. In contrast, although we assume the technology is constant-return-to-scale with respect to labor for the urban sector and they shall get exactly the same salary, state-contingent wealth of urban workers will drop since the same amount of money in hand can purchase fewer rural goods as the price goes up.

According to our assumption, a rural resident makes decision on whether he should conduct the seasonal move or not *ex ante*. Given the uncertain nature of the world, the decision is made by comparing the expected *ex ante* utility of working in rural sector and urban sector. A rural resident would be willing to conduct the seasonal move iff $\mathrm{E}W_1<\mathrm{E}W_3$ and the marginal seasonal worker would find himself indifferent of working in either sector, which implies the *ex ante* equilibrium must hold:

$$\mathrm{E}W_1=\mathrm{E}W_3 \quad (1.8)$$

Comparative statics of the *ex ante* equilibrium with respect to factor mobility:

$$\frac{d\mathrm{E}W_1}{dc},\frac{d\mathrm{E}W_3}{dc}<0,\frac{d\mathrm{E}W_2}{dc}>0,$$

which implies that when transaction costs increase, expected utility of rural workers and seasonal workers decreases while urban residents get benefit. Less seasonal workers explicitly means rural workers' welfare decreases. As for seasonal workers, they benefit from lower relative price but suffer from higher transaction costs. Unfortunately, effect of the later one is dominant so they finally get worse off.

On the other hand, if we assume the costs for shipping the rural and the urban good are the same, $\delta_x=\delta_y=\delta$, comparative statics are

$$\frac{dn^*}{d\delta}>0,\frac{d\mathrm{E}W_1}{d\delta},\frac{d\mathrm{E}W_2}{d\delta},\frac{d\mathrm{E}W_3}{d\delta}<0,$$

which implies that the transaction costs for shipping goods are definite social loss in terms of expected ex ante utility.

4. Social optimum

Consider the optimal risk allocation and population distribution problem in the society. The wise central planner is supposed to maximize the weighted sum of expected utility. The optimum is achieved through determining *ex post* redistribution of wealth for consumption and *ex ante* number of seasonal workers (allocating of resources and labor). In the previous section it has been proved that *ex post* indirect utility only depends on state-contingent wealth for consumption. Therefore, *ex post* redistribution of both rural goods and urban goods can be simplified to determining economic values of goods allocated to individuals, namely $\omega_i(\cdot)$:

$$\max_{n,\omega_1(s,t),\omega_2(t),\omega_3(t)}U=\gamma_1\sum\nolimits_{N_1-n}\mathrm{E}W_1+N_2\gamma_2\mathrm{E}W_2+n\gamma_3\mathrm{E}W_3$$

Subjected to

$$\begin{aligned}\alpha(s,t)&:\sum\nolimits_s\pi(s\mid t)\left(N_1-n\right)\omega_1(s,t)=\Omega_1(t)\\ \alpha(t)&:\Omega_1(t)+N_2\omega_2(t)+n\omega_3(t)=\Omega(t)\\ \mu&:\mathrm{E}W_1=\mathrm{E}W_3\\ &:n,\omega_1(s,t),\omega_{2,3}(t)\geq 0\end{aligned} \quad ,(1.9)$$

for all *s*, *t*. Throughout this thesis, the Greek letter ahead of each constraint is its corresponding Lagrangian Multiplier. By assuming interior solutions, the first-order conditions with respect to state-contingent wealth can be derived as:

$$\gamma_2 \frac{dW_2(\cdot)}{d\omega_2(t)} = \frac{\gamma_1(N_1-n)+\mu}{N_1-n}\cdot\frac{dW_1(\cdot)}{d\omega_1(t)} = \frac{\gamma_3 n-\mu}{n}\cdot\frac{dW_3(\cdot)}{d\omega_3(t)} = \frac{\alpha(t)}{\pi(t)}, \quad (1.10)$$

for all *t*. Equation (1.10) implies that the allocation of wealth among individuals should equalize the weighted marginal *ex ante* utility across all individual types in a given collective state *t*.

The first-order condition with respect to the number of seasonal workers is:

$$\begin{aligned}
&\gamma_3 \mathrm{E}W_3 - \gamma_1 \mathrm{E}W_1 \\
&+(N_1-n)\gamma_1\frac{d\mathrm{E}W_1}{dn} + n\gamma_3\frac{d\mathrm{E}W_3}{dn} + N_2\gamma_2\frac{d\mathrm{E}W_2}{dn} \\
&+\sum\nolimits_t \alpha(t)\left[\omega_1(s,t)-\omega_3(t)+\frac{d\Omega(t)}{dn}\right] \\
&-\mu\left(\frac{d\mathrm{E}W_1}{dn}-\frac{d\mathrm{E}W_3}{dn}\right)=0
\end{aligned} \quad (1.11)$$

which implies that the allocation of labor (the number of seasonal workers) must equalize social marginal benefit and social marginal cost of moving one more rural resident to work in the urban sector.

Solving for the equilibrium, it is found that the optimal redistribution will let each group of individuals consume the amount of goods worth a fixed proportion of the social aggregate economic value of goods, $\rho_1, \rho_2, \rho_3 < 1$:

$$\begin{aligned}
&\rho_2 = \gamma_2/\phi \\
&\rho_1 = \frac{\mathrm{e}^{A_3}}{\left[(N_1-n)\mathrm{e}^{A_3}+n\mathrm{e}^{A_1}\right]}\left(1-N_2\rho_2\right), \\
&\rho_3 = \frac{\mathrm{e}^{A_1}}{\left[(N_1-n)\mathrm{e}^{A_3}+n\mathrm{e}^{A_1}\right]}\left(1-N_2\rho_2\right)
\end{aligned} \quad (1.12)$$

for all *t*, with $\phi = \gamma_1(N_1-n)+\gamma_2 N_2+\gamma_3 n$, and e^z is the Natural logarithm, $A_i = \sum_t \pi(t)\ln A_i(t)$.

5. Risk allocation via the insurance market

In this section, Malinvaud-Arrow (M.A.) insurance system is employed to insure the disaster risk. When there is M.A. insurance system in the world of this model, the sequence of events change to: a) decision-making on migration; b) underwriting of M.A. insurance policy; c) production; d) determination of the state of the world; e) exercise of insurance contract, trade, and consume. For the convenience of discussion, individuals are allowed to pay premium of M.A. insurance *ex post*. Individuals' optimization problem is:

$$\max_{m(s,t),a_i(t)} \mathrm{E}W_i = \sum \pi(\cdot)W_i\left(v_i\left(\omega_i(\cdot)\right)\right),$$

for *i*=1,2,3, subject to:

$$\begin{aligned}
&\omega_1(s,t) = e_1(s,t)+\left[m(s,t)-\sum\nolimits_{s'}\pi\left(s'\mid t\right)m\left(s',t\right)\right] \\
&\qquad +\left[a_i(t)-\sum\nolimits_{t'}r\left(t'\right)a_i\left(t'\right)\right] \\
&\omega_{2,3}(t) = e_{2,3}(t)+\left[a_{2,3}(t)-\sum\nolimits_{t'}r\left(t'\right)a_{2,3}\left(t'\right)\right] \\
&e_1(s,t)=p(t)X(s), e_2(t)=w(t), e_3(t)=w(t)-c
\end{aligned} \quad ,(1.13)$$

for all *s, t*. The second item on the *r.h.s.* (right hand side) of the budget constraint for the rural worker denotes the mutual insurance contract. $m(s,t)$ is the mutual insurance coverage against a joint state of (s,t). Urban workers do not use the mutual insurance system as they have no difference in their individual states, or in other words all urban workers have only one and the same individual state. The last items on the *r.h.s.* denote the transaction of Arrow security with $a_i(t)$ denoting the amount of Arrow security held by individual of type *i* and $r(t)$ denoting the market-clearing price of per unit of Arrow security against a collective state *t*.

The first-order conditions for budget constraints are:

$$\pi(t)\frac{dW_i(\cdot)}{d\omega_i(t)} = \lambda_i(t), \lambda_i = \sum\nolimits_t \lambda_i(t), r(t) = \frac{\lambda_i(t)}{\lambda_i}, \quad (1.14)$$

for all *t*. Again we assume $\theta = 1$ and get following result:

$$r(t) = \frac{\pi(t)}{\Omega(t)}\Big/\sum\nolimits_{t'}\frac{\pi\left(t'\right)}{\Omega\left(t'\right)}, \text{ for all } t \quad (1.15)$$

$$\lambda_i = \frac{\sum_t \pi(t)/\Omega(t)}{\sum_t \pi(t)e_i(t)/\Omega(t)}, \quad (1.16)$$

$$\omega_i(t) = \frac{\pi(t)}{\lambda_i r(t)} = \Omega(t)\sum\nolimits_{t'}\pi\left(t'\right)\frac{e_i\left(t'\right)}{\Omega\left(t'\right)}, \text{ for all } t \quad (1.17)$$

The *r.h.s.* of (1.17) is a constant times the state-contingent social aggregate economic value of goods. It is an interesting feature of the M.A. insurance to let each type of individuals to consume exactly the amount of goods worth a fixed proportion of social aggregate economic value irrespective of the state the world. A special case is that if the state-contingent income in terms of urban goods is proportional on social aggregate wealth in terms of urban goods across all collective states, $e_i(t) = k\Omega(t)$, we shall have:

$$\omega_i(t) = \Omega(t)\sum_{t'}\pi\left(t'\right)k = k\Omega(t) = e_i(t)$$

It means that individuals whose state-contingent income is proportionate to social aggregate wealth will not use the Arrow security market. In our model when goods tradability is assumed to be perfect, rural workers will commit so. This comes from the assumption of CES utility which consequently preserves the value of rural goods in the society. So after fulfilling mutual insurance contract, individual wealth of rural workers is not contingent on collective states any more. Naturally, there is no need for them to insure.

6. Efficiency issues

Given the equilibria determined in (1.11) (social optimum), economic efficiency is compared across cases. In order to make the social optimum and market solution comparable, we apply the necessary condition for equivalency of social optimum and market solution:

$$\gamma_i \lambda_i = 1 \tag{1.18}$$

which has been proved by Yokomatsu and Kobayashi (2000). As equations are not tractable analytically, numerical examples are employed to show the impact intuitively. Specifications for numerical examples are listed below:

$t \in \{0,1\}$, $\pi(t=0) = 0.5$, $\pi(t=1) = 0.5$;
$s \in \{0,1\}$, $\pi(0 \mid 0) = 1$, $\pi(1 \mid 0) = 0$, $\pi(0 \mid 1) = 1/3$, $\pi(1 \mid 1) = 2/3$;
$N_1 = 30000$, $N_2 = 10000$;
$X(0) = 20$, $X(1) = 5$, $w(0) = 30$, $w(1) = 20$;
$\epsilon = 1$; and use $\delta_x = \delta_y = \delta$ and c as parameters.

Numerical results are shown in Fig. 1 and Fig. 2.

Several pieces of important information can be summarized from the result of numerical examples:

When goods tradability is perfect, labor mobility actually has no impact on the efficiency of insurance market solutions. Equilibria achieved by M.A. insurance market are equivalent to social optima. This is because the CES *ex post* utility function preserves the value of rural good and consequently collective risk only exists in the urban sector. Meanwhile, social optimal number of seasonal workers is no larger than that in the benchmark case. In this sense, the number of seasonal workers should be controlled.

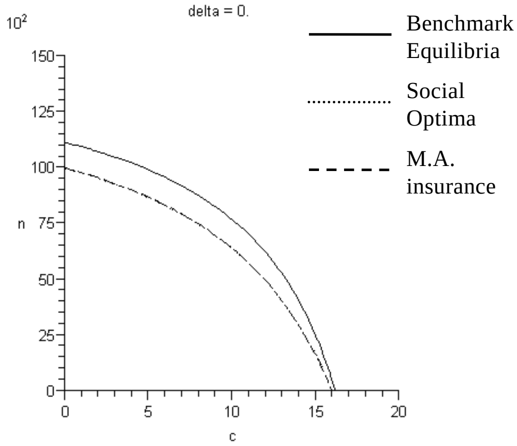

Figure 1. Number of seasonal workers at equilibria

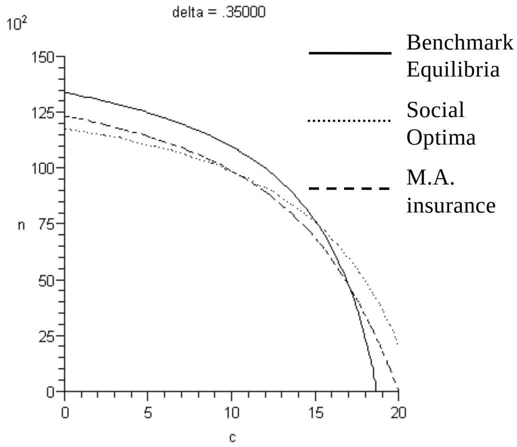

Figure 2. Number of seasonal workers at equilibria

When goods tradability is not perfect with positive transaction costs, seasonal moves could be discouraged or encouraged. When the costs for working in the urban sector is low, seasonal moves should be controlled, the same as the previous case. In case the transaction costs for seasonal move is high, however, social optimum requires more workers allocated to the urban sector than the benchmark case. Meanwhile, the social optima and M.A. insurance equilibria diverge. We see $n_m > n_s$ when c is relatively small. This is because actually only the rural workers are paying the transaction costs for shipping goods, as mentioned before. n_m, however, drops faster than n_s. If the transaction costs for moving to the urban area is high enough to let the negative impact on seasonal workers larger than the impact of goods tradability on rural workers, we have $n_m < n_s$ and social optimum encourages more rural residents to work in the urban sector and.

This divergence between social optima and M.A. insurance equilibria implies that externality is induced due to the existence of imperfect goods tradability, the transaction costs in transporting goods between rural and urban areas in this model. Therefore, government intervention is necessary to modify the M.A. insurance equilibrium.

7. Conclusion and Discussion

This paper constructs a model to discuss the disaster risk diversification and labor allocation problem between rural and urban sectors. It takes a focus on the migration behavior (the seasonal move in this model) as a sort of risk management practice of rural labors. Following the most classical way of discussion on resources and risk allocation among multi-jurisdictions, this paper incorporates the concept of collective risk as well as M.A. insurance to show the unique feature of disaster risk. Labor mobility and goods tradability are introduced in this model as susceptible issues that might influence the efficiency of resources and risk allocation.

According to the result of the model, it is inappropriate to argue whether the government should encourage or discourage rural residents to move to work in urban sectors universally. It can be seen in the model that when goods are assumed to be free to trade, the number of seasonal workers should always be controlled, either with centralized or decentralized instruments. When the transaction costs for shipping goods are taken into account, however, rural residents should be discouraged to work in the urban sector to some extent in case that the transaction costs for moving is low, or vice versa.

When goods are perfectly tradable (the transportation cost for moving goods between rural and urban areas in this model is 0), the M.A. insurance market allocates exactly the social optimum number of seasonal workers. Moreover, in this case rural workers use only the mutual insurance system but not the Arrow security market, because when we assume CES utility function, the value of rural good is preserved and shows no cross-collective-state variability as urban good are the numeraire good, the "money" in this model.

When goods tradability is not perfect, however, we see externality rises and the M.A. insurance system cannot achieve efficient allocation of labor between sectors. The reason can be found in the *ex post* optimal consumption bundle of rural workers. Goods tradability actually only has impact on rural workers' consumption quantity of urban good, which definitely make rural workers worse off given all other factors remaining the same. In this sense, more rural workers are willing to move to work in the urban than the social optimum one, when the transaction cost for the seasonal move is not large. The situation changes when the transaction cost for the seasonal move goes so high that its negative impact on seasonal worker exceeds the negative impact of goods tradability on rural workers. Then social optimum would encourage more rural residents to conduct the seasonal move than the M.A. insurance equilibrium.

The authors believe that what is happening in most less developed countries follows the benchmark case with some government redistributive policies. So the number of seasonal workers is likely to lie between the one in the benchmark equilibrium and social optimum one. Specific policies, of course, should be designed according to specific economic environment as this model only provides a very general view on this issue.

There are still several important issues that are well framed and explained in this model. We have proved that externalities are induced by goods tradability but due to the page limitation of this paper, optimal government intervention issues have not been discussed yet. The CES utility function cannot reflect some important features of agriculture goods, especially subsistence products. A group of utility functions associated to inelastic demand system with respect to agriculture products will help us to track the essential issues of disaster risk management for agriculture production better. Secondly, rural workers' decision-making on optimal output level could also be an expanding point of the current model.

Acknowledgements

This paper is financially supported by National Natural Science Foundation of China Key Project (NSFC No. 40535024) and DRH (Disaster Reduction Hyper-base) – CASiFiCA (Case Station -- Field Campus) funded by Special Coordination Fund for Promoting Science and Technology, Ministry of Education, Culture, Sports, Science and Technology of Japan. The authors are grateful to researchers involved in the discussion of this paper.

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部門間災害リスク配分：部門間の財政移転は適切なインセンティブを提供するのか？

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要　旨

農業部門は災害に対して脆弱であると認識されており，多くの国では政府が財政的手段によって税を原資に農業生産者を補助している。そのような政策は農家も対して，より高くてかつ安定した収入を保証するだけでなく，彼らに農業を継続させる誘因も提供する。一方でそれらの政策は，資源とリスク配分への市場メカニズムを歪ませ，非効率性を誘発する可能性がある。本研究では，労働人口と商品の地域間流通を考慮した二重経済モデルを定式化し，農民の農村流

出を防ぐための農業保護政策の効率性について検討する。分析の結果，災害保険市場が存在しない場合，政府の財政移転は効率性を向上させることが明らかになった。また，災害保険市場が存在する場合には，商品の地域間輸送に取引費用がかからないときには，市場は社会的な最適配分を成し遂げることができる。一方，商品の地域間輸送に費用がかかるときには政府の介入が効率性を向上させることが判明した。このとき，輸送費用が低い時には政策は地域間移動を抑制し，高い時には移動を促す方向の介入が望ましくなることが明らかになった。

キーワード: 部門間災害リスク配分，労働移動性，輸送費用