[*Jpn. J. Rural Econ.* Vol. 4, pp. 11-31, 2002]

The Double-Tier Management System in Rural China: Assignment of Decision Making, Jobs, and Ownership between Individuals and the Collective

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At present, the double-tier management system is promoted by the government in rural China to overcome agricultural stagnation. This system is a rural organization that has multifaceted characteristics of people's communes and the private farm household system. It is defined as the management assigned between individuals and the collective. We answer the following questions in this article. First we seek to clarify what the organizational rationality of this system is with respect to its coordination and motivation. Second we will clear up how jobs and ownership are assigned between individuals and the collective to motivate individuals according to this organizational rationality and the natural and economical features of each province. Organizational rationality is explained as follows. (1) Coordination: Decision making should be assigned to the individuals to use their personal information to maintain stimulating individual incentives. On the other hand, the collective is committed to use common information to effectively carry out coordination. The double-tier management system is an elaborative organization designed to use personal information to stimulate individual incentives and to simultaneously use common information to employ coordination under the collective. (2) Motivaton: The assignment of jobs and ownership are designed to motivate individuals according to risk-aversion or instability, input-effectiveness of technology, incentive for maintenance, and cultivation. Even though production is stimulated under the household responsibility system, contracted small lands do not afford households the ability to bear risk. Small contracted land brings about technological retrogression that reduces incentives to own and maintain machines. The double-tier management system is a system in which the collective absorbs the risk of jobs and maintains the machines, thus reliering the individuals. The designs of the double-tier management system are explained as follows. First we show the importance of the system's coordination by introducing two case studies. The order of land preparation by the village machine station creates strong conflicts that need to be closely coordinated. These conflicts are especially intensified by the heterogeneity of farm householuds and coordinated by members of the villager's community. Second, we apply econometric analyses to the assignment of jobs and to ownership by using data from the Yearbook of China's Agriculture. We conclude that the assignment of jobs and ownership is designed according to the organizational rationalities, that is, risk-aversion, input-effectiveness, and maintenance-incentive. Farthermore, we find that the assignment is also determined by the natural and economic features of each province such as income taxation, differences of agricultural and nonagricultural provinces, differences of crops, degree of privatization, and collective leadership.

Key words: double-tier management system, China, motivation, coordination, incentive, risk sharing, ownership, maintenance.

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1. What is the Double-Tier Management System?

1) Establishment of the double-tier management system

Rural reform in China was started with the introduction of the household responsibility system in 1979. This system brought about a drastic improvement in agricultural productivity by enhancing incentives to individual farm households. In the system's beginning, productivity appeared to increase continuously. However, the upward trend came to a halt in 1985, mainly because the small-scale farming induced the adoption of a more labor-intensive farming system that caused technological retrogression, or detractorization. This situation is referred to as "agricultural stagnation."

It seemed as if private family-farms would resuscitate under the household responsibility system, but this did not happen in China. Originally, the household responsibility system there comprised two phases, individual and collective. Emphasis on the individual phase was placed before 1985, but the people and the government began to think of the advantages of the collective phase again under the agricultural stagnation. The collective phase had been carried out by people's communes before the reforms started. The communes, however, were later decollectivized, allowing the household responsibility system to diffuse because the people's commune system lacked the efficiency and incentives to motivate individuals. Nevertheless, the communes had the strength of collective power, and with their decollectivization under rural reform, their collective power began to deteriorate.

The Chinese government considered that agricultural stagnation was caused by this lack of collective power, or the weakening of socialism. To overcome the stagnation, the collective phase of the responsibility system was reestablished to complement the individual phase. A rural system that would revive the collective power and ensure individual incentives was required.

The "double-tier management system" (*shaungceng jingying tizhi*) is considered to be an answer to this problem (Fig. 1). "Individuals," or farm households, are defined as "division," and the lands of individuals in the division are contracted to be managed by the collective. Individuals can improve the productivity by providing incentives. The "collective," or the village that was established instead of a production battalion, is defined as "unification," which owns land and helps individuals to manage this land through the collective leadership. Farm management is considered to be completed by the double-tier management, which combines individual management and collective management. The name "double-tier management system" emerged first from official documents in 1986, and currently this system is promoted by the Chinese government as a basic rural system.[1)]

More specifically, under the double-tier management system, individuals manage contracted land by themselves, and the collective designated as cooperative economy organization based on the village provides essential farming services to individuals. These services include machine services for cultivation and harvesting, services related to irrigation, control of insects and pests, joint purchase of fertilizer and seeds, joint marketing of products, and technological advisory services. In fact, individuals receive some parts of these services as supply from "the socialized services system" (*shehuihua fuwu tixi*).[2)] They can be obtained more efficiently by a realization of the economies of scale and scope at the collective level rather than at the individual level. To receive these services from the collective, individuals must pay not only a fee for them, but also a payment to the collective as a social obligation. This consists of a public accumulation fund, public support fund, and free labor service to the community.

2) Nature of the double-tier management system

We must answer how the rural setup under the double-tier management system can be characterized from an economic perspective. This rural setup is a rural organization in which individuals and the collective are organized under one system. Farm households do not act independently as in the perfectly competitive market, but as members of the organization. This rural setup can be considered the double-tier management system organization. Thus we are confronted with the following matters of concern.

We first consider why this organization is

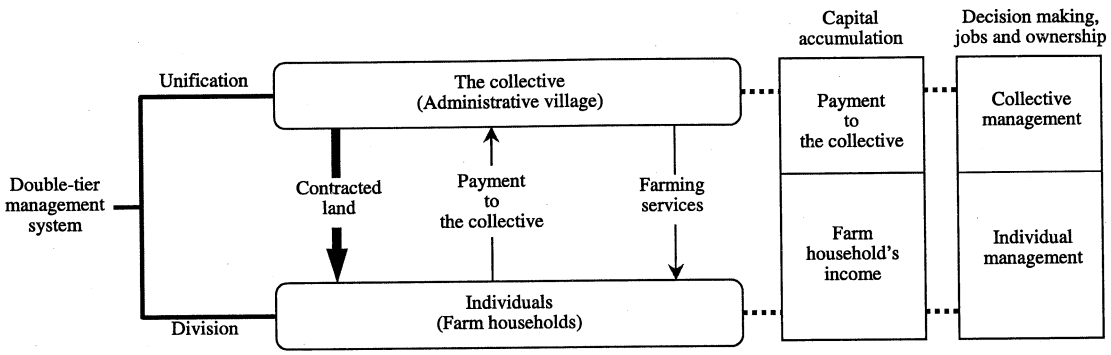

Figure 1. Double-tier management system

formed. Efficient farming services can be obtained by exploiting the economies of scale and scope at the collective level. But these economies could also be realized at an individual level without the help of the organization. Individual service suppliers such as private machine contractors can provide these same services to the farm households. These economies are not concerned with the formation of the organization. Instead, a stronger organizational rationality must exist that had led to the formation of the double-tier management system organization. We must seek the first question, that is, what the organizational rationality of this system is.

Second we express the double-tier management system organization from the standpoint of analysis. The double-tier management system simply means that farm management is carried out both by the individuals and the collective. Some farming activities are carried out by individuals, and the other are conducted by the collective. Namely, the double-tier management system is defined as an organization that assigns farm management activities between individuals and the collective. We wonder how these activities are assigned. We assume that this assignment is designed according to the organizational rationality mentioned. This will lead us to the next question, that is, how this assignment is designed.

Third we consider what kinds of attribute the double-tier management system organization has. This system is not a simple organization in which members are grouped equally. It has two phases, as follows. (1) Divisional phase. At this level, individuals are acting as one division of the collective without owning land privately. They are provided land under the contractual basis to manage under the double-tier management system. Individuals are not allowed to decide perfect land management because the ownership of land still belongs to the collective. The collective makes decisions of land management from the standpoint of the communist party. This surely represents that the individual is acting as one division of the collective decision-making body. As for one section of the collective such as the machine station, it is operating as a division of the collective. (2) Independent phase. At the independent phase, individuals are also acting as independent family farms. Even though they only contracted the land from the collective, they can make many independent decisions. This is an incentive for a farm household to be more productive.

3) Objectives and method

We know now that (1) the double-tier management system is an organization in which management is assigned between the individuals and the collective, and (2) that this organization has both a divisional phase and an independent phase. The objective of this paper is to address two questions: what is the organizational rationality of the system and how is the assignment of the system designed?

The organization of the system can be analyzed by new institutional economics that have been well developed during the past 25 years.[3] Traditional neoclassical economics neglects the organization. The market is assumed to be able to solve all problems, and organization is not an essential part of the neoclassical framework. But organizations do exist in reality. Since new institutional economics has been well developed to analyze organization directly, we will adopt new

institutional economics to analyze the double-tier management system organization.

Especially, a new institutional economic approach to firm organization is suitable to analyze the double-tier management system because firm organization and the double-tier management system have many common characteristics. Firm organization consists of two phases, horizontal and vertical structures. The horizontal structure represents a relationship between divisions in a multidivisional corporation. The vertical structure represents the relationship between employee and employer in a hierarchical corporation. As mentioned above, the double-tier management system has divisional and independent phases. The relationship that exists among divisions in a corporation resembles the divisional phase of the double-tier management system. On the other hand, the relationship between the employee and the employer stands for the relationship between the corporation and the independent employee. This has common characteristics with the independent phase of the double-tier management system. Thus the new institutional economic approach to firm organization is considered to be the most suitable method of analysis.

The task in the horizontal structure is considered as "coordination," and the task in the vertical structure is considered as "motivation."[4] Coordination is therefore the main task of the divisional phase of the double-tier management system. Coordinating divisions are analyzed by the Crémer model. First the organizational rationality of the divisional phase will be analyzed by use of the Crémer model. On the other hand, motivation is the main task of the independent phase of the double-tier management system. Motivation of the employee is analyzed by the Milgrom model. Second, accordingly, the organizational rationality of the independent phase will be analyzed by use of the Milgrom model. We will clarify the organizational rationality of the system based on both models.

After analyzing the organizational rationality, we will answer empirically how the assignment is designed. The assignment of the system is designed naturally according to organizational rationality. However, the objective of our empirical study is the whole land of China, a huge country where natural and economical features strikingly differ from province to province. We must notice that types of crops and machinery appear manifoldly in agriculture, and the degree of industrialization is different in every province. These differences influence strongly the design of the system. Besides organizational rationality, the effect of these natural and economic features of provinces on the design will be studied. We will first show how the coordination is embodied in the case studies. Second we will study econometrically how the double-tier management system is designed according not only to the organizational rationality, but also to the natural and economic differences in rural China.

2. Assignment Model under the Double-Tier Management System

1) Coordination and assignment of decision making

We will first study the organizational rationality of the divisional phase in the double-tier management system. The main task of the divisional phase is the coordination. "Decision Making" should be coordinated in the case of a multidivisional corporation. Although it is the main duty in each division, coordinating it is also important. Analogically, decision making in the divisional phase should be analyzed from the viewpoint of coordination. Decision making in the double-tier management system can be expressed as the assignment of decision making between individuals and the collective. We will then construct the assignment model of decision making by applying the Crémer model of firm organization.[5] Using this model, we will analyze the assignments from the viewpoints of "coordination" and "information."

To simplify, we consider the relationship between the producer and the farming service supplier and compare three cases, that is, the private farm household system, the people's commune system, and the double-tier management system. Under the people's commune system, the producer and the supplier are both incorporated within one commune. Decision making is assigned only to the commune. Under the private farm household system, the producer represents the private farm household and the supplier represents the private contractor. Decision making is assigned to the private farm household and to the private

contractor. Under the double-tier management system, the producer represents the "division" or individual farm household. The supplier represents the individual operator of machine station under the umbrella of collective "unification." A portion of the decision making is independently assigned to individual farm households and to individual operators. An other portion, however, is assigned to collective "unification."

Comparing three types of assignments, we will clarify the organizational rationality of double-tier management. Suppose that the business activity level of a farmer is X_1 and the level of a service supplier is X_2. According to the Crémer model, rural payoff π can be realized by the activity levels of X_1 and X_2 in the following quadratic function.[6]

$$\pi=A(X_1+X_2)-\frac{1}{2}B(X_1+X_2)^2 -\frac{1}{2}C(X_1-X_2)^2 \qquad (1\text{-}1)$$

Where A is uncertainty about decision making of the business activity level, B is the influence of competitiveness of the farmer and supplier, and C is the effect of coordination between both. The first term of equation (1-1) represents each "single conduct" without the other part, and the second and third terms represent "bilateral conducts" between producer and supplier. The business activity level depends on given information η. The activity can be decided by the linear function $X=\lambda\cdot\eta$, where λ is defined as a multiplier. Information η consists of (1) common information α that the communist party provides to each producer and supplier based on its total observation of the village, and (2) personal information β that is observed directly by producers and suppliers. The business activity level is also influenced by error of observation ε in addition to α and β. α, β, and ε are random variables. These are assumed to be distributed normally with zero mean and variance σ_β, σ_α, and σ_ε respectively. Thus three types of assignment of decision making are possible:

(1) The first type is where the producer and the supplier make decisions depending on personal information β. It is assumed that the producer observes β_1 and the supplier observes β_2. This personal information is accompanied with error of observation ε_1 and ε_2, respectively. Therefore we get rural payoff π and its expected value as follows.

$$\pi=\beta_1\cdot\lambda(\beta_1+\varepsilon_1)+\beta_2\cdot\lambda(\beta_2+\varepsilon_2)-\frac{1}{2}B(\lambda(\beta_1+\varepsilon_1) +\lambda(\beta_2+\varepsilon_2))^2-\frac{1}{2}C(\lambda(\beta_1+\varepsilon_1)-\lambda(\beta_2+\varepsilon_2))^2 \qquad (1\text{-}2)$$

$$E(\pi)=2\sigma_\beta{}^2\lambda-\frac{1}{2}(B+C)(2\sigma_\beta{}^2+2\sigma_\varepsilon{}^2)\lambda^2 \qquad (1\text{-}3)$$

λ^*, which maximizes $E(\pi)$, and E^*, which is maximized by λ^*, are derived as follows, according to Aoki and Okuno [1],[7] by setting the derivative $E(\pi)$ equal to 0:

$$\lambda^*=\frac{1}{B+C}\frac{\sigma_\beta{}^2}{\sigma_\beta{}^2+\sigma_\varepsilon{}^2} \qquad (1\text{-}4)$$

$$E^*=\frac{1}{B+C}\frac{\sigma_\beta{}^4}{\sigma_\beta{}^2+\sigma_\varepsilon{}^2} \qquad (1\text{-}5)$$

These equations are derived on the basis that the producer and the supplier both make decisions independently based on personal information not only in "single conduct," but also in "bilateral conduct." That is the "private farm household system," where the producer is understood as a private farm household and the supplier as a private contractor.

(2) The second type is where the producer and the service supplier make decisions depending on common information α, which the communist party provides. This common information is given with an accompanying error of observation ε. In this case, payoff π and its expected value $E(\pi)$ can be reached as follows.

$$\pi=\alpha\cdot\lambda(\alpha+\varepsilon)+\alpha\cdot\lambda(\alpha+\varepsilon)-\frac{1}{2}B(\lambda(\alpha+\varepsilon) +\lambda(\alpha+\varepsilon))^2-\frac{1}{2}C(\lambda(\alpha+\varepsilon)-\lambda(\alpha+\varepsilon))^2 \qquad (1\text{-}6)$$

$$E(\pi)=2\sigma_\alpha{}^2\lambda-2B(2\sigma_\alpha{}^2+2\sigma_\varepsilon{}^2)\lambda^2 \qquad (1\text{-}7)$$

λ^* maximizes $E(\pi)$ and E^* is maximized by λ^*, in this case as follows, according to Aoki and Okuno [1].

$$\lambda^*=\frac{1}{B+B}\frac{\sigma_\alpha{}^2}{\sigma_\alpha{}^2+\sigma_\varepsilon{}^2} \qquad (1\text{-}8)$$

$$E^*=\frac{1}{B+B}\frac{\sigma_\alpha{}^4}{\sigma_\alpha{}^2+\sigma_\varepsilon{}^2} \qquad (1\text{-}9)$$

These equations are reached on the basis that both the producer and the supplier make decisions depending on common information in both "single" and "bilateral" conduct. This means that every agent makes decisions uniformly according to the communist party's indication. This type represents "people's commune system" with both the producer and the supplier incorporated.

(3) The third type is where both the producer and the supplier make a decision depending on personal information β in "single conduct." But both make the decision according to the communist party's common information α in "bilateral conducts." That is, personal information β is given in the first term of equation (1-1), and common information α is given in the second and third terms of (1-1). π, $E(\pi)$, λ^*, $E(\pi)$, and E^* of this type can be reached as follows.

$$\pi=\beta_1\cdot\lambda(\beta_1+\varepsilon_1)+\beta_2\cdot\lambda(\beta_2+\varepsilon_2)-\frac{1}{2}B(\lambda(\alpha+\varepsilon)+\lambda(\alpha+\varepsilon))^2-\frac{1}{2}C(\lambda(\alpha+\varepsilon)-\lambda(\alpha+\varepsilon))^2 \quad (1\text{-}10)$$

$$E(\pi)=2\sigma_\beta{}^2\lambda-2B(2\sigma_\alpha{}^2+2\sigma_\varepsilon{}^2)\lambda^2 \quad (1\text{-}11)$$

$$\lambda^*=\frac{1}{B+B}\frac{\sigma_\beta{}^2}{\sigma_\alpha{}^2+\sigma_\varepsilon{}^2} \quad (1\text{-}12)$$

$$E^*=\frac{1}{B+B}\frac{\sigma_\beta{}^4}{\sigma_\alpha{}^2+\sigma_\varepsilon{}^2} \quad (1\text{-}13)$$

Here the producer and the supplier make decisions with their personal information independently in "single conduct." But when they face bilateral conducts, which influence each other, they must make decisions according to the indication of the communist party. Decision making is originally assigned to the producer and the supplier independently. But these decisions are also complemented collectively by the coordination of the communist party. Suppose the producer is an individual farm household and the supplier is the operator of the collective machine station. The decision making is assigned to the individual farm household and operator under the coordination of the communist party. This coordinated assignment of decision making exactly represents the double-tier management system organization.

We wonder which is the most economically rational under the given circumstances out of these three types. This can be answered by comparing the maximum expected value of rural payoff, namely, comparing among equations (1-5), (1-9), and (1-13) based on the following two aspects.

The first is related to "coordination," that is, by comparing $1/(B+C)$ with $1/(B+B)$. The expected value of rural payoff under the private farm household system is greater than that of the other two types if $C<B$. On the contrary, the expected value under the people's commune system and the double-tier management system is greater than under the private farm household system if $C>B$. The condition $C<B$ means that the influence of competitiveness is stronger than coordination. On the other hand, condition $C>B$ means that the effect of coordination is stronger than the competitiveness. If $C>B$, coordination is worthwhile being utilized, so an elaborate coordination system needs to be established. Chinese agriculture originally consisted of a great many small peasants, just after the formation of the People's Republic of China. A greater performance could be expected by the collective action of many small peasants compared to the individual activities of each peasant. Coordination was needed to enable the collective action. This situation represents $C>B$, which promoted a collaboration of peasants and an establishment of the people's commune in those days.

But the failure of the people's commune brought about the introduction of the household responsibility system, which allowed farm households to enhance their individual incentives. A greater performance could be expected by the individual activities of each farm household, compared to the collective action by the people's commune. This condition implies $C<B$, or a weakening effect of coordination. But this is exactly the problem caused by a lack of collective power that bought on agricultural stagnation. It is required to intensify the effect of coordination ($C>B$) or to activate the collective power that had been well cultivated in the people's commune days.

The second aspect is related to "information." This can be analyzed by (1) comparing $\sigma_\beta{}^4/(\sigma_\beta{}^2+\sigma_\varepsilon{}^2)$ with $\sigma_\alpha{}^4/(\sigma_\alpha{}^2+\sigma_\varepsilon{}^2)$ and (2) comparing $\sigma_\alpha{}^4/(\sigma_\alpha{}^2+\sigma_\varepsilon{}^2)$ with $\sigma_\beta{}^4/(\sigma_\alpha{}^2+\sigma_\varepsilon{}^2)$. The

expected value of rural payoff under the people's commune system is greater than the other two if $\sigma_\beta^2 < \sigma_\alpha^2$. On the contrary, the expected value under the private farm household system and the double-tier management system is greater than under the people's commune system if $\sigma_\beta^2 > \sigma_\alpha^2$. σ^2 represents the magnitude of uncertainty and implies the importance of information for decision making. The differences among small peasants were very small just after the formation of the People's Republic of China. Every small peasant could behave only in the same way and face similar productive conditions. Collective action was the most effective strategy for improving the incomes of peasants. Therefore productive uncertainty was caused by the collective action rather than by the individual conduct. In other words, common information the communist party provides to each peasant holds a key to increasing production. Common information must treat large variety of cases. On the other hand, personal information treats a small variety because of the equalities of individual behavior. The variance of common information was greater than personal information. This situation represents the condition $\sigma_\beta^2 < \sigma_\alpha^2$ which was suitable to the choice of the people's commune type.

But the household responsibility system raised the incentives of individuals after the rural reform. The role of individual conduct became more dominant than that of collective actions. Production uncertainty was caused by individual conduct rather than collective actions. The equality of each peasant disappeared, and differences among farm households surfaced. The variance of personal information became larger, bringing about $\sigma_\beta^2 > \sigma_\alpha^2$. To adapt $\sigma_\beta^2 > \sigma_\alpha^2$ while stimulating individual incentives, the establishment of a private farm household system or the double-tier management system was the only choice.

On the other hand, as we mentioned above, for $C > B$, either the people's commune system must be revived or the double-tier management system must be established. We can conclude the answer easily. Only the double-tier management system can fulfill both conditions of $C > B$ and $\sigma_\beta^2 > \sigma_\alpha^2$. This is the organizational rationality of the double-tier management system. This system is an elaborative organization designed to use personal information in "single conduct" to stimulate individual incentives and to simultaneously use common information in "bilateral conduct" to utilize coordination under the collective.

2) Motivation and assignment of jobs and ownership

We will now examine the organizational rationality of the independent phase of the double-tier management system. The core task of this phase is the motivation. "Jobs" and "ownership" of individuals are motivated under the double-tier management system.

Agricultural production from land is realized by a combination of labor and capital as inputs. The labor effort is accompanied by capital, and capital is generated from capital accumulation through a combination of labor effort and existing capital. We assume that all accumulated capital in the first period is used as capital for investment in the second period, in which the combination of labor effort and capital generates more capital. It is assumed that the outcome of this combination in the second period is equal to capital accumulation for investment in the third period. The capital accumulation is the results of this combination, which is defined as "jobs."[8] The question we must address is how these jobs are assigned to motivate individuals; thus the assignment of jobs can be measured by the assignment of capital accumulation.

Besides jobs, we need to take ownership into account. Jobs represents a combination of labor effort and capital. When capital is considered, we should especially turn our attention to the "ownership" of fixed capital. In the case of a family farm, fixed capital is owned by the family that engages in jobs. In the double-tier management system, although land is owned collectively, a portion of fixed capital is owned by individuals privately, and the other portion is owned by the collective. Thus when we analyze the double-tier management system, the assignment not only of jobs, but also of ownership should be considered.

The question is how jobs and ownership are assigned to motivate individuals. The answer lies in "incentives" and "risk sharing." Incentives stimulate individuals to do jobs and to own fixed capital by themselves. But this will require individuals to bear some risks themselves. The more incentives the individual is offered, the higher the risk he is willing to

take. Generally farm households are assumed to be risk-averse. But since the collective can bear the risk because it represents a great many villagers, it can take the risk better than individuals can. Therefore the collective can be assumed to be risk-neutral. This difference in attitude toward risk leads to risk sharing between individuals and the collective. Risk sharing must be taken into account when assignment is designed.

The question can be represented as follows. What proportion of jobs and ownership should be assigned to the individuals who invest in their own funds and engage in jobs by themselves, and what proportion should be assigned to the collective that invests by using the payment from individuals and offers supplementary farming services for individuals? To answer these questions, we apply the Milglom model.[9]

It analyzes the contract between the employee and the employer in terms of incentives and risk sharing.

(1) Assignment of jobs

We assumed that capital is accumulated by "jobs," that is, the combination of labor effort and capital. Suppose that jobs are denoted by j and capital accumulation is denoted by K. K is supposed to be produced according to the linear function $K=b\cdot j$, where b is a productive incentive of jobs on capital accumulation. The success of jobs partly depends on uncertainty. In other words, the outcomes of jobs are influenced by a random variable ρ. Therefore K can also be expressed as $K=b\cdot j+b\cdot\rho$, where ρ is assumed to be distributed normally with mean 0 and variance σ_ρ^2. Furthermore, there is a cost associated with jobs because jobs j is used to create capital accumulation. This cost is a function of j or $C(j)$; thus capital accumulation can be written as $K=b\cdot j+b\cdot\rho-C(j)$.

Now we will consider how capital accumulation K, which is a measure of jobs, is designed to be assigned to individuals and the collective under the double-tier management system. Assignment can be realized by the payment of capital accumulation from individuals to the collective. The proportion the collective bears out of the total capital accumulation is defined as "collective assignment ratio of jobs" $\theta(0<\theta<1)$.The proportion θ is paid to the collective from the total capital accumulation. Collective jobs, KC, which the collective is assigned to, can be written as $KC=\theta(b\cdot j+b\cdot\rho)-\theta C(j)$. On the other hand, individual jobs, KI, which individuals are assigned to is $KI=(1-\theta)(b\cdot j+b\cdot\rho)-(1-\theta)C(j)$ after payment to the collective. When $\theta=0$, it represents the "private farm household system." On the contrary, when $\theta=1$, it represents the "people's commune system."

Here risk sharing must be taken into consideration in the assignment. Individuals are assumed to be risk-averse. The amount they pay to keep the same level of utility when they switch from random and expected assigned capital accumulation to certain assigned capital accumulation is called risk premium. The amount left after the risk premium from random and expected assigned capital accumulation is defined as certainty equivalent. Individuals consider that certainty equivalent is equal to original random, but expected capital accumulation, keeping the same level of utility.

The expectation of individuals' random capital accumulation can be computed as $(1-\theta)bj$, because we assume the mean of ρ to be 0. We suppose that risk premium is $R(\cdot)$, variance is $Var(\cdot)$, and magnitude of risk-aversion is r.[10] The risk premium of individuals' random capital accumulation can be derived as[11]

$$R((1-\theta)(b\cdot j+b\cdot\rho))=\frac{1}{2}rVar((1-\theta)(bj+b\cdot\rho))=\frac{1}{2}r(1-\theta)^2b^2\sigma_\rho^2 \quad (2\text{-}1)$$

Because the collective is defined as risk-neutral, its risk premium is not considered.

In the consideration of risk premium and the assigned cost of jobs, each assigned certainty equivalent is derived as follows:

Individuals: $$(1-\theta)b\cdot j-(1-\theta)C(j)-\frac{1}{2}r(1-\theta)^2b^2\sigma_\rho^2 \quad (2\text{-}2)$$

Collective: $$\theta b\cdot j-\theta C(j) \quad (2\text{-}3)$$

We will now consider how jobs are assigned to maximize the welfare, the total rural system rather than each farm household. The welfare of the rural system is derived from both individual utility and collective utility. The total utilities of both groups can be measured by summing the certainty equivalent of two groups. This is total certainty equivalent and

defined as the sum of equations (2-2) and (2-3), or $F(j)=b\cdot j-C(j)-\frac{1}{2}r(1-\theta)^2b^2\sigma_\rho^2$. We maximize this with respect to j to get welfare maximization. However, this maximization should be subject to the incentive compatibility of individuals. The utility of individuals must be maximized for them to participate in this contract. This constraint is $(1-\theta)b=C'(j)$. That will be substituted for $(1-\theta)^2b^2$ in equation (2-4). After setting the derivative of $F(j)$ equal to 0 in (2-5), $(1-\theta)b$ is again substituted for $C'(j)$ in (2-6). When we solve (2-6) for θ, we will obtain equation (2-7).

$$F(j)=b\cdot j-C(j)-\frac{1}{2}rC'(j)^2\sigma_\rho^2 \qquad (2\text{-}4)$$

$$dF/dj=b-C'(j)-rC'(j)C''(j)\sigma_\rho^2=0 \qquad (2\text{-}5)$$

$$dF/dj=b-(1-\theta)b-r(1-\theta)bC''(j)\sigma_\rho^2=0 \qquad (2\text{-}6)$$

$$\theta=\frac{1}{[1/(rC''(j)\sigma_\rho^2)]+1} \qquad (2\text{-}7)$$

We will now examine the assignment model of jobs determined by equation (2-7). The nearer θ is to 1, the stronger the characteristics of the people's commune system. The nearer θ is to 0, the stronger the characteristics of the private farm household system. As values of r, $C''(j)$, and σ_ρ^2 become larger, θ gets bigger or θ approaches 1. This can be explained as follows.

(1) When r is larger or the magnitude of risk aversion is bigger, individuals are unwilling to bear the assignment of jobs and prefer to entrust them to the collective. (2) $C''(j)$ is the derivative of the marginal cost of jobs. In the technology with higher $C''(j)$, compared to the technology with lower $C''(j)$, marginal cost is larger for a given input of jobs. This means that the technology with higher $C''(j)$ is the one whose effect of jobs input is smaller, that is, less input-effective technology. When $C''(j)$ is larger (or the technology is less input effective), individuals are willing to entrust their jobs to the collective. (3) The case in which σ_ρ^2 is larger or accumulated capital is fluctuating sharply leads to managerial instability. Risk-averse individuals dislike this kind of instability. They are reluctant to bear jobs with investment under this instability and are willing to entrust them to the collective because of risk-aversion. The (1) risk-aversion and (3) instability have similar phases. Thus either or both of risk-aversion and instability will be taken up, depending on circumstances.

Under the case of strong risk-aversion (large r) or unstable capital accumulation (large σ_ρ^2) and less input-effective technology (large $C''(j)$), the collective is suited to bear all jobs. In fact, just after the foundation of the People's Republic of China, low and unstable agricultural productivity and subsistence level of living inevitably resulted in the establishment of people's communes ($\theta=1$). Because agricultural productivity is increasing and living standards are improving, individual farm households can start by using modern technology that is more input-effective (small $C''(j)$). But they are required to bear higher risks (small r). As a response to this change, people's communes were tried to be converted into private farm households ($\theta=0$) under a household responsibility system. But the economic background is not mature enough for individuals to possess the ability to bear risk better (large r). Under a household responsibility system, very small fragments of land are allocated equally among many households. Even though agricultural technology is improving, independent small land contracted households cannot bear risk well. On one hand, the collective needs to still bear the risk ($\theta=1$), and on the other, individuals are required to adopt modern technology ($\theta=0$). The double-tier management system ($0<\theta<1$) enables risk sharing by the collective and individual partial adoption of modern technology. We can find here the organizational rationality of this system.

Because the degree of assignment θ varies between 0 and 1 ($0<\theta<1$), many kinds of double-tier management systems can be designed. The degree of assignment is determined by the magnitude of risk-aversion, stability of accumulated capital, the effectiveness of technology, and other natural and economic features in each village. We will show empirically in the next section how the assignment in the double-tier management system is designed according to these organizational rationalities and other features.

(2) Assignment of ownership

We will now analyze the organizational rationality of the assignment of ownership in the

double-tier management system. We can consider the case of agricultural machines as an example for the fixed capital whose ownership is assigned between individuals and the collective. If the farm household owns the machinery privately, he will take good care of it, which will make it more durable and reduce the depreciation cost. Reducing depreciation cost will result in a higher profit to the owner. On the other hand, if the machinery is owned by the collective, an individual farm household's effort to maintain it is indifferent to an individual's profit. Farm households who don't own machines have tendencies to operate them carelessly and spend much less time on maintenance. This will result in shortening the machinery's lifetime. We will now focus on the effect of different maintenance scenarios on fixed capital ownership.

The assignment model of ownership can be constructed by applying the assignment model of jobs. But here we will pay attention to "maintenance." First, we divide farming process into (1) "cultivation," which includes land preparation, planting, and harvesting, and (2) "maintenance," which is done after "cultivation." Jobs j must be divided into input toward cultivation j_c and input toward maintenance j_m. Therefore jobs cost can be written as $C(j_c, j_m)$. Suppose that "cultivation incentive" for j_c is a and capital accumulation from j_c is K_c, and that K_c is assumed to be generated according to $K_c=a\cdot j_c$. Then suppose that "maintenance incentive" for j_m is d and capital accumulation from j_m is K_m, which is derived from reduced depreciation cost, and that K_m is assumed to be generated according to $K_m=d\cdot j_m$. K_c is assumed to be capital accumulated by cultivation and utilized for cultivating process jobs. K_m is assumed to be capital accumulated by maintenance and utilized for maintaining process jobs. The success of jobs is partly subject to uncertainty, that is, K_c and K_m are influenced by the random variable of cultivation ρ_c and the random variable of maintenance ρ_m, respectively. Random variables are assumed to be distributed normally, with mean 0 and variance ${\sigma_{\rho c}}^2$ and ${\sigma_{\rho m}}^2$. Then, $K_c=a\cdot j_c+a\cdot\rho_c$ and $K_m=d\cdot j_m+d\cdot\rho_m$.

Next we will consider how K_c and K_m are assigned to individuals and the collective under the double-tier management system. As for cultivation, the proportion of capital that is assigned to the collective from the total capital accumulation K_c (or jobs in cultivation) is defined as "collective assignment ratio of cultivation" ξ $(0<\xi<1)$. As for maintenance, the proportion of capital accumulation that is assigned to the collective from the total capital accumulation K_m (or jobs in maintenance) is defined as "collective assignment ratio of maintenance" ε $(0<\varepsilon<1)$. On the contrary, the maintenance by individuals means private ownership of fixed capital. Thus $(1-\varepsilon)$can be defined as the "ratio of privatization." Consequently, $(1-\xi)(a\cdot j_c+a\cdot\rho_c)+(1-\varepsilon)(d\cdot j_m+d\cdot\rho_m)$ is assigned to individuals in the total process of cultivation and maintenance. On the other hand, $\xi(a\cdot j_c+a\cdot\rho_c)+\varepsilon(d\cdot j_m+d\cdot\rho_m)$ is assigned to the collective. Labor effort cost $C(j_c, j_m)$ is also borne by individuals and the collective. When $\xi=\varepsilon=0$, it represents the private farm household system, and $\xi=\varepsilon=1$ represents the people's commune system.

We will now consider the assignment of cultivation and maintenance with regard to risk sharing. Again, we suppose that the magnitude of risk-aversion is r. As for cultivation and maintenance, risk premium $\frac{1}{2}r(1-\xi)^2 a^2{\sigma_{\rho c}}^2$ and $\frac{1}{2}r(1-\varepsilon)^2 d^2{\sigma_{\rho m}}^2$ should be reduced from individuals' utility, respectively. To obtain welfare maximization of the rural system, total certainty equivalent $E(j_c, j_m)$, which is the sum of individuals' and collective's certainty equivalents, should be examined. This can be done as follows:

$$E(j_c, j_m)=a\cdot j_c+d\cdot j_m-\frac{1}{2}r(1-\xi)^2 a^2{\sigma_{\rho c}}^2 -\frac{1}{2}r(1-\varepsilon)^2 d^2{\sigma_{\rho m}}^2-C(j_c, j_m) \quad (3\text{-}1)$$

We differentiate (3-1) with respect to j_m and set the derivative equal to 0 to get the first order condition for welfare maximization. However, this maximization is simultaneously subject to two kinds of incentive compatibilities, that is, $(1-\xi)a=\partial E/\partial j_c$, which maximizes the utility of individuals with respect to j_c, and $(1-\varepsilon)d=\partial E/\partial j_m$, which maximizes the utility of individuals with respect to j_m. Just as the same way as the assignment model of jobs was derived, equation (3-2) can be obtained. Here we suppose that $\partial E/\partial j_c=\Phi_c$, $\partial E/\partial j_m=\Phi_m$, $\partial\Phi_c/\partial j_m=\Phi_{cm}$, and $\partial\Phi_m/\partial j_m=\Phi_{mm}$.

$$\varepsilon=\frac{[(1-\xi)(a\Phi_{cm}\sigma_{\rho c}^{2})/(d\Phi_{mm}\sigma_{\rho m}^{2})]+1}{[1/(r\Phi_{mm}\sigma_{\rho c}^{2})]+1} \quad (3\text{-}2)$$

$(1-\varepsilon)$ stands for the ratio of privatization, so (3-2) represents the assignment model of ownership. As ε gets bigger or approaches 1, ownership is designed to be more similar to the people's commune system. As ε becomes smaller or approaches 0, ownership is designed to be more similar to the private farm household system. We would here like to focus especially on d, r, a, and ξ because these variables have significant meanings. As d is enlarging, ε becomes smaller or approaches 0. As r, a, and $(1-\xi)$ are enlarging, ε also becomes larger or approaches 1. These relations can be interpreted as follows. When maintenance incentive d is bigger, individuals are apt to own and maintain fixed capital privately by themselves. When the magnitude of individuals' risk-aversion r is bigger, individuals are inclined to entrust the collective to own and maintain assets collectively. When cultivation incentive a and the individual assignment ratio of cultivation $(1-\xi)$ are bigger, individuals prefer to turn the input of jobs toward the cultivation process instead of the maintenance process. This means that individuals are not willing to own fixed capital privately.

Just after the foundation of the People's Republic of China, low production and subsistence levels of living caused households to become intensively risk-averse, which stands for large r. Larger r brought about larger ε, which resulted in the establishment of people's communes ($\varepsilon=1$). However, as agricultural productivity began to grow after a few decades, the household responsibility system started to diffuse. In this system, residual income, which was the income left after payment to the collective could be obtained by farm households. That situation enhanced farm households' motivation to input more jobs toward cultivation to receive more residual income. Income could also be increased by more farm households' maintenance jobs through a reduction of depreciation cost. Now that the residual income could be obtained by farm households, the maintenance incentive d was also intensified, which accelerated privatization ($\varepsilon=0$). However, a small scale of contracted land brought about technological retrogression, which reduced individual incentives to use machinery. Accordingly, individuals tended to devote their jobs toward cultivation instead of to the maintenance of machines. This situation means that cultivation incentive a and collective assignment ratio of cultivation $(1-\xi)$ became relatively bigger, which accelerated collective ownership ($\varepsilon=1$). The double-tier management system ($0<\varepsilon<1$) enables partial acceleration toward both privatization and collective ownership. This is exactly what the double-tier management system intended to do. As for ownership, we can also find the organizational rationality of that system. The degree of ownership varies among $0<\varepsilon<1$, so that we will show later empirically how ownership is designed.

3. Empirical Studies of Double-Tier Management System in China

Next we will study empirically how the assignment of the double-tier management system is designed in China. Besides the theoretical organizational rationality, it should be noticed that the design of the system is actually influenced by the natural and economic features of each province. First, by introducing two cases of the double-tier management system, whose natural and economic features are different, we will show how coordination is embodied in the system. Second, we will econometrically study how the double-tier management systems are designed to motivate individuals by organizational rationality and the natural and economical features of provinces.

1) Case study of double-tier management system and coordination

We showed in section 2 that conditions of $C>B$ and $\sigma_{\beta}^{2}>\sigma_{\alpha}^{2}$ would decide the rationality of the double-tier management system. An increase of C and σ_{β}^{2} lead up to the necessity to organize the double-tier management system. With the help of two case studies, we will show the situation that C and σ_{β}^{2} are increasing.[12]

(1) Shanxi Province, Dianxiang Prefecture, Zhenansai Village

This village is in a typical nonpaddy agricultural area in the north of Taiyuan City. There are 763 farm households that occupy a 6,000 mu cultivated area. Although this village is in an agricultural area, it succeeded in the development of a nonagricultural industry, such as

manufacturing boilers, under a township and village enterprises (TVE) system. Gross nonagricultural output is 78.9 million yuan, and gross agricultural output comes to 14.3 million yuan. The double-tier management system has been well established and supported by plentiful money from the nonagricultural industries. The characteristic of this village system is independent activities at village level. The village owns agricultural machines and provides supplementary service to farm households such as land preparation. Besides machine services, the village offers an irrigation service, joint purchasing of seeds, joint marketing of wheat, and technological advisory services.

(2) Jiangsu Province, Xishang City

Xishang is a prefecture-level city composed of 33 towns and 126 villages. It is adjoined to Wuxi city and located in a well-industrialized area near Shanghai. Even though the area is well developed by industrialization, paddy farming still plays an important role in supplying food to inhabitants. There are 250,000 farm households that occupy 750,000 mu of cultivated land. The gross output of this city is 25 billion yuan, of which 52.4% comes from manufacturing, 30.8% comes from commerce, and only 16.8% is contributed to by agriculture. However, the agricultural double-tier management system of this city is well established, supported by funds from nonagricultural sectors. The system is systemically organized from upper-city level to lower-village level. As for agricultural machinery services, the bureau of machines of the municipal city government governs the agricultural mechanization scheme of the entire city; the agricultural machinery station of the municipal town government manages the agricultural mechanization scheme at the town levels; and the general service station concretely provides agricultural machinery services to farm households at the village levels. As for other services, although each is specialized at each bureau at the upper level of administration, every kind of service, such as machine service, irrigation service, insect protection, advisory service, or the joint purchasing of seeds, are provided by the general service station at the village levels.

First we will consider coordination between the farm household and the machine operator. We show the case of coordination by means of a questionnaire submitted to members of the villager's committee in Shanxi Zhenansai. One member, who is in charge of agricultural machinery, manages large tractors. The tractors are owned by the village, and three farmers are employed as operators. The fee of 5.5 yuan per mu is charged for land preparation. However, the order of land preparation was a conflicting interest among farm households. The timing of land preparation and seeding is correlated with crop yields. Every farm household preferred a higher slot in the order of the land preparation list. This caused heavy conflict between machine operators and farm households, thus requiring proper coordination among them. The villager's committee member in charge proposed the changing order system to farm households to attain coordination. If land is prepared in order from west to east in this year, an order from east to west should be adopted in the next year. Farm households accepted the idea because the proposer was a member of the villager's committee who had some authority. If a private machine contractor had proposed the same idea, it would be more difficult to get a consensus of agreement. This suggests the need for coordination, that is, an increase in C. We could find similar situations in Jiangsu Xishan. The general service station provides machinery service in which a fee of 10 yuan per mu is charged for preparation and 30 yuan per mu for harvesting. The order of land preparation and harvesting also held severe conflicting interests among farm households. The manager of machine operations at the general service station had meetings with farm households many times over the year to coordinate the undertaking. He proposed an idea that the village would be divided into three parts, and the order of three parts be changed every year. This idea was also easily accepted by farm households because the manager is a member of the villager's committee. This also suggests a need for coordination, that is, an increase in C.

Second, we show an expanding variation of personal information. In Shanxi city, opportunities for nonagricultural employment were increasing because of industrial development. The number of the farm households willing to quit farming to get nonagricultural jobs was increasing. To adjust to the changing conditions, paddy fields were classified into two

types, food land (*kou liang tian*) and contract land (*ze ren tian*). Contract lands were planned to be offered to professional farm households that needed more lands. The professional large farm households were called *zhongtian dahu* and were engaging in the cultivation of more than 15 mu. Furthermore, the village-run farms, which managed more than 100 mu of contract land, had been emerging. In Huozhuang town of this city, there exist 80 professional large farm households and 19 village-run farms who manage contract lands. This represents that the differences among farm households were increasing. An increasing difference of farm households implies an increasing difference of personal information that each farm household must observe directly. Differences were also expanding in Shanxi because contract lands were being offered to professional farm households, even though these differences were smaller compared to Xishang. All these suggest a large variation in personal information, that is, an increase of σ_β^2. The condition that both σ_β^2 and C increase led up to establishment of the double-tier management system.

2) Econometric study of double-tier management system and motivation

(1) Preliminary analyses for econometric studies

(a) Data and new interpretation of the double-tier management system

In this section, we will test econometrically the assignment model of jobs and ownership based on the Milgrom model[13] and show how the double-tier management systems are designed by a theoretical model and the natural and economic features of provinces. But unfortunately we have no village level data on the double-tier management system. However, the "Yearbook of China's Agriculture" provides us with the data of assignment between the farm household and the public sector (village, province, and state), such as a sharing of total rural revenue and total fixed capital ownership among them on each provincial level. We use these provincial data for evaluating how assignments between individuals and the collective are designed.

Originally, the double-tier management system was supposed to be completed within the agricultural sector and at the village level. However, it is practically very difficult to complete everything only within the agricultural sector and at the village level. This system cannot but be supplemented by industrial profit from the TVE. Moreover, national and provincial governments offer rural services to individuals, including nonproductive services (socialized services system). But these services originally come from taxes paid to the government by individuals. The actual double-tier management system should be understood as being beyond the agricultural sector and the village level. From this viewpoint, we will interpret the system as an assignment between the farm household as individuals and the public sector as the collective. Farm households will decide whether they carry out whole economic activities, including nonproductive activities with their own money, or they can ask the public sector to undertake these activities.

We pay attention to "net rural revenue," which is the total rural revenue minus cost, in the data of the yearbook. The net rural revenue is the surplus that is accumulated and invested as capital with labor effort for expanding production. The assignment of net rural revenue can be interpreted as the proxy of the assignment of capital accumulation that is the direct measure of "jobs."

Farm households engage in their own jobs based on the net rural revenue assigned to them. The public sector engages in public jobs based on the net rural revenue for the public. According to the yearbook, the net rural revenue consists of farm household share (farm household income) and public share (payment from farm households to the public sector). This is interpreted as an assignment of jobs, that is, net rural revenue (jobs) = assignment to individuals (farm household income) + assignment to the collective (payment to the public sector).

We exclude Beijing, Shanghai, and Tianjing because these three provinces are large nonagricultural cities. In the yearsbooks, we use the data on number of rural laborers (person), food production (t), total rural revenue (yuan), agricultural revenue (yuan), net rural revenue (yuan), farm household income (yuan), net value of total whole machines (yuan), net value of household-owned whole machines (yuan), net value of collectively owned whole machines (yuan), net value of

state-owned whole machines (yuan), wattage of total large tractor (w), wattage of farm household owned large tractor (w), wattage of total water pump (w), and wattage of farm household owned water pump (w) in each province. We use the yearbooks from 1986 to 1997, which were deflated by consumer price indexes obtained from the "China Labor Statistical Yearbooks." Because differences of price indexes among regions are small and we cannot get price indexes by region for all years, we didn't adjust price differences among regions.

(b) Risk-aversion of Chinese farm households

We assume that individuals are risk-averse and they enter into a risk-sharing contract with the collective. Here we will confirm that Chinese farm households are risk-averse. An individual's certainty equivalent (*ICE*) is computed as follows:

$$ICE=(1-\theta)(b\cdot j-C(j))-\frac{1}{2}rVar((1-\theta)(b\cdot j+b\cdot\rho)) \quad (4\text{-}1)$$

$$(1-\theta)(b\cdot j-C(j))=ICE+\frac{1}{2}rVar((1-\theta)(b\cdot j+b\cdot\rho)) \quad (4\text{-}2)$$

We assume that farm household income in the yearbook is the proxy of *ICE*. This income is the result that the individual obtained after fully assenting to the contract with the collective. Risk-aversion is already taken into account if he satisfactorily consents to the contract. That's the reason why farm household income is chosen to be the proxy of a certain equivalent. By using farm household income data from 1986 to 1997, we can estimate the magnitude of risk-aversion r from the regression of the mean and the variance of 11 years of farm household income data. The result of the estimation is

$$(1-\theta)(bj-C(j))=5804.4559+0.0006Var((1-\theta)(b\cdot j+b\cdot\rho))$$
$$(1.3341)\qquad(9.4143)$$
$$R^2=0.7665$$

Here $\frac{1}{2}r=0.006$; r can then be computed as 0.012. We can say this estimated r is significantly different from zero from the t-test. Because r is not equal to zero stands for the risk-aversion of individuals. The risk-aversion of Chinese farm households can be confirmed.

Table 1. Risk absorption by the collective

	CV of farm household income	CV of payment to the public sector
Hebei	28.87	46.48
Shanxi	15.89	27.21
Inner Mongolia	18.29	38.67
Liaoning	16.14	30.95
Jilin	15.61	17.42
Heilongjiang	24.01	29.28
Jiangsu	25.01	39.72
Zhejiang	26.15	47.36
Anhui	24.57	48.87
Fujian	36.34	53.08
Jiangxi	16.99	23.12
Shandong	19.08	51.50
Henan	25.24	27.24
Hubei	17.85	30.03
Hunan	10.67	32.33
Guangdong	21.80	53.29
Guangxi	27.59	60.36
Hainan	14.21	18.98
Sichuan	10.78	35.39
Guizhou	11.52	43.75
Yunnan	12.74	38.47
Shaanxi	11.95	18.66
Gansu	11.29	26.21
Qinghai	9.28	21.47
Ningxia	14.14	27.70
Xinjiang	7.16	33.03

Source: Yearbook of China's Agriculture (1986-1997)

(c) Risk sharing between individuals and the collective

The coefficient of variation (CV) from 1986 to 1997 of farm household income and payment to the public sector are shown for each province in Table 1. We find that the coefficients of variation of farm household income are lower than of payments to the public sector in all provinces. A higher coefficient of variation implies an absorption of risk. The collective absorbs risk from individuals. Especially in the western provinces where levels of income are lower than in the other provinces, the coefficients of variation of payment to the public sector are much bigger than of farm household income. This explains that the role of the collective that absorbs risk from individuals is more important, especially in low-income areas where risk is intensively averse.

(2) Econometric studies of the assignment of jobs

(a) Preliminary consideration

In theory, the assignment of jobs is decided by organizational rationality in regard of risk-aversion or instability and input-effectiveness. Besides these rationalities, however, the assignment design is influenced by natural and economic features in each province. Especially the economic development gap between eastern (Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guandong, Guanxi, and Hainan) and other provinces influences the attitude toward risk and input-effectiveness. The income of people has grown sharply in eastern provinces, where especially nonagricultural industries support income growth. On the contrary, the income of people has increased very little in other provinces where agriculture is still the main industry. These differences act as follows.

(1) Differentiating risk-aversion in agriculture: As for agricultural activities, the risk-aversion of farm households in eastern provinces is expected to be less intensive than in other regions. This is because the income of people in eastern regions is supported by nonagricultural industries, and it is not easily influenced by the instability of agricultural production. Conversely, the instability of agricultural production makes poor farm households face the risk of hunger and extreme destitution. (2) Differentiating risk-aversion in nonagriculture: As for nonagricultural activities, people in eastern provinces are more risk-averse because their incomes mostly come from nonagricultural industries. The people in other provinces, however, live principally on agriculture. Even though nonagricultural income could be unstable, people are expected to be less risk-averse in other provinces because nonagricultural industry provides lucrative income. (3) Differentiating the input-effectiveness: Eastern provinces have been economically well developed so that efficient advanced technologies are adopted. The effects of additional input become larger in eastern provinces than in others because of the more-efficient technologies. (4) Taxation: In the case of empirical study, besides risk-averseness or instability and input-effectiveness, we need to notice that assignment design is also influenced by taxation because payment to the public sector, which determines the collective assignment ratio of jobs, is also affected by income. As individual income increases, the income taxation ratio rises progressively so that the collective assignment ratio consequently increases. (5) Differentiating taxation: Therefore because people are more taxed in the eastern provinces where income level is higher, the collective assignment ratio is higher there.

(b) Model

Regarding the above consideration, we have built eight hypotheses, as follows. (1) As the magnitude of risk-aversion is larger, (2) as the technology is less input effective, and (3) as the capital accumulation is more unstable, the double-tier management system is designed to assign jobs more to the collective rather than to individuals. (4) Risk-aversion in agriculture is less intensive in eastern provinces. (5) Risk-aversion in nonagriculture is more intensive in eastern provinces. (6) Input-effectiveness is better in eastern provinces. (7) The collective assignment ratio of jobs increases in corporation to income. (8) This collective assignment ratio is higher in eastern provinces.

We specify equations that test these hypotheses as follows. First, the collective assignment ratio of jobs θ is defined as YT which is (1−(farm household's income/net rural revenue)). Second, to clarify these influences on the assignment by an economic development gap among provinces, we use the dummy variable DE, taking value one for eastern provinces. Third, we choose NPR (net rural revenue of each province per 10,000 laborers) as a proxy for individual income. Fourth, we choose $ORVR$ (variance of nonagricultural revenue, nonagricultural revenue=total revenue−agricultural revenue) and $FOVR$ (variance of food production) as proxies of r and σ_ρ^2. These are the reasons why: We cannot directly obtain data for risk-aversion, which is estimated in equation (4-2). Only one datum of risk-aversion can be obtained on each province, since we use year data (1986-1997) for each province in equation (4-2). For the purpose of regression analysis on each province, we need more data of risk-aversion on each province. We need to search for other variables. Recall that the reluctance against instability comes from the behavior of risk-aversion. r and σ_ρ^2 have similar phases; so we can use only variance σ_ρ^2 as a proxy for risk-

aversion instead of both r and σ_ρ^2. Therefore to clarify different influences among eastern nonagricultural provinces and agricultural provinces, *ORVR* and *FOVR* are chosen. The variance is computed as a square of the mean deviation from 1986 to 1997. Fifth, *NRTR* (net rural revenue/total rural revenue) is used as a proxy for the input-effectiveness of technology. This is because NRTR measures efficiency performance, which is how much net rural revenue the input can create per unit.

Consequently, equation (5-1) is specified to test the hypotheses (Table 2).

$$YT=\alpha_0+\alpha_1 NRP+\alpha_2 DE\cdot NRP+\alpha_3 ORVR+\alpha_4 DE\cdot ORVR+\alpha_5 FOVR+\alpha_6 DE\cdot FOVR+\alpha_7 NRTR+\alpha_8 DE\cdot NRTR+\mu \quad (5\text{-}1)$$

where α_0 is constant, $\alpha_i s$ are parameters to be estimated, and μ is the stochastic residual component.

(c) Results

The estimates of the parameters are presented below (figures in parentheses are t-values).

$$YT=\underset{}{0.2299}+\underset{(17.3962)}{0.0008}NRP+\underset{(1.0891)}{0.0049}DE\cdot NRP+\underset{(5.8540)}{}$$
$$-\underset{(-3.0046)}{1.4280E\text{-}11}ORVR+\underset{(2.9569)}{1.4603E\text{-}11}DE\cdot ORVR$$
$$+\underset{(1.0839)}{3.1580E\text{-}08}FOVR-\underset{(-0.1401)}{8.3540E\text{-}09}DE\cdot FOVR$$
$$-\underset{(-12.1780)}{0.2461}NRTR-\underset{(-4.1035)}{0.07250}DE\cdot NRTR \quad (5\text{-}2)$$
$$R^2=0.7460 \quad D.W.=1.3060$$

We observe that the estimated parameters are significantly different from 0, except for *DE·FOVR*. We can support the hypotheses from interpreting the estimated parameters as follows. $0<\alpha_3+\alpha_4$, $\alpha_3<0$: This implies that the collective assignment ratio is positively influenced by the risk-aversion for nonagricultural activities in eastern provinces. But individuals in other provinces could be less risk-averse for nonagricultural activities. These support hypotheses (1), (3), and (5). $0<\alpha_5$, $0<\alpha_5+\alpha_6$, $\alpha_5+\alpha_6<\alpha_5$: It is evident that the collective assignment ratio is positively influenced by the risk-aversion for agricultural activities in eastern and other provinces. But risk-aversion in eastern provinces is less intensive than in others. These support hypotheses (1), (3), and (4). $\alpha_7<0$, $\alpha_7+\alpha_8<0$, $\alpha_7+\alpha_8<\alpha_7$: The collective assignment ratio is negatively influenced by the input ineffectiveness of technology, but this reaction to input-effectiveness is stronger in eastern provinces than in others. These support hypotheses (2) and (6). $0<\alpha_1$, $0<\alpha_1+\alpha_2$ and $\alpha_1<\alpha_1+\alpha_2$: The collective assignment ratio is also positively influenced by taxation, which is progressively imposed on the individuals' incomes in any provinces. Especially, in habitants are required to pay to the public sector more in eastern higher income provinces. These support hypotheses (7) and (8). Thus we conclude that the assignment of jobs is designed according to organizational rationality and different economic features of each province.

(3) Econometric study of the assignment of ownership

(a) Preliminary consideration

The next step is to study the assignment of fixed capital ownership. There are so many kinds of fixed capitals, but we concentrate on studying agricultural machines because they play predominant roles for agricultural devel-

Table 2. List of variables in equation (5-1)

	Definition	Meaning	Average	Standard deviation	
YT	1−(farm household income/net revenue)	Collective assignment ratio of jobs	15.6	7.17	(%)
NRP	Net rural revenue per 10,000 laborers	Individual income	11.4	5.07	(10,000Yuan)
ORVR	Variance of nonagricultural revenue	Risk-aversion in nonagriculture	8.91E+08	2.17E+09	
FOVR	Variance of food production	Risk-aversion in agriculture	37984.7	83408.2	
NRTR	Net revenue/total revenue	Input-effectiveness of technology	36.8	11.1	(%)

opment. We will take up tractors and water pumps as typical agricultural machines. On the one hand, according to the Yearbook of China's Agriculture, almost 100% of small tractors are privately owned. On the other, from 40% to almost 100% of large tractors are privately owned, and from 10% to 90% of water pumps are privately owned in each province. Thus ownership assignments of large tractors and water pumps are concentratedly studied. The assignment of ownership is equivalent to the privatization of large tractors and water pumps.

The assignment of ownership is determined by the organizational rationality in regard to risk-aversion and incentives, that is, risk-aversion r, maintenance incentive d, cultivation incentive a, and collective assign ratio of cultivation $(1-\xi)$. First, however, because we cannot measure input for cultivation separately from input for maintenance, a and $(1-\xi)$ cannot be estimated. Instead of studying a and d separately, besides risk-aversion r, the incentives that include a and d are going to be studied. Second, as far as ownership is concerned, risk-aversion r has specific attributes. Risk-aversion in ownership is closely related to the value of agricultural machines. Therefore, the higher value of the machine causes more-intensive risk-aversion. When a machine is privately owned, the owner himself needs to compensate the loss with more money in proportion to the value of the machines when the machines break down. The ownership of a highly valued machine causes the owner to have a strong aversion to risk. Third, incentives of a farm household are formed by individual farm household income left after payment to the collective, because a self-made effort directly increases the individual farm household income that he can obtain. This income stimulates not only the cultivation effort, but also the maintenance effort because a farm household can obtain a greater income by reducing the depreciation cost. In other words, maintenance incentive d is supposedly intensified by individual farm household income. On the one hand, individual farm household income is determined by (1 − (farm household income/net rural revenue)), which is defined as a collective assignment ratio of jobs. This ratio is determined according to equation (5-1). On the other hand, individual farm household income is determined by individual agricultural production. In the provinces where individual agricultural production is higher, farm households can obtain more individual farm household income, which generates more maintenance incentive. This strong incentive compels a farm household to maintain a large tractor and water pump independently. Therefore the province in which the per capita agricultural production is higher is considered to have a greater tendency for a privatization of a large tractor and a water pump.

Besides this organizational rationality, the assignments of ownership are also influenced by natural and economic features on each different province, as follows. The differences in farming systems among provinces will influence the assignment of ownership of the large tractor and the water pump. Especially, the difference between rice (paddy) and maize (upland) production influences the design of ownership of large tractors and water pumps.

Furthermore, when ownership is considered with regard to economical features, we must notice that the collective assignment ratio of jobs is greatly influenced by the collective leadership. The collective leadership, which is supported by communist party, had been fostered under the people's commune. After the rural reform, this leadership is still activated to one degree or another in each province. The value of collectively owned whole kinds of machines increases when the collective leadership is activated more vividly. In proportion as the value of collectively owned whole machines augments, the collective assignment ratio of jobs also increases.

The collective leadership is determined by a privatization tendency of whole machines and individual agricultural production. This tendency toward whole machines, which includes tractors and water pumps, is the farm household's disposition to be independently willing to own machines and farm by themselves. As privatization progresses, because of greater intensity for self-making effort and so on, the collective leadership becomes inactivated. This privatization tendency toward whole machines is also determined by risk-aversion and incentives according to equation (3-2). On the contrary, the collective leadership is encouraged in the province where individual agricul-

tural production is low, and low individual production must be complemented by services from the collective.

(b) Model

Regarding these considerations, we built six hypotheses, as follows: (1) The degree privatization of large tractors and water pumps, that is, $(1-\varepsilon)$ is negatively determined by the value of each machine, which is the proxy of risk-aversion. (2) This degree of privatization is positively determined by maintenance incentives, defined by the collective assignment ratio of jobs and individual agricultural production. (3) This privatization diversifies differently among rice-producing provinces and maize-producing provinces. (4) The collective assignment ratio of jobs is determined by equation (5-1). Furthermore, it is also determined positively by the collective leadership represented as the value of collectively owned whole machines. (5) The collective leadership is negatively determined by a privatization tendency and individual agricultural production. (6) The privatization tendency is determined negatively by risk-aversion for whole machines and positively by incentives.

We specify the equations to test these hypotheses as follows. The ratio of wattage of farm households' ownership to total wattage is used as the privatization ratio for large tractors (*LPR*) and water pumps (*WPR*), respectively. Because the wattage is proportioned to the value of a machine, *LAP* (wattage of large tractors per 10,000 laborers), *WAP* (wattage of water pumps per 10,000 laborers), and *MNAP* (net value of whole machines per 10,000 laborers) are used as proxies for risk-aversion for each machine. *YT*, that is (1−(farm household income/net revenue)) is used as a proxy for maintenance incentives. Individual agricultural production is estimated by *AGP* (total product of agriculture per 10,000 laborers). The differences of rice-, maize- and other crop-producing provinces are estimated by dummy variables *DR* and *DM*. *DR* is a dummy variable taking value one for the top 10 rice-producing provinces (Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, and Sichuan), and *DM* is a dummy variable taking value one for the top 10 maize-producing provinces (Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Henan, Yunnan, and Shaanxi).

YT is also determined by individual income, input-effectiveness of technology, and risk-aversion, which was explained in the previous section. *NRP* (net rural revenue per 10,000 laborers) and *NRTR* (net rural revenue / total rural revenue) and variance are used as proxies of these factors one by one in the same way of equating (5-1). As for variance, we can ignore the difference of agriculture and nonagriculture because they have already been analyzed in equation (5-1). *GRVR* (variance for trend of total revenue) is employed for total variance σ_ρ^2. Moreover, *YT* is also determined by collective leadership, whose proxy is the value of collectively owned whole machines. This value is estimated by the variable *MNSC* (net value of collectively owned whole machines). The collective leadership is determined by the individual agricultural production and privatization tendency of whole machines. The proxies of collective leadership, individual agricultural production and degree of privatization are supposed to be *MNSC*, *AGP*, and *MNPR* (ratio of net value of farm households' ownership to total net value of whole machines). Privatization tendency *MNPR* is determined by risk-aversion and incentives. *MNAP* (net value of whole machines per 10,000 laborers) is used as the proxy of risk-aversion, and *YT* is used as the proxy of incentives. According to the preliminary consideration, equations are specified to be as follows (Table 3).

$$LPR=\alpha_0+\alpha_1 LAP+\alpha_2 YT+\alpha_3 AGP+\alpha_4 DR+\alpha_5 DM+\mu_1 \quad (6\text{-}1)$$

$$WPR=\beta_0+\beta_1 WAP+\beta_2 YT+\beta_3 AGP+\beta_4 DR+\beta_5 DM+\mu_2 \quad (6\text{-}2)$$

$$YT=\gamma_0+\gamma_1 NRP+\gamma_2 GRVR+\gamma_3 NRTR+\gamma_4 MNSC+\mu_4 \quad (6\text{-}3)$$

$$MNSC=\delta_0+\delta_1 MNPR+\delta_2 AGP+\mu_5 \quad (6\text{-}4)$$

$$MNPR=\varepsilon_0+\varepsilon_1 MNAP+\varepsilon_2 YT+\mu_3 \quad (6\text{-}5)$$

α_0, β_0, γ_0, δ_0, and ε_0 are constants. α_is, β_is, γ_is, δ_is, and ε_is are parameters to be estimated. μ_is are stochastic residual components. We assume that μ_1 through μ_5 are correlated.

(c) Results

The results of two stage least squares estimates of the system are as follows (figures in parenthesis are t-values):

Table 3. List of variables in equation (6-1), (6-2), (6-3), (6-4), and (6-5)

	Definition	Meaning	Average	Standard deviation	
LPR	Privatization ratio of large tractor in wattage	Degree of privatization of large tractor	73.4	16.9	(%)
LAP	Wattage of large tractor per 10,000 laborers	Degree of risk-aversion in large tractor	0.104	0.162	(W)
AGP	Total product of agriculture per 10,000 laborers	Individual agricultural production	16.6	8.80	(10,000Yuan)
WPR	Privatization ratio of water pump in wattage	Degree of privatization of water pump	55.4	25.2	(%)
WAP	Wattage of water pump per 10,000 laborers	Degree of risk-aversion in water pump	0.159	0.135	(W)
YT	1−(farm household income/ net revenue)	Maintenance incentive	15.6	7.17	(%)
NRP	Net rural revenue per 10,000 laborers	Individual income	11.4	5.07	(10,000Yuan)
GRVR	Variance of total revenue trend	Degree of risk-aversion in jobs	34.6	36.2	
NRTR	Net revenue/total revenue	Input-effectiveness of technology	36.8	11.1	(%)
MNPR	Privatization ratio of whole machines in value	Privatization tendency of whole machine	82.7	11.0	(%)
MNAP	Net value of whole machines per 10,000 laborers	Degree of risk-aversion in whole machine	1.19	0.78	(10,000Yuan)
MNSC	Net value of collectively owned whole machines	Collective leadership	273	289	(10,000Yuan)

$$LPR = \underset{(15.9418)}{0.8155} - \underset{(-3.3630)}{0.5134}LAP - \underset{(-3.0660)}{0.9910}YT + \underset{(1.5222)}{40.0358}AGP + \underset{(1.7208)}{0.0860}DR + \underset{(1.4520)}{0.0708}DM$$

$$R^2 = 0.1700 \quad D.W. = 2.3732 \qquad (6\text{-}6)$$

$$WPR = \underset{(5.9027)}{0.4223} + \underset{(2.7385)}{0.5571}WAP - \underset{(-3.4735)}{1.6720}YT + \underset{(2.3962)}{59.8041}AGP + \underset{(3.5028)}{0.2448}DR + \underset{(4.0984)}{0.2865}DM$$

$$R^2 = 0.2696 \quad D.W. = 1.8708 \qquad (6\text{-}7)$$

$$YT = \underset{(6.4723)}{0.1845} + \underset{(2.8294)}{0.0029}NRP + \underset{(2.8428)}{0.0006}GRVR - \underset{(-4.3532)}{0.2461}NRTR + \underset{(0.7886)}{1.9805E\text{-}05}MNSC$$

$$R^2 = 0.6860 \quad D.W. = 1.1113 \qquad (6\text{-}8)$$

$$MNSC = \underset{(8.7650)}{3037.89} - \underset{(-8.3772)}{3132.42}MNPR - \underset{(-3.1394)}{104805}AGP$$

$$R^2 = 0.4848 \quad D.W. = 1.9355 \qquad (6\text{-}9)$$

$$MNPR = \underset{(36.5096)}{1.0247} - \underset{(-6.1711)}{0.0667}MNAP - \underset{(-5.4480)}{0.7604}YT$$

$$R^2 = 0.4028 \quad D.W. = 1.8157 \qquad (6\text{-}10)$$

It can be totally judged that the estimated values are significantly not equal to 0, except for *MNSC* in (6-8). We can draw the conclusion from the results that follows. $\alpha_1 < 0$, $\varepsilon_1 < 0$, $\alpha_2 < 0$, $\beta_2 < 0$, $\varepsilon_2 < 0$, $0 < \alpha_3$, $0 < \beta_3$: These imply that the privatization of machines is repressed by risk-aversion. And the privatization is determined negatively by the collective assignment ratio and positively by the individual agricultural production; that is, the privatization is progressed by maintenance incentives. These support hypotheses (1), (2). $0 < \beta_1$: The estimated parameter is positive, which is inconsistent with the hypothesis. This can be explained as follows. Because the value of a water pump is small, possession of pumps is a slight burden on farm households. Water pumps are easier to be privatized than other machines, and an increase of wattage is considered to be inconsistent with privatization. $0 < \alpha_4$, $0 < \alpha_5$, $\alpha_5 < \alpha_4$, $0 < \beta_4$, $0 < \beta_5$, $\beta_4 < \beta_5$: These imply that privatization is more progressive in rice- and maize-producing provinces than in the others. This is because higher individual agricultural production is realized in rice- and maize-producing provinces. A trend that large tractors are apt to be owned more by the collectives in maize-producing provinces than in

rice-producing provinces can be observed. On the contrary, a trend that a water pump is apt to be owned more by the collective in rice-producing provinces than in maize-producing provinces is observed. Even though privatization is progressing, important machines (large tractors in the uplands and water pumps in paddy fields) are very likely to be owned by the collective. These support the hypothesis (3).

$0<\gamma_1$, $0<\gamma_2$, $\gamma_3<0$: These indicate that the collective assignment ratio of jobs is determined by equation (5-1). These support hypothesis (4). $0<\gamma_4$: This implies that this ratio is also determined positively by the collective leadership. This supports hypothesis (4). $\delta_1<0$, $\delta_2<0$: These indicate that the collective leadership is negatively determined by privatization tendency and individual agricultural production. These support hypothesis (5). $\varepsilon_1<0$, $\varepsilon_2<0$: The privatization tendency is negatively determined by risk-aversion. And this is positively determined by maintenance incentives or negatively determined by the collective assignment ratio. These support hypothesis (6).

The small R^2 in (6-6) and in (6-7) explains that ownership is determined by many other factors that we cannot measure. But as far as our organizational aspects are concerned, we can conclude significantly that ownership is designed according to the organizational rationality and natural and economic features in each province.

4. Concluding Remark

Besed on our economic analyses, we can conclude that the double-tier management system has organizational rationalities. The double-tier management system is now promoted in rural areas by the Chinese government. We can confirm that this promotion is supported not only by political reasons, but also by economic rationalities. Organizational rationalities are shown as follows.

(1) Organizational rationality of coordination: The double-tier management system utilizes personal information to enhance incentives and also common information to carry out the coordination. (2) Organizational rationality of motivation: Contracted small lands do not allow households to bear risk. Small lands also bring about technological retrogression, which reduces incentives for households to maintain their own machines. The double-tier management system is a setup in which the collective absorbs risk and maintains the machine for individuals. These two organizational rationalities of the double-tier management system are tested by case studies and econometric studies. Through the case studies, it is found that the order of land preparation can be coordinated under the double-tier management system. Econometric tests support the hypothesis that the assignment of jobs and ownership is designed according to organizational rationalities and natural and economic features in each province. We can assert that the double-tier management system is the setup most fitted to today's rural China.

1) Although the double-tier management system in China has been examined in many books, such as *Nongyebu Nongcum Guding Guanchadian Bangongshi* [9], it has not yet been investigated in other countries. The latest rural reform in China has been examined by Shiraishi [10], Lin and Zhou [7], Yan [12], Cheng [2] and Yamamoto [11].
2) In rural China, the movement in which farm household's activities are supported sufficiently by public services is progressing. This is called as socialized service system. On the contrary, in some cases that the collectives don't provide farming services, private contractors offers these services to farmers to some degree.
3) Analytical validities of new institutional economics are explained in Eggertson [4].
4) Milgrom and Roberts [8] also insists that coordination and motivation are the main task to manage the organization.
5) Crémer [3].
6) This equation is based on Taylor's expansion. See Crémer [3].
7) The results (1-4), (1-5), (1-8) and (1-9) can be obtained in chapter 2 of Aoki and Okuno [1] in which Crémer model was introduced. But those are driven to explain the case of multidivisional corporation. We apply Crémer model to explain the coordination of China's rural system from different analytical aspects.
8) The concept "jobs" is generally utilized in management of organization. See Milgrom and Roberts [8].
9) See Milgrom and Roberts [8] Chap. 7 and Holmstorm and Milgrom [5]. Originally the Milgrom model is built to analyze the design of employer's contract with employee. The purpose of the model is to decide employee's jobs to maximize the profit of employer. But the double-tier

management organization is not the firm but the rural setup where both the collective and the individuals engage in farming. The purpose of our model is to decide jobs of both the collective and the individuals to maximize the total welfare of village.

10) Strictly speaking, r is defined as the coefficient of absolute risk-aversion.

11) See Milglom and Robert [8] Chap. 7.

12) These cases were surveyed by the author in November 1998.

13) Milgrom model in the case of firms was studied econometrically in Kawasaki and McMillan [6].

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(Received July 19, 1999; accepted July 19, 2001)