A Model of Institutional Change in Rice Village

by
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Abstract

This paper presents a non-cooperative game model of agricultural institutional change in Philippines to explain findings by Hayami and Kikuchi(2000) that harvesting system has changed from Hunusan (collecting harvesting) to Gama (contract harvesting) and again Gama to Hunusan. In the model, the social norm is formulated by assuming the externality in the utility functions of farmers. It is shown that such institutional changes may occur not because of the productivity growth but because of the population changes.

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1 Introduction

The purpose of this paper is to present a game theoretic model that explain the agricultural institutional changes of harvesting system in Philippines from 1960's to 1980's. In their celebrated book, Hayami and Kikuchi(2000) observed that rice harvesting system has changed from Hunusan (collecting harvesting) to Gama (contract harvesting) during 60's and 70's and again Gama to Hunusan during 80's in East Laguna village located near Manila, Philippines.

These changes might have emerged as a result of many complex factors. Indeed, during those periods, the village experienced a lot of shocks such as green revolution, land reform, modernization, establishment of irrigation system and migration. Probably every such shock might be attributed to these changes in harvesting system. But the major factor for these changes has been still unknown. Hayami and Kikuchi claim that these changes are attributed to the productivity growth and the existence of social norm in the village:

> "the gama contract represents an institutional arrangement designed to reduce disequilibrium between the renumeration rate of labour and its marginal productivity within the framework of work and income-sharing in the community.(p.173)"

Accompanied with many empirical findings, their explanation seems to be plausible, but it still remains unclear what the social norm is and how the norm affects the change in harvesting system.

To answer these questions, I construct a multi stage non-cooperative game model in which each farmer's choice of the harvesting system on his land between Hunusan and Gama is given as a Nash equilibrium. In the model Hunusan is the harvesting system that permits everyone in the village to participate in harvesting on the farmer's land and earn a certain share of output. On the other hand, Gama is the one that permits one laborer to harvest the land exclusively. Also, the social norm is introduced in the way that farmers are sympathetic to the villagers. The sympathy is embodied in form of externality in the utility function of each farmer.

There are two types of agricultural laborers, workers and outsiders, in the model. Every farmer feels sympathy to the former people as well as the other farmers, but not to the latter, and his choice of the harvesting system is affected by not only his own consumption of rice, but also that of workers and other farmers. In his choice of the harvesting system, the choice of Gama gives a laborer more amount of rice, but at the same time it excludes the opportunity of other individuals, including other workers and farmers, to harvest his land by which his utility may decrease through decreases in other villagers' utilities. In the model, there are three types of subgame perfect Nash equilibrium; i) Hunusan prevails in all lands; ii) Gama prevails in all lands; and iii) Hunusan and Gama coexist.

In literature related to this paper, North(1990) discusses the institutional change and economic growth. Theoretically, from the viewpoint of institutional arrangement in game theoretic framework, the change of institution in the form of the state are discussed by Okada and Sakakibara (1991) and Okada, Sakakibara and Suga (1997) in a dynamic public good economy. Also the emergence of property rights on ownership of wealth in a Hobbesian anarchy are discussed by Sakakibara and Suga (1997) and Sakakibara(2000).

The main result of this paper is as follows. First, the more number of the outsiders and the stronger the social norm, the more lands are under Gama contract in equilibrium. And without outsiders or the social norm, no Gama prevails in the resulting equilibrium.

Secondly, the productivity of the economy and the fraction of share of harvesting, though these values affect the consumption level of each individual in the economy, do not matter on the equilibrium number of Gama and Hunusan which depend only on the number of individuals of each type. This result is different from the traditional view of institutional change that attributes it mainly to the productivity growth of the economy. In the model, the productivity growth might affect the resulting equilibrium indirectly through the change in the population, but if there exists a competitive labor market, then the effect of growth is completely absorbed in the change of the fraction of share and consequently has no effect on the equilibrium number of Hunusan and Gama.

By using these features of the model and comparing them to actual observations, it seems that the first change from Hunusan to Gama could be explained as a result of the increase in the number of outsiders through migration, and that the second change from Gama to Hunusan as a result the social norm to be weakened. This explanation seems to suggest that the productivity growth affects the institutional change only indirectly, and that the population growth could be a more important factor of it.

The paper is organized as follows. In the following section, I present a game theoretic model and define the equilibrium. In section 3, some propositions and features of the equilibrium are discussed. All proofs of the propositions are given in Appendix. Then in section 4, the applicability of the model to the historical observations is discussed. Finally, in section 5, some remarks are given.

2 Economy

Let us consider a three period economy in which there is only one consumption good named rice. There are three types of individuals named farmers, workers and outsiders. There are n_0 farmers, n_1 workers and m outsiders. The farmers are descendants of the founders of the village, and the workers are relatives of the farmers. While the outsiders migrated recently from outside. Each farmer owns one unit of land that produces y units of rice in the second period. While the workers and the outsiders do not own any land. I denote N_0, N_1 and M as the set of the farmers, the workers and the outsiders, respectively. The utility of each farmer i, u_i ($i \in N_0$) is given by

$$u_i = c_i + \theta \sum_{j \in N_0 \cup N_1, j \neq i} c_j,$$

where c_i is the amount of rice consumed by farmer i $(i \in N_0)$ at the end of the third period.[1] The utility of each individual i of workers and outsiders, u_i $(i \in N_1 \cup M)$, is given by

$$u_i = c_i,$$

where c_i is the amount of rice consumed by him at the end of the third period.

Note that there is an externality on each farmer's utility of the consumption level of other farmers and workers. This externality might be explained as a social norm in the village.

There are two harvesting systems, named Gama and Hunusan, in the village. Gama is the contract between a farmer and a worker or outsider that permits the worker or outsider to harvest the farmer's land exclusively in the third period. The worker or outsider receives αy units of rice by this contract, where α $(0 < \alpha < 1)$ is determined exogenously before the first period. On the other hand, in Hunusan, a farmer opens the opportunity of harvesting his land to every individual (including himself) in the economy.[2] I assume that he economy's harvesting is made made in the following manner.

Period One

In the first period, given N_0, N_1, M, and α, each farmer i $(i \in N_0)$ chooses the way of harvesting, Gama (abbreviated to G) or Hunusan (abbreviated to H). At the same time, each farmer i who chooses Gama selects an individual j_i among workers and outsiders $(N_1 \cup M)$. If the farmer's choice is Hunusan (i.e., $a_i = H$) j_i is set to be 0. Let a_i $(a_i \in \{G, H\})$ be his choice of the way of harvesting. If there is no available workers or outsiders, then farmer i must choose Hunusan. Let $n_0(G)$ be the number of farmers who choose Gama. Then $n_0(G)$ satisfies $n_0(G)$ □ $n_1 + m$. For simplicity, I assume that the first $n_0(G)$ farmers chose Gama, i.e., $a_i = G$ for $i = 1, 2, ..., n_0(G)$. Also let $n_1(G)$ be the number of workers selected as a Gama worker. The choice of each farmer i $(i \in N_0)$ in the first period is given by a pair (a_i, j_i).

Period Two

After the selection, i.e., given (a_i, j_i) $(i \in N_0)$, each farmer i will ask individual j_i whether he will harvest the farmer i's land in the third period. If the answer is yes, then the land of farmer i is harvested exclusively by j_i. If the agreement is not reached, then the farmer has to change his choice from Gama to Hunusan.

Let n_g be the number of farmers who succeeded in making Gama contract after the end of this period. I denote the state of each farmer i $(i \in N_0)$ at the end of the third period by a pair (a'_i, j_i), where $a'_i = a_i$ $(i = 1, 2, ..., n_0(G))$ if he succeeded in making Gama contract and $a'_i = H$ if not, and the second term j_i $(j_i \in N_1 \cup M)$ implies the contracted harvester for the farmer i. If the farmer's choice is Hunusan (i.e., $a'_i = H$), as in the first period, j_i is set to be 0.

Period Three

At the beginning of the third period, given $\{(a'_i, j_i)\}_{i=1}^{n_0}$, there are n_g units of land under Gama and $n_0 - n_g$ units of land under Hunusan, and each land produces y units of rice. If the land of farmer i is under Gama contract, i.e., ($a'_i = G$), then the output of y units of rice is devided by $(1 - \alpha)y$ for farmer i and αy units of rice for individual j who harvests the land.[3)]

If the land of farmer i is under Hunusan, i.e., $a'_i = H$, then the land is opened to every individual including himself for harvesting. If the number of individuals who participate in harvesting the land is given by s, then the output of the land y is divided by $(1-\alpha)y$ for farmer i and $(\alpha y)/s$ units of rice for each of those who harvest the land.

Let H_3 be the set of $n_0 - n_g$ units of land under Hunusan in the third period, i_3 ($i_3 = 1, 2, ..., n_0 - n_g$) be the i_3-th element of H_3, and $h(i_3)$ be the number of individuals who participates in harvesting land $i_3 \in H_3$. In the economy, every individual j except those who has engaged in harvesting under Gama contract, including every farmer, can participate in harvesting on every land under Hunusan. Let $L^h(j) \in H_3$ be the set of lands individual j participates in harvesting. Then individual j obtains from each land $i_3 \in L^h(3)$ the amount of $\alpha y/h(i_3)$ units of rice by participating the harvest.

After every land has harvested, the total amount of rice that each individual j obtains which he consumes at the end of the third period, c_i, is given as follows. First, if individual i works as Gama harvester, then his income is given by αy. Because he cannot participate in Hunusan harvesting, we have

$$c_i = \alpha y.$$

Next, if individual i is a worker or outsider who does not make contract as a Gama harvester, his income comes from Hunusan harvesting only. Therefore we have

$$c_i = \sum_{i_3 \in L^h(i)} \alpha y/h(i_3).$$

Finally, if individual i is a farmer, irrelevant to whether he chooses Gama or Hunusan, his income is given by

$$c_i = (1-\alpha)y + \sum_{i_3 \in L^h(i)} \alpha y/h(i_3).$$

Note that if no workers or outsiders exist, i.e., $n_1 = m = 0$, then, under the above setup, farmers cannot make Gama contracts, and Hunusan prevails in every land in the economy.

Under the above setup, we consider a subgame perfect Nash equilibrium.

2.1 Solution

Step 1

At the beginning of the third period, there are n_g units of land are harvested by n_g workers and/or outsiders under Gama. Each individual i who harvests under Gama receives αy units of rice and does not participate in sharecropping under Hunusan.

Let W_h be the set of $n_0 + n_1 + m - n_g$ individuals who may participate in Hunusan, and let i_w be the i_w th individual in W_h. At the third period, each individual $i_w^* \in W_h$ decides the set of lands he participates in harvesting, $L^h(i_w^*)$, given the decision of other individual $i_w \in W_h$, $L^h(i_w)$ $(i_w \neq i_w^*)$.

Case 1: $i_w^* \in N_0$

If i_w^* is a farmer, then his problem is to maximize

$$u_i = c_i + \theta \sum_{j \in N_0 \cup N_1, j \neq i} c_j$$

given $L^h(i_w)$ $(i_w \neq i_w^*)$.

For each land $i_3 \in H_3$, let $n'(i_3)$ be the number of villagers except i_w^* who participate in harvesting on i_3. Also let $h*(i_3)$ be the number of individuals except i_w^* who participates in harvesting on i_3. If he does not participate in harvesting on i_3, then his utility gain from the harvesting on land i_3 is given by

$$(\theta n'(i_3)\alpha)/(h*(i_3)y)$$

and if he does, then it is given by

$$\alpha/((h*(i_3)+1)y) + (\theta n'(i_3)\alpha)/((h*(i_3)+1)y).$$

The former is less than the latter if and only if $h*(i_3) - \theta n'(i_3) > 0$. Since $h*(i_3) \geq n'(i_3)$ and $\theta < 1$, he decides to participate in harvesting. This condition is satisfied for every land $i_3 \in H_3$, and he decides to participate in harvesting on all lands under Hunusan.

Case 2: $i_w^* \in N_1 \cup M$

If i_w^* is a worker or an outsider, then his problem is to maximize

$$u_i = c_i$$

given $L^h(i_w)$ $(i_w \neq i_w^*)$.

If he does not participate in harvesting on i_3, then his utility gain from the harvesting on land i_3 is zero. If he does, then it is given by

$$\alpha/((h*(i_3)+1)y)$$

Therefore, obviously, he decides to participate in harvesting on i_3. This condition is satisfied for every land $i_3 \in H_3$. and he decides to participate in harvesting on all lands under Hunusan. Summing up, every individual except those who harvests under Gama contract participates in every land under Hunusan, and he obtains from Hunusan the total of $[(n_0 - n_g)/(n_0 + n_1 + m - n_g)]\alpha y$ units of rice.

Let n_1^g be the number of workers who participate in Gama. Then the utility of every farmer i, u_i is given by

$$\begin{aligned} u_i &= (1-\alpha)y + [(n_0 - n_g)/(n_0 + n_1 + m - n_g)]\alpha y \\ &+\theta[n_1^g \alpha y \\ &+(n_0 - 1)[(1-\alpha)y + [(n_0 - n_g)/(n_0 + n_1 + m - n_g)]\alpha y] \\ &+(n_1 - n_1^g)[[(n_0 - n_g)/(n_0 + n_1 + m - n_g)]\alpha y]. \end{aligned}$$

For a worker or an outsider i, if he harvests under Gama, then his utility u_i is given by

$$u_i = \alpha y,$$

and if he does not harvest under Gama, then his utility u_i is given by

$$u_i = [(n_0 - n_g)/(n_0 + n_1 + m - n_g)]\alpha y.$$

Step 2

In the second period, given $\{(a'_i, j_i)\}_{i=1}^{n_0}$, every farmer i who has chosen an individual j_i, asks individual j_i whether he agrees to be a harvester of his land. If individual j_i agrees, then Gama is contracted between farmer i and individual j_i. If not, then the farmer i sets his land under Hunusan. Let $n_0(G)$ be the number of farmers who offered Gama and let $n_1(G)$ the number of workers who has offered Gama in the first period.

Let us consider the decision problem of individual j_i who has been selected as a candidate of Gama harvester, given other the decisions of other selected individuals j_i ($j_i = j_1, j_2, ...j_{i-1}, j_{i+1}, ..., j_{n_0(G)}$). Other than j_i, in the decision, let n_0" be Gama contracts agreed upon and let n_1" be the number of Gama harvesters among workers.

If he accepts the offer, then his utility u_{j_i} is given by αy. If he does not accept the offer, then his utility is given by

$$u_{j_i} = [(n_0 - n_0")/(n_0 + n_1 + m - n_0")]\alpha y.$$

It is obvious that individual j_i always accepts the offer since the utility under Gama is larger than that under Hunusan.

¿From above, in the second period, given $\{(a'_i, j_i)\}_{i=1}^{n_0}$, all individuals who offered Gama agree, and the number of Gama agreed n_g is given by $n_0(G)$ and the nunber of workers under Gama contract, n_1^g, is given by $n_1(G)$.

Step 3

Now consider the choice problem of farmer i in the first period. Each farmer i either chooses Gama and selects an individual j_i as a Gama harvester or Hunusan and does not select anyone ($j_i = 0$).

Under the condition that other farmers' choices (a_s, j_s) $(s \neq i, s \in N_0)$ be given, I consider farmer i's problem. Let n'_g be the number of farmers other than i who select Gama, and let n_w be the number of workers whom the farmers other than i select as Gama harvesters.

Case 1

If he chooses Hunusan, i.e., $a_i = H$ and $j_i = 0$), then total of n'_g farmers select Gama and n_w workers are selected as Gama harvesters. Therefore the utility of farmer i under the choice of Hunusan, u_i^H, is given by

$$\begin{aligned} u_i^H \quad = \quad & (1-\alpha)y + [(n_0 - n'_g)/(n_0 + n_1 + m - n'_g)]\alpha y \\ & +\theta[n_w \alpha y + (n_0 - 1)[(1-\alpha)y \\ & +[(n_0 - n'_g)/(n_0 + n_1 + m - n'_g)]\alpha y] \\ & +(n_1 - n_w)[[(n_0 - n_g)/(n_0 + n_1 + m - n'_g)]\alpha y]. \end{aligned}$$

Case 2

If he chooses Gama and select a worker, i.e., $a_i = G$ and $j_i \in N_1$), then total of $n'_g + 1$ farmers select Gama and $n_w + 1$ workers are selected as Gama harvesters. Therefore the utility of farmer i under Gama with the choice of a worker, $u_i^{G_1}$, is given by

$$\begin{aligned} u_i^{G_1} \quad = \quad & (1-\alpha)y + [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y \\ & +\theta[(n_w + 1)\alpha y + (n_0 - 1)[(1-\alpha)y + [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y] \\ & +(n_1 - n_w - 1)[[(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y]. \end{aligned}$$

Case 3

If he chooses Gama and select an outsider, i.e., $a_i = G$ and $j_i \in M$), then total of $n'_g + 1$ farmers select Gama and n_w workers are selected as Gama harvesters. Therefore the utility of farmer i under Gama with the choice of a worker, $u_i^{G_m}$, is given by

$$\begin{aligned} u_i^{G_m} \quad = \quad & (1-\alpha)y + [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y \\ & +\theta[n_w \alpha y + (n_0 - 1)[(1-\alpha)y + [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y] \\ & +(n_1 - n_w)[[(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\alpha y]. \end{aligned}$$

¿From above, since

$$[(n_0 - n'_g)/(n_0 + n_1 + m - n'_g)] > [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]$$

holds, we have

$$u_i^H - u_i^{G_m} > 0.$$

Therefore, for farmer i, case 3 is dominated by case 1.

As for case 1 and case 2, we have

$$\begin{aligned}[u_i^H - u_i^{G_1}]/(\alpha y) &= \{[(n_0 - n'_g)/(n_0 + n_1 + m - n'_g)] - \\ &\quad [(n_0 - n'_g - 1)/(n_0 + n_1 + m - n'_g - 1)]\} \cdot \\ &\quad [1 + \theta(-m + n'_g + n_w - 1)].\end{aligned}$$

Therefore farmer i chooses Hunusan in the first period if and only if the above value is non-negative.

Definition: A subgame perfect Nash Equilibrium is $\{(a_i^*, j_i^*)\}_{i=1}^{n_0}$ such that for every i $(i \in N_0)$, (a_i^*, j_i^*) maximizes farmer i's utility given (a_s^*, s_i^*) with $s = 1, 2, ..., n_0$ and $s \neq i$.

Note that the equilibirum defined above does not depend on the fraction α or the productivity of land y since farmer's choice depends only on the number of people in the village and is independent of such values.

3 Equilibrium

In this section I discuss some features of the equilibrium in relation to the populations, n_0, n_1 and m, and the strength of sympathy, θ. First we have the following two propositions.

Proposition 1 If $\theta = 0$, then there exists a unique subgame perfect Nash equilibrium with $(a_i, j_i) = (H, 0)$ for all $i \in N_0$.

Proposition 2 If $n_1 = 0$, then there exists a unique subgame perfect Nash equilibrium with $(a_i, j_i) = (H, 0)$ for all $i \in N_0$.

Proposition 3 If $m = 0$, then there exists a unique subgame perfect Nash equilibrium with $(a_i, j_i) = (H, 0)$ for all $i \in N_0$.

The above three propositions give necessary conditions for the emergence of Gama in the village. The first condition is the sympathy to other villagers and the second and third one are the existence of poor landless villagers and outsiders, respectively. If farmers do not have any sympathy, then he does not choose Gama because, by doing so, he lose the opportunity of harvesting his land. Even though he has a positive sympathy to other villagers, if there is no worker, then the choice of Gama implies to hire an outsider as the harvester of his land, by which every villager loses the opportunity of harvesting his land. Also, if there is no outsider, the choice of harvesting system is the matter of income distribution, and it is better for the farmer to choose Hunusan rather than Gama. Thus under such conditions, every farmer's choice is to select Hunusan rather than Gama.

Below I consider the case that these three parameters, n_1, m and θ are all positive.

Propositon 4 If m satisfies

$$1 - \theta(m+1) < 0,$$

then there exists a subgame perfect Nash equilibrium with $n_0(G) = n_g^*$, where n_g^* the largest integer that satisfies the following conditions:

i) $n_1 \geq n_g^*$,

ii)$n_0 \geq n_g^*$

and iii) $(m + 3 - 1/\theta)/2 \geq n_g^*$

Propositon 5 If m satisfies

$$1 - \theta(m+1) \geq 0,$$

then there exists a subgame perfect Nash equilibrium with $(a_i, j_i) = (H, 0)$ for all $i \in N_0$.

The above two propositions give conditions for the existence of Gama in the village. If m is greater than or equal to $1/\theta - 1$, then Hunusan prevails, and if not, then Gama may emerge in the village. This critical value $1/\theta - 1$ solely depends on the sympathy θ of farmer to other villagers. And, from condition iii) of Proposition 4, more the number of outsiders are, the more farmers choose Gama. To see this feature, let us consider the following example.

Example 1

Let $n_0 = 100$, $n_1 = 100$, $\theta = 0.1$, $\alpha = 1/2$ and $y = 1$.

case 1: $m = 0$

Since $1 - \theta(m+1) = 1 - 0.1 > 0$, by Proposition 5, the equilibrium is given by

$$(a_i, j_i) = \{\ (H, 0) \quad \text{for all } i \in N_0.$$

Each worker and farmer consume 1/4 units of rice and 3/4 units of rice, respectively.

case 2: $m = 20$

Since $1-\theta(m+1) = 1-2.1 < 0$, n_g^* units of land are under Gama. Since $(m+3-1/\theta)/2 = 13/2$, we have $n_g^* = 6$. Therefore the equilibrium is given by

$$(a_i, j_i) = \begin{cases} (G, j_i) & j_i \in N_1 \text{ for } i = 1, 2, ..., 6 \\ (H, 0) & \text{for } i = 7, ..., 100. \end{cases}$$

Each outsider and worker without Gama contract consumes 47/214 units of rice and each worker with Gama contract consumes 1/2 units of rice. Each farmer consumes77/107 units of rice.

case 3: $m = 50$

Since $1-\theta(m+1) = 1-5.1 < 0$, n_g^* units of land are under Gama. Since $(m+3-1/\theta)/2 = 43/2$, we have $n_g^* = 21$. Therefore the equilibrium is given by

$$(a_i, j_i) = \begin{cases} (G, j_i) & j_i \in N_1 \text{ for } i = 1, 2, ..., 21 \\ (H, 0) & \text{for } i = 22, ..., 100. \end{cases}$$

Each outsider and worker without Gama contract consumes 79/398 units of rice and each worker with Gama contract consumes 1/2 units of rice. Each farmer consumes139/199 units of rice.

case 4: $m = 210$

Since $1-\theta(m+1) = 1-21.1 < 0$, n_g^* units of land are under Gama. Since $(m+3-1/\theta)/2 = 203/2$, we have $n_g^* = 100$. Therefore the equilibrium is given by

$(a_i, j_i) = (G, j_i) \in N_1$ for all $i \in N_0$. Each worker is under Gama contract and consumes 1/2 units of rice, while each outsider consumes no rice. Each farmer consumes1/2 units of rice.

¿From the above example, we can see that the increase in the number of outsider m causes the increase in the number of Gama contract, and for sufficiently large m, all lands are under Gama contract and all outsiders are excluded from harvesting.

Another parameter other than m that affects the existence of Gama is the sympathy θ. To see this feature, let us consider the following example.

Example 2

Let $n_0 = 100$, $n_1 = 100$, $m = 20$, $\alpha = 1/2$ and $y = 1$.

case 1: $theta = 0.01$

Since $1-\theta(m+1) = 1-0.21 > 0$, by Proposition 5, the equilibrium is given by $(a_i, j_i) = (H, 0)$ for all $i \in N_0$.

Each worker and outsider consume 5/22 units of rice and each farmer consumes 8/11 units of rice.

case 2: $\theta = 0.1$

Since $1 - \theta(m+1) = 1 - 2.1 < 0$, n_g^* units of land are under Gama. Since $(m + 3 - 1/\theta)/2 = 13/2$, we have $n_g^* = 6$. Therefore the equilibrium is given by

$$(a_i, j_i) = \begin{cases} (G, j_i) & j_i \in N_1 \text{ for } i = 1, 2, ..., 6 \\ (H, 0) & \text{for } i = 7, ..., 100. \end{cases}$$

Each outsider and worker without Gama contract consumes 47/214 units of rice and each worker with Gama contract consumes 1/2 units of rice. Each farmer consumes77/107 units of rice.

case 3: $\theta = 0.5$

Since $1 - \theta(m+1) = 1 - 10.5 < 0$, n_g^* units of land are under Gama. Since $(m + 3 - 1/\theta)/2 = 21/2$, we have $n_g^* = 10$. Therefore the equilibrium is given by

$$(a_i, j_i) = \begin{cases} (G, j_i) & j_i \in N_1 \text{ for } i = 1, 2, ..., 10 \\ (H, 0) & \text{for } i = 11, ..., 100. \end{cases}$$

Each outsider and worker without Gama contract consumes 9/44 units of rice and each worker with Gama contract consumes 1/2 units of rice. Each farmer consumes31/44 units of rice.

¿From the above example, we can see that the increase in the sympathy θ causes the increase in the number of Gama contract. However, differently from the case of m in Example 1, the number of Gama is bounded above by $m+3$. Therefore, if the number of outsider m is sufficiently smaller than that of farmer n_0, some lands are under Hunusan and outisiders are to earn some amount of rice by harvesting.

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4 Application to History

In this section I consider the applicability of the model to the actual institutional changes in East Laguna village described by Hayami and Kikuchi(2000). In the model, there are three types of individuals, farmers, workers and outsiders. These types seem to correspond to large farmers, all farmers and agricultural laborers, respectively in their book. According to their book, the first change occurred as that from Hunusan to Gama in the 60's and 70's and the second one as that from Gama to new Hunusan in the 80's. In 1950, in the village, Hunusan prevailed on all lands. But during 60's it had been changing to Gama, and in 1976, almost all lands are under Gama. Around 1976, new Hunusan appeared and it has been dominating over Gama during 80's.

First, as for the population, during the first change, net migration to the village of large farmer, small farmer and agricultural laborer are given by -7, 22 and 11, respectively in 60's and -41, -15 and 85, respectively in 70's. During the second change, the net migration of them are given by 7, -5 and 7, respectively (p.65, Table 3.10).

As for the first change, it seems to be explained by the model as a result of the increase in the number of agricultural laborers(outsiders) like Example 1. On the other hand, in the second change, the migration was small, it does not seem to affect the change. However, as Hayami and Kikuchi describes;

> The hunusan contract that became widespread in the 1098's and 1990's was different from the traditional hunusan that prevailed before 1970. In the traditional hunusan that everyone could participate in harvesting and receive an output share, but in the new hunusan only the labourers who received specific invitation from employing farmers were allowed to participate.(p.179)

In the above, among the workers and outsiders, those who without "specific invitation" are considered not to be in the set of workers n_1 and outsiders m. As it is shown in Example 1, since the decrease in m causes the decrease in Gama, the model might explain the second change.

The second change could be explained as the effect of the change in θ. Hayami and Kikuchi explained the second change of Gam to Hunusan as "the shift from the community-type to the market-type of contract". If such a shift took place in the village, it seems to imply the decrease of the sympathy, θ. As it is shown in Example 2, such a decrease would cause the shift from Gama contracts to Hunusan.

In what follows, I consider the effect of green revolution on the institutional changes. In the model, the productivity y and the share of harvesting α do not affect the resulting way of harvesting, i.e., the choice of Gama or Hunusan, in equilibrium. In this sense, productivity shocks, like green revolution, does not matter. However, the productivity shock might affect the parameters of economy by which the resulting equilibrium might be affected.

To consider this, first, suppose there exists a competitive labor market and the real wage ω in terms of rice is applied to harvesting. Then the share of worker αy must be equal to the real wage ω and the increase in y will be absorbed completely through the decrease of α.

However, such a decrease in α will exaggerate the inequality of income distribution, because all the increase in output will go to the farmer and the harvester's income will stay the same as before. Such an exaggeration may cause the increase in the sympathy parameter θ, by which more farmers choose Gama in equilibrium. To see this feature, let us consider the following example.

Example 3

case 1

Let $n_0 = 100$, $n_1 = 100$, $m = 20$, $\theta = 0.01$, $\alpha = 1/2$ and $y = 1$.

Since $1 - \theta(m + 1) = 1 - 0.21 > 0$, by Proposition 5, the equilibrium is given by

$(a_i, j_i) = (H, 0)$ for $i \in N_0$.

Each outsider and worker consumes 5/22 units of rice and each farmer consumes8/11 units of rice.

case 2

Let $n_0 = 100$, $n_1 = 100$, $m = 20$, $\theta = 0.1$, $\alpha = 1/4$ and $y = 2$.

Since $1 - \theta(m+1) = 1 - 2.1 < 0$, n_g^* units of land are under Gama. Since $(m + 3 - 1/\theta)/2 = 13/2$, we have $n_g^* = 6$. Therefore the equilibrium is given by

$$(a_i, j_i) = \begin{cases} (G, j_i) & j_i \in N_1 \text{ for } i = 1, 2, ..., 6 \\ (H, 0) & \text{for } i = 7, ..., 100. \end{cases}$$

Each outsider and worker without Gama contract consumes 47/214 units of rice and each worker with Gama contract consumes 1/2 units of rice. Each farmer consumes 184/107 units of rice.

In the above example, by comparing case 1 to case 2, we can see that the productivity shock together with the decrease in α exaggerates the inequality in income between farmers and workers. The farmer's income is 38/5 times larger than the worker's one in case 2 while the ratio is 16/5 in case 1. While in case 3, as the sympathy parameter θ increases from 0.01 in case 2 to 0.1 in case 3, the average income of the worker is 5154/21400, so that the ratio is 36800/5154 which is smaller than that in case 2.

For the another case, if there is no competitive labor market in the economy, then it might occur that α is incompletely adjusted and the share of harvesting αy becomes higher than the market wage rate ω. In this case, it seems that the higher share attracts people outside the economy and cause the increase in the number of outsider m through migration. As we have seen in Example 1, the increase in m causes the increase in the number of Gama. The increase of Gama decreases the working opportunity of outsiders by which the migration will decrease.

According to the above two cases, the productivity shock seems to increase indirectly the number of Gama. In this sense, the productivity shocks seem to matter on the economy.

5 Concluding Remarks

This paper has presented a game model that explains the institutional changes from Hunusan to Gama and from Gama to Hunusan from the viewpoint of the population structure and the social norm in the village. Apparently there are many other factors that affect actual historical changes observed on East Laguna village in Philippines. However, it seems important that such changes could emerge without the productivity growth which has been a dominant view of the historical change.

In the model, I assumed identical farmers who have the same amount of land and the same strength of sympathy to other villagers. However, as Hayami and Kikuchi described in their book, the structure of land ownership is more complicated than that assumed in the paper. Also there exists other specification of the social norm than that in this paper by which the result could be different from that in this paper. Such extensions should be done in future research.

Footnotes

1. For the discussion of the social norm from the viewpoint of Economics, see, for example, Sen(1987).
2. For simplicity, I assume that the farmer can harvest his own land under Hunusan. This assumption can be modified in the way that he cannot harvest his own land, which seems to be more plausible. However, such a modification affects only the allocation, and does not affect the equilibrium choice of harvesting system.
3. Actually Gama is a contract that incudes free weeding on the land. However, if the labor market is competitive, such free weeding must be compensated by the farmer in some manner. Therefore, for simplicity, the free weeding is not considered in this paper.

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Appendix

Proof of Proposition 1

I consider farmer i's problem. Let (a_s^*, s_i^*) with $s = 1, 2, ..., n_0$ and $s \neq i$ be given, and let n_g' be the number of farmers other than i who select Gama and let n_w be the number of workers whom the farmers other than i select as Gama harvesters.

Suppose $\theta = 0$. Then we have

$$[u_i^H - u_i^{G_1}]/(\alpha y)$$
$$= \{[(n_0 - n_g')/(n_0 + n_1 + m - n_g')] - [(n_0 - n_g' - 1)/(n_0 + n_1 + m - n_g' - 1)]\} \cdot$$
$$[1 + \theta(-m + n_g' + n_w - 1)]$$
$$= \{[(n_0 - n_g')/(n_0 + n_1 + m - n_g')] - [(n_0 - n_g' - 1)/(n_0 + n_1 + m - n_g' - 1)]\}$$
$$> 0$$

for any number of n_g'. Therefore farmer i chooses Hunusan. This completes the proof.

Proof of Proposition 2

Apparent from case 3 of Step 3 in Solution.

Proof of Proposition 3

I consider farmer i's problem. Let (a_s^*, s_i^*) with $s = 1, 2, ..., n_0$ and $s \neq i$ be given, and let n_g' be the number of farmers other than i who select Gama and let n_w be the number of workers whom the farmers other than i select as Gama harvesters.

Suppose $m = 0$. Then we have

$$[u_i^H - u_i^{G_1}]/(\alpha y)$$
$$= \{[(n_0 - n_g')/(n_0 + n_1 + m - n_g')] - [(n_0 - n_g' - 1)/(n_0 + n_1 + m - n_g' - 1)]\} \cdot$$
$$[1 + \theta(-m + n_g' + n_w - 1)]$$
$$= \{[(n_0 - n_g')/(n_0 + n_1 - n_g')] - [(n_0 - n_g' - 1)/(n_0 + n_1 - n_g' - 1)]\} \cdot$$
$$[1 + \theta(n_g' + n_w - 1)],$$

which is always positive. Therefore i chooses Hunusan. This completes the proof.

Proof of Proposition 4

Suppose m satisfies

$$1 - \theta(m + 1) < 0$$

Then there exists some integer $n^* \geq 1$ satisfying

$$[1 + \theta(-m + 2n^* - 3)] < 0.$$

Let n_g^* be the largest number n^* that satisfy
i) $n_1 \geq n^*$,
ii)$n_0 \geq n^*$
and iii) $(m + 3 - 1/\theta)/2 \geq n^*$.
Then we have

$$\{[(n_0 - n_g^* - 1)/(n_0 + n_1 + m - n_g^* - 1)] - [(n_0 - n_g^* - 2)/(n_0 + n_1 + m - n_g^* - 2)]\}\cdot$$
$$[1 + \theta(-m + 2n_g^* - 3)]$$
$$\square\ 0$$

.

Therefore $\{(a_i^*, j_i^*)\}_{i=1}^{n_0}$ with $n_0(G) = n_g^*$ is an equilibrium. This completes the proof.

Proof of Proposition 5

Apparent.