Endowments, Technology, and Factor Markets: A Natural Experiment of Induced Institutional Innovation from China's Rural Reform

by

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Abstract

The induced institutional innovation hypothesis postulates that new institutions are innovated to take advantages of profitable opportunities arising from institutional disequilibrium. The removal of bans on factor market exchanges in recent reforms in China resulted in an institutional disequilibrium. This paper utilizes data from a household survey in China to verify hypotheses about: 1) the relationship between the emergence of factor markets--namely land, labor, and rental markets--in a region and the distribution of factor endowments across rural households in that region; and 2) the impact of technology, specifically the hybrid rice, on the emergence of factor markets in that region. The results are consistent with the predictions from the induced institutional innovation hypothesis.

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The study of institutions and their evolution is one of the foci of Marxist economics. In contrast, conventional neoclassical economists used to take the market institutions of Western economies for granted, and focused their attentions to the issues related to individual utility maximization in the given institutional structure. However, non-market institutions exist side by side with markets in real-world. Taking market institutions as given, economists will not be able to deal with a variety of critical issues in the process of economic development. In recent decades, economists such as Williamson (1975, 1985), North (1981, 1990) and Hayami and Ruttan (1985) have attempted to endogenize institutions. A new branch, named the new institutional economics, is emerging in the mainstream economics.

Two propositions have been widely entertained by the new institutional economists: (i) institutions matter, and (ii) institutions provide valuable service to the economy and the determinants of institutions are susceptible to the tools of economic analysis. However, as commented by Matthews (1986), "Theory has made an indispensable contribution in recent times to advances of understanding in this area. But ... the economics of institutions theory is now outstripping empirical research to an excessive extent." In a recent extensive literature survey of economics of institution, Eggertsson (1990) echoed Matthews' view. Interesting case-studies exist. Rigorous empirical analyses are wanting. The main reason for the underdevelopment of empirical research in this area is the lack of data. Institutions are complex, difficult to quantify, and evolve gradually. The data related to institutions are not routinely gathered by the national statistical offices. However, as Herbert

Simon (1991) comments: "Until that (empirical) research has been carried out, ..., the new institutional economics and related approaches are acts of faith or perhaps piety."

Economic theory predicts that, as long as the marginal products of land, labor, and other factors of production are different across production entities, factor market exchanges among these entities are mutually beneficial. The differences in marginal products may reflect the differences in factor endowments or in the adopted technology. The emergence of factor markets in history can thus be viewed as an institutional innovation induced by the differences in factor endowments or adopted technologies across production units. Transactions in land, labor, and rental markets among different production units, however, were prohibited in the collective period in China. The transition from the collective system to a household-based farming system began in 1979. The Chinese government lifted the bans on these markets in 1984. So far rural land, labor, and rental markets just begin to emerge. The removal of bans constitutes a natural experiment for the evolution of factor market institutions. In this paper I attempt to utilize data from a household survey in China to verify hypotheses about: 1) the relation between the emergence of factor markets--namely land, labor, and rental markets--in a region and the distribution of factor endowments across rural households in that region; and 2) the impact of technology, specifically the hybrid rice, on the emergence of factor markets in that region.

The organization of the paper is as follows: Section I gives an overview of the economic reforms and the innovation of hybrid rice in China. Several testable propositions derived from the induced institutional innovation hypothesis á la Hayami and Ruttan, and Davis and North are presented in this

section. It is followed by a description of the study areas and the extent of land, labor, and rental markets in those areas. Section III discusses the functional forms and the estimation methods. Section IV reports the econometric results. The last section summarizes the paper.

I. Rural Reforms and the Innovation of Hybrid Rice

Before the recent rural reforms in China, a production team, usually consisting of about 20-30 neighboring households, was generally the basic unit of production. The team was entitled to all factors of production. These factors were allocated under the unified management of a team leader with the exception of small private plots reserved for households' use in their spare time. Peasants, working under the supervision of a team leader, obtained work points for a day's work that they had done. At the end of a year, the net team income was first distributed among team members according to basic needs, then the rest was distributed according to the work points that each one had accumulated during the year. This institution was detrimental to peasants' work incentives.

At the end of 1978, the government introduced the practice of dividing a team into smaller groups within the team along with a package of other policies aiming at improving agricultural production in rural areas.[1] At first, this policy was designed to improve the management and incentive problems within a team. However, it evolved into a specific form now called "the household responsibility system" that dissolved the production teams and restored individual households as the basic unit of agricultural production.[2] By the end of 1983, 98% of production teams in China adopted the new system. Recent empirical studies found that the shift from the production team system to the household responsibility system was the major source of a remarkable

agricultural growth in 1978-84 (McMillan, Whalley and Zhu 1989, Lin 1992a).

When a production team adopted the household responsibility system, land and other resources in the team were in most cases allotted to each household in proportion to its size. Therefore, for the households in a team, their land-person ratio was equalized after the household responsibility system reform. Households are at different stages of a life cycle. Their members also differ in education, experience and other abilities. They thus have different stocks of effective family labor. As a result, the egalitarian allocation of land in the process of reform results in disparities in the marginal products of land and labor across households. The differences in marginal productivity across households represent an allocation inefficiency.[3] Market exchanges in land, labor and other factors among households can improve the efficiency.

When the household responsibility system first appeared, hiring labor and leasing land among individual households were explicitly prohibited by government policies. Since then there have been substantial changes in government positions. Leasing out land to other farmers, hiring workers within a limited number (less than eight), and renting farming capitals were formally sanctioned in 1984. The removal of the legal restriction on exchanges in rural factor markets enlarged a peasant's institutional choice set. The original institutions would have been in disequalibrium. It is thus interesting to examine whether the emergence of rural factor markets in China can be explained by the induced institutional innovation hypothesis, which states that institutions evolved to take advantages of new profitable opportunities arising from institutional disequilibrium (Hayami and Ruttan 1985, North and Thomas 1971).

Institutions provide the structure of exchange in order to obtain the

gains from cooperations (North 1990). Given a production technology, if land, labor, and capital endowments differ across households, the marginal products of these factors will also be different. Market exchanges in land, labor, and capital to reduce the disparities are mutually beneficial to the households involved in the exchanges. If the induced institutional innovation hypothesis is valid, several relationships between a household's endowment structure and its factor market transactions are expected to exist:

H1: Increasing a household's family labor force has a positive effect on its supply of labor to labor market and a negative effect on its demand for hired labor.

H2: Increasing a household's landholding has a positive effect on its supply to land market and a negative effect on its demand for land lease.

H3: Increasing a household's capital stock reduces its demand for hired tractor and draft animal services.

In agricultural production, as in any other production, the optimal input mix depends on the specific technology used in the production process. Therefore, in addition to its endowment structure, a household's decision about factor market exchange also depends on the specific technology that the household adopts. The technology that will be investigated in this paper are the conventional modern rice and the hybrid rice. Despite its many shortcomings concerning economic development, the socialist system in China seems to have contributed remarkably to China's rice research. China began full-scale distribution of semi-dwarf rice varieties in 1964, two years earlier than the International Rice Research Institute's release of IR-8,

which was the varieties marking the beginning of the Green Revolution in other parts of Asia. The diffusion of semi-dwarf varieties was rapid in China. By the end of 1970s, more than 80% of the rice crop area was planted to the improved varieties. The commercial dissemination of hybrid rice in 1976 was claimed as the most significant achievement of rice research in the 1970s (Barker and Herdt 1985). In 1990, about 40 percent of China's rice area was planted in hybrid rice. So far, China remains the only country in the world that produces hybrid rice commercially.[4]

In a related study, it is founded, compared with the use of conventional semi-dwarf varieties, the productivity advantage of producing hybrid rice on farmer's field is about 20 percent. It is also found that, compared with conventional semi-dwarf varieties, the cultivation of hybrid rice (1) requires significantly less labor and draft animal power, (2) needs significantly more chemical fertilizer, and (3) has no perceivable differences on the usage of other inputs (Lin 1992c).[5]

From the above technical properties we can predict that, if a household adopts hybrid rice, *ceteris paribus*, the household's likelihoods of hiring labor and renting draft animal service are reduced, and the household's likelihood of being hired for agricultural work is increased. The impact of hybrid rice on land market transaction, however, may be ambiguous. On the one hand, due to the lower requirement for labor input, the adoption of hybrid rice may increase the demand for land due to the increasing availability of labor. On the other hand, because of the existence of a discriminate price policy against rice, the cultivation of rice is less profitable than producing other crops and pursuing other activities. A household may cultivate just enough rice for its own consumption and to meet the quota obligation. Hence

the adoption of hybrid rice may result in a reduction of rice acreage and thus a smaller demand for land. What the net impact will be is an empirical issue. Because hybrid rice has no perceivable difference in the usage of other inputs, the adoption of hybrid rice may not have significant effects on the transactions of other factor markets. In short, the adoption of hybrid rice is expected to have the following testable effects on factor market exchanges:

R1: The adoption of hybrid rice increases a household's supply to labor market and reduces its demand for hired labor.

R2: The adoption of hybrid rice reduces a household's demand for hiring draft animal services.

II. The Study Areas and the Extent of Factor market Activities[6]

The data underlying the study were obtained through a farm household survey in five counties in Hunan province organized by the author in the winter of 1988: Tiaojiang and Xiangxiang are located in the hill region of the province; Nanxian and Anxiang are in the lake-plain region, and Zhijiang is in the mountain region. These five counties are among the 34 counties in the province annually surveyed by the State Agricultural Household Survey Team. One-hundred households from each county are included in the samples. Data on hybrid rice adoption and factor market exchanges were collected along with other information including a household's landholding, labor endowments, capital endowments, and so on. Among these 500 households, six households have given up farming.

The household responsibility system was adopted in the study areas in 1982 and 1983. As in other areas in China, when the new system was adopted, land and most farming equipments in a collective team were distributed to a

household in proportion to the size of the household. Table 1 reports the endowment positions of the sampled households in each county. In the hill and mountain regions, on the average a household has about 4.2 persons and 0.35 hectares of land, whereas in the lake-plain areas the average household size is about 4.6 persons and the landholding are about .55 hectare. Households in the two lake-plain counties had the largest farm size. The main reason for the large farm sizes in that region is because a substantial amount of cultivated land has been newly reclaimed from Dongting Lake, one of the five largest lakes in China. As expected, the landholding are very fragmented.[7] A household, on average, has about 5 to 11 tracts of land. With the exception of Tiaojiang county in the hill region, the fragmented situation has not improved since the adoption of the household responsibility system. Table 1 also reports the number of households with investments in various types of farm capital. With the exception of Xiangxiang county in the hill region, over three-quarters of households in each county own draft animals. In Xiangxiang county only one-fifth of the households own draft animals, but two-fifths of the households in the county own hand tractors. The possession of hand tractors in the other counties is rare. Again, with the exception of Xiangxiang county where one-third of the households owned threshers, the ownership of threshers is uncommon in all other counties. In the entire sample only nine households owned a medium or large tractor.

When the household responsibility system was first introduced, the land contracts in general ranged from one to three years. When an original contract expired, land was reassigned and adjusted according to changes in household size. This practice was soon found to be impractical. Because the usufruct right of land might be assigned away in the next contract, each household

lacked incentive to invest in land improvement and to maintain the soil fertility properly. To overcome this disincentive involving land investment and land maintenance, the Chinese government adopted a policy of lengthening the contract of land usage to each household for up to 15 years or longer in 1984. A 15-year contract is standard in the study areas.

The hybrid rice was introduced to the study areas in 1976. Among the five hundred households 494 households allocated parts of their cultivated land to rice production. The detailed information on the adoption of hybrid rice in each cropping season in the sample is reported in table 2. Whereas only a few (thirteen) among the 494 households planted hybrids in the early rice season, the majority of households adopted hybrid seeds either in the middle season, if only one crop of rice is grown per year, or in the late season if two crops of rice are grown each year. A substantial portion of the households in each county planted both hybrid and conventional rice in a single crop season.

Table 3 summarizes the extent of labor, machine, and draft animal hiring in terms of the percentage of hired service within the total service for the cultivation of rice in the samples. As shown, the percentage of hired labor within the total labor input in the cultivation of rice is negligible. A household devoted about 100 to 145 days per year to rice cultivation in the samples. On the average, a household hired less than two labor days per year. The extent of rented service for tractor and draft animals is substantially higher than hiring in labor markets. For the rented tractor service, the percentage ranged from 0 to 41.3, and for rented draft animal service from 3 3 to 17.1. However, because the total tractor and animal services are small, on the average, a household rented less than one day each of tractor and draft

animal service.

In terms of the percentage of service, the extent of labor and rental markets is very limited. However, in terms of the number of households involved, the extent of markets for labor and rental markets is quite substantial. Table 4 reports the number of households that participated in labor and rental markets. As shown, out of the 500 surveyed households, 98 households hired labor for the cultivation of rice, 43 households were hired for off-farm agricultural jobs, 31 households hired tractor service, and 73 households hired draft animal service.

Land market transactions in rural China are confined to the subleasing form because land is still owned collectively. However, a household can sublease its land, which it leased from the collective, to other households or lease more land from the collective and other households. A household may also return a certain portion of its land to the collective if it shifts its major activities to non-farm jobs. The situation in the land market is similar to the labor and rental markets. As shown in table 5, in terms of the land that is involved in the lease-in or lease-out, the percentage is very limited. However, the number of households involved in the transaction is substantial. In each county, the amount of lease-in land is larger than the amount of lease-out land. This is because part of the lease-in land is from the collective's reserved land.[8]

III. Functional Form Specification

The underlying equations for factor market determinations that I attempt to estimate are semi-reduced forms. Except for the variables involving the adoption of hybrid rice, all other explanatory variables in the market determination equations are predetermined. The adoption of hybrid rice is

itself an endogenous decision (Lin 1991). Therefore, to estimate the impact of the adoption of hybrid rice on a type of market transaction, such as the hiring-in of labor or the leasing-in of land, I shall use a simultaneous equations model.

$$M^* = \alpha_1 D^* + \beta_1' Z_1 + \mu_1 \quad (1)$$

$$D^* = \beta_2 M^* + \beta_2' Z_2 + \mu_2, \quad (2)$$

where M^* is a column vector indicating the extent to which a household is involved in various types of factor market transaction. The market transactions include hiring-in and hiring-out labor, leasing-in and leasing-out land, and renting-in tractor and draft animal services. D^* is a variable indicating the ratio of paddy land that a household allocated to hybrid rice. Z_1 and Z_2 are respectively a matrix and a vector of predetermined variables determining the extent of factor market exchanges and the adoption of hybrid rice. And μ_1 and μ_2 are error terms.

The predetermined variables affecting a household's involvement in a type of market transaction are assumed to be identical across all types of market activities. Several groups of variables are included. The first group is a household head's personal characteristics, including his/her sex, age, and years of schooling. The second group is a household's endowments, including its landholding,[9] labor force and capital stock. Both groups of variables may affect a household's opportunity costs of being involved in a type of market exchange. The third group of variables is the village-level wage rate, rent for tractor service, and rent for draft animal service.[10] This group of variables represents the economic environment. The last group is composed of county dummies that represent some county-specific

characteristics, such as infrastructure, topology, population density, and so on. These variables may affect the extent of market development in a county; however, they are not observable to an econometrician.

The group of predetermined variables in expression 2--the hybrid rice adoption function--is similar to the set that is used in Lin's previous study on the effect of education on the adoption decision (Lin 1991). The differences between Z_1 and Z_2 are as follows: the village-level wage rate and rents for tractor and draft animal services in Z_1 are replaced by the village-level prices for hybrid rice seeds, chemical fertilizers, and pesticides.[11] In addition, Z_2 also includes dummies to indicate whether a household has the quota obligation of selling a certain amount of grain to the state at below market prices and whether a household has the experience of borrowing in the credit market in the previous two years. Table 6 reports the definitions, means and standard deviations of the dependent and predetermined variables.

As tables 3 and 5 suggest, the factor markets in rural China are nascent. The extent of transactions in labor, land, and rental markets is very small. Therefore, instead of asking what factors determine the <u>extent</u> of a household's participation in a factor market, the more interesting question is what factors determine a household's <u>probability</u> of participating in the factor market exchanges. Accordingly, I shall estimate a linear probability model. That is, the dependent variables in expressions 1 and 2 will be replaced by dummy variables.

$M_i = 1$ if $M_i^* > 0$,

$M_i = 0$ otherwise.

$D = 1$ if $D^* > 0$,

D = 0 otherwise.

Since M_i and D are both binary variables taking the value of 1 or zero, probit is an appropriate method for fitting the equations. Because the endogenous variable, D^*, is likely to correlate with μ_1 and M^* to correlate with μ_2, estimating the parameters in expressions 1 and 2 by probit directly will not produce consistent estimates. Therefore, a two-stage method as proposed by Mallar is used (Mallar 1977; see also Maddala 1983, pp. 246-7). In the first stage, we use probit to estimate the reduced forms:

$$M^* = \gamma_1 Z + \nu_1 \qquad (1')$$

$$D^* = \gamma_2 Z' + \nu_2, \qquad (2')$$

where Z and Z' are a matrix and a vector that include all different variables in Z_1 and Z_2. Then we substitute the predicted values of M^* and D^* and estimate the linear probability models by the probit method.

IV. Empirical Results

The regression results for the market determination functions are reported in table 7. For simplicity, results for the first-stage estimation and results for the hybrid rice adoption function are omitted. I will first discuss the effects of hybrid rice adoption on the likelihood of a household's involvement in market transactions and then the effects of a household's endowment structure.

Labor Markets

Columns 1 and 2 in table 7 report the regression results for labor-market transactions.

Since hybrid rice requires less labor input compared with that needed

for the conventional rice, we expect, given other conditions, a household's adoption of hybrid rice to reduce the household's likelihood of hiring labor for rice cropping and increase the likelihood of offering labor for off-farm agricultural employment, as postulated in R1. The result in column 1 of table 7 is consistent with the prediction of R1. The estimated coefficient of the hybrid rice adoption dummy is negative and highly significant. The sign of the hybrid rice adoption dummy in column 2 is also consistent with R1, however, it is not statistically significant. The insignificance may arise from the fact that the off-farm agricultural employment is only one of several areas that a household can utilize the labor released from adopting hybrid rice.[12]

The signs of the estimates for a household's family labor stock is also consistent with the predictions of H1. If a household has a larger stock of family labor, the likelihood of hiring labor service for rice cropping is significantly lower, and its effect on the likelihood of supplying labor to labor market is positive. The latter effect, however, is not statistically significant. The reason for the insignificance may be also because off-farm agricultural employment is only one of several ways that a household can utilize its larger labor force.

In the labor-hiring equation, the village-level wage rates are expected to have a negative sign, and in the off-farm agricultural employment equation wage rates are expected to have a positive sign. The estimates are consistent with the first prediction but not with the second prediction. However, none of them are statistically significant.

It is interesting to note that the signs of most other variables in columns 1 and 2 are also consistent with the hypothesis that factor markets exist to equalize marginal products of factor across households. A household's

landholding have a positive sign in column 1. The estimate is statistically significant. A larger farm size requires more labor inputs; therefore, while holding a household's labor force constant, increasing its farm size raises the household's likelihood of hiring labor. The coefficient of a household's capital stock is negative and significant in the labor-hiring equation. This effect is also expected because capital is a substitute for labor. A household with a household head who has received higher education is found significantly more likely to hire labor for rice cultivation than a household head who has less education. This is probably due to the fact that a farmer with a better education is more likely to obtain a non-farm job. Therefore, the likelihood of hiring labor is increased. The estimate of a female dummy in column 1 is positive and significant. The evidence suggests that a female household head's effective labor is less than that of a male household head.

Land Markets

The regression results for land market transactions are reported in columns 3 and 4 of table 7.

The signs of the hybrid rice adoption dummy are positive both in the lease-out equation and in the lease-in equation. However, none of them are statistically significant. Since, as argued in Section 2, the adoption of hybrid rice has no unambiguous effects on a household's demand or supply of land, the results are expected.

The estimates of a household's initial landholding in columns 3 and 4 have the expected signs as postulated by H2. The estimates are positive in the lease-out equation and negative in the lease-in equation. Both estimates are highly significant. Holding labor force, capital stock, and other variables constant, increasing a household's landholding raises the household's

likelihood of lease-out land and reduce its likelihood of leasing land. Land market transactions carried out in this way equalizes the marginal product of land and labor, and improve the efficiency of resource allocation.

The estimated coefficients of the labor force are negative in the lease-out equation and positive in the lease-in equation. These signs are consistent with the hypothesis that factor markets exist to improve resource allocation. However, the estimates are not statistically significant. Column 4 also shows that a household's capital stock has a positive and statistically significant effect on the likelihood of lease-in land. Capital is a substitute for labor and a complement to land; therefore, the positive impact of capital on the likelihood of lease-in land is consistent with the theory.

The estimates of the household head's characteristics on land market transactions are also very informative. The education of a household head has a significantly negative effect on the likelihood of lease-out land. A household head's managerial ability is likely to increase with his educational level. The effective labor of a household head with a higher education is larger than that of a household head with a lower education. Therefore, education has a negative effect on the likelihood of lease-out land. Even if a household head with a higher education obtains a non-farm job, he can overcome the labor shortage by hiring labor, as the estimate in column 1 suggests.[13] However, the estimate of education in the lease-in equation is not significant. This phenomenon may reflect the state's price discrimination against the rice sector. Due to the unfavorable prices, the incentives for a household head with higher education to increase its landholding is small. The estimated coefficient of age in the lease-in equation is negative, and the estimated coefficient of the female dummy in the lease-out equation is

positive. Both estimates are significant at a 10-percent level of confidence. The estimates may arise from the adverse effects of age and gender on effective labor.

Rental Markets

The estimates for the rental markets are reported in columns 5 and 6 in table 7.

As postulated in R2, because of the less requirement for draft animal power in the production of hybrid rice, the adoption of hybrid rice is expected to reduce a household's likelihood of hiring draft animal service. The coefficient for hybrid rice adoption dummy in column 6 is negative and highly significant. The result is consistent with this prediction. The estimate in column 5 suggests that the adoption of hybrid rice has no significant effect on a household's likelihood of hiring tractor service. This result is also expected.

The estimates in columns 5 and 6 for the own-price effects on a household's likelihood of hiring services from rental markets are consistent with the predictions from economic theory. As suggested by the estimates, a higher tractor rent significantly reduces a household's likelihood of hiring tractor service and a higher draft animal rent significantly reduces a household's likelihood of hiring draft animal service. Since tractor services and draft animal services are substitutes, the cross-price effects are expected to be positive. This expectation is confirmed in the regressions. The estimate of draft animal rent in column 5 and the estimate of tractor rent in column 6 are both positive. Moreover, the estimate of draft animal rent in column 5 is highly significant.

In columns 5 and 6, a household's landholding have a significantly

negative effect on the likelihood of hiring tractor service and a significantly positive effect on the likelihood of hiring draft animal service. Whereas the second effect is consistent with the prediction from theory, the first effect is unanticipated. The question of why a household that has a larger landholding tends to hire draft animals but not tractors deserves further investigation. The estimates for a household's capital stock are both negative and significant in the tractor hiring equation and in the draft animal hiring equation. The farm equipment included in the capital stock consists of tractors, hand-tractors, and draft animals. Therefore, a household with a larger capital stock is expected to reduce the likelihood of hiring tractor and draft animal service.

Among the variables representing a household's characteristics in columns 5 and 6, only the estimate of the female dummy in the draft animal hiring equation is statistically significant. The estimate suggests that a household with a female household head is more likely to hire draft animals than a household with a male household head. The reason, as in the case of labor hiring, may again arise from its gender effect on effective labor.

IV. Concluding Remarks

The induced institutional innovation hypothesis, as formulated by Hayami and Ruttan (1985, chap. 4) as well as Davis and North (1970), suggests that institutions evolve to take advantages of new profitable opportunities arising from institutional disequilibrium. The removal of restrictions on factor market transactions after the household responsibility system reform provides a natural experiment for testing the hypothesis. Factor markets are nascent in rural China. If the induced institutional innovation hypothesis is valid, the likelihood of a household's involvement in the nascent markets can be

predicted by its factor endowments and adopted technology. This prediction is confirmed by the econometric analysis. The finding constitutes an evidence to the induced institutional innovation hypothesis and to the proposition that the determinants of institutions are susceptible to the tools of economic analysis.

Notes

[1]These policies included diversification of the rural economy, production specialization, crop selection in accordance with regional comparative advantages, expansion of local fairs, marked rises in state procurement prices, and rapid growth in the availability and better allocation of chemical fertilizers.

[2]When the rural reforms started, the government explicitly prohibited the practice of subdividing a team's land and production to individual households. Nevertheless, toward the end of 1978, a small group of production teams secretly tried out the system of contracting land and other resources to individual households. A year later, these teams brought in yields far exceeding those of neighboring teams. The government later accepted the existence of this new system but restricted its applicability to poor teams only. However, most teams ignored this restriction. Full official recognition of the household responsibility system was granted in late 1981, when 45 percent of the production teams in China had already been dismantled. By the end of 1983, 98 percent of production teams had adopted this new system. The change in this institutional arrangement by and large evolved spontaneously in response to underlying economic forces. It provides an evidence for the induced institutional innovation hypothesis. For an econometric tests of this hypothesis, see Lin (1987).

[3]In addition to the disparity in marginal products created by the household responsibility system, the allocation inefficiency has another source in China. Like any other country, the endowments of land and other resources vary greatly from village to village. Since migration between rural areas failed to exist at any significant level before the reforms, the differences in land-labor ratio across regions have long been maintained. Therefore, marginal products in land

and labor should also be different across regions.

[4]The invention and diffusion of hybrid rice in China can be viewed as an technological innovation induced by market demand. For an empirical test of the market-demand induced technological innovation hypothesis á la Griliches-Schmooker, see Lin (1992b).

[5]The lesser requirements for labor and draft animal power may arise from the fact that the seed requirement for hybrid rice is only one-third to one-fourth of that of conventional semi-dwarf varieties, due to the heterosis of hybrid rice. Therefore, less labor and draft animal power are needed for seed-bed preparation and transplanting.

[6]For a more detailed discussion of the study area and the data set, see Lin (1991).

[7]When a production team adopted the household responsibility system, the team's land was first divided into several different grades. Each household in the team then acquired a tract from each grade.

[8]The population size of a household may have changed after the allocation of land at the time of the household responsibility system reform. To meet the demand for the marginal adjustment of landholding in case of changes in a household's size, most production teams retained a portion of their land as reserve. This reserved land was leased to other households before it was allocated to a household.

[9]For the equations of leasing-in land and leasing-out land, the landholding refers to the initial landholding at the time of adopting the household responsibility system. For other types of market transactions, the landholding refers to the current operational holdings.

[10]Theoretically, the land rent should also be included as an explanatory variable. However, due to the ideological heritage, the land rent is suppressed in most cases of subleasing. Therefore, this variable is not included. The wages and rents are derived from each household's actual expenditures on hiring labor, tractor service, and draft animal service, divided by the number of days using hired labor, tractors, and draft animals. For wages, the expenditures include both the money payment and the costs for food. The wages and rents used in the regression are the village-level average. In the case where a village did not have these data, the county average wage and rent are used. The village-level, instead of household-level, information is used so as to prevent the possibility of simultaneity.

[11]The village-level prices are derived in a similar way as that explained in footnote 7.

[12]For example, a household can use the newly released labor to cultivate other more labor-intensive crops, to engage in its own non-farm business, and so on.

[13]This is because in rural China most households take land as an insurance, when they have non-farm occupations.

Reference

Barker, R. and R. W. Herdt, 1985, The Rice Economy of Asia. Washington, D.C.: Resources for the Future.

Davis, L. and D. C. North, 1970, "Institutional Change and American Economic Growth: A First Step Towards a Theory of Institutional Innovation." Journal of Economic History, 30, 131-49.

Eggertsson, T., 1990, Economic Behavior and Institutions. Cambridge: Cambridge University.

Hayami, Y. and V. W. Ruttan, 1985, Agricultural Development: An International Perspective (revised and expanded), Baltimore: the Johns Hopkins University Press.

Lin, J. Y., 1992, "Rural Reforms and Agricultural Growth in China." American Economic Review, 82, 34-51 (a)

Lin, J. Y., 1992, "Hybrid Rice Innovation in China: A Study of Market-Demand Induced Technological Innovation in A Centrally-Planned Economy." Reviews of Economics and Statistics, 74, 14-20 (b).

Lin, J. Y., 1992, "The Impact of Hybrid Rice on Input Demand and Productivity." Beijing: Department of Rural Economy, DRC, Working Paper, 92-01. (c).

Lin, J. Y., 1991, "Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China," American Journal of Agricultural Economics, 73, 713-723.

Lin, J. Y., 1987, "The Household Responsibility System Reform in China: A Peasant's Institutional Choice." American Journal of Agricultural Economics, 69, 410-15.

Maddala, G.S., 1983, Limited-Dependent and Qualitative Variables in Economics, New York: Cambridge University Press.

Mallar, C.D., 1977, "The Estimation of Simultaneous Probability Models." Econometrica, 45, 1717-22.

Matthews, R. C. O., 1986, "The Economics of Institutions and the Sources of Growth." the Economic Journal, 96, 903-18.

McMillan, J., J. Whalley, and L. Zhu, 1989, "The Impact of China;s Economic Reforms on Agricultural Productivity Growth," Journal of Political Economy, 97, 781-807.

North, D. C., 1990, Institutions, Institutional Change and Economic Performance. Cambridge: Cambridge University Press.

North, D. C., 1981, Structure and Change in Economic History. New York:

Norton.

Simmon, H. A., 1991, "Organization and Markets." Journal of Economic Perspectives, 5, 25-44.

Williamson, O. E., 1975, Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.

Williamson, O. E., 1985, The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting, New York: Free Press.

Table 1: Household Size, Landholding, and Capital Endowments

	Tiaojiang	Xiangxiang	Nanxian	Anxiang	Zhijiang
Household size (persons)	4.28 (.92)	4.26 (1.42)	4.62 (1.19)	4.63 (1.20)	4.20 (1.22)
Initial landholding (ha)	.34 (.15)	.32 (.12)	.55 (.19)	.60 (.19)	.40 (.18)
No. of plots	10.62 (7.26)	6.30 (2.80)	7.00 (2.48)	5.42 (1.71)	11.86 (5.92)
Current landholding (ha)	.33 (.15)	.31 (.11)	.55 (.20)	.56 (.20)	.40 (.17)
No. of plots	8.38 (3.40)	6.35 (2.55)	6.94 (2.15)	5.33 (1.61)	10.62 (2.55)
No. of household owned:					
Tractors	4	0	3	2	0
Hand tractors	1	1	39	3	0
Threshers	3	12	33	5	0
Draft animals	81	76	20	76	84

Table 2: The Adoption of Hybrid and Conventional Rice in 1988

	Hill		Lake-Plain		Mountain
	Tiaojiang (N=100)	Xiangxiang (N=100)	Nanxian (N=97)	Anxiang (N=99)	Zhijiang (N=99)
No. of Households					
Early-Season Rice:					
Hybrid	4	7	0	0	2
Conventional	98	98	92	98	6
Both	2	5	0	0	0
Middle-Season Rice:					
Hybrid	0	1	8	8	99
Conventional	0	0	11	9	14
Both	0	0	0	2	14
Late-Season Rice:					
Hybrid	79	67	63	90	9
Conventional	35	49	78	51	0
Both	14	18	46	43	0

Table 3: The Extent of Labor and Rental Markets

	Tiaojiang	Xiangxiang	Nanxian	Anxiang	Zhijiang
Labor Day per Household:	120.1	101.0	129.3	145.5	97.9
% hired	1.0	1.3	0.9	0.7	2.3
Machine Day per Household:	0.3	12.5	4.3	0.8	0.1
% rented	3.3	12.0	15.3	41.3	0
Animal Day per Household:	12.1	7.9	3.5	7.2	17.8
% rented	6.1	14.9	17.1	15.0	3.3

Table 4: Households Engaged in Labor and Rental Markets Activities in Rice Production

	Tiaojiang (100)	Xiangxiang (100)	Nanxian (100)	Anxiang (100)	Zhijiang (100)
Labor Market					
Hiring Labor for Rice Cropping:					
Yes	16	23	24	25	10
No	84	77	76	75	90
Employed in Off-farm Agri. Job:					
Yes	10	5	9	0	19
No	90	95	91	100	81
Rental Market					
Hiring Tractors for Rice Cropping:					
Yes	1	2	21	7	0
No	99	95	79	93	100
Hiring Draft Animals for Rice Cropping:					
Yes	10	24	15	19	5
No	90	76	85	81	95

Table 5: Land Market Transactions

	Tiaojiang	Xiangxiang	Nanxian	Anxiang	Zhijiang
Changes in Landholding					
Lease-out Land per Household (ha)	.0008	.0042	.0346	.0465	.0195
Lease-in Land per Household (ha)	.0069	.0072	.0369	.0204	.0180
Land Market Transactions					
Lease out Land?					
Yes	1	10	21	20	14
No	99	90	79	80	86
Lease-in Land?					
Yes	9	14	24	20	18
No	91	86	76	80	82

Table 6: Variable Definitions, Means, and Standard Deviations

Dependent Variables:	
Dummy for hiring labor, = 1 if labor is hired	.20 (.40)
Dummy for working in off-farm agr. job, = 1 if off-farm agr.income>1.	.09 (.28)
Dummy for lease-out land, = 1 if part of land is leased out.	.14 (.34)
Dummy for lease-in land, = 1 if part of land is leased in.	.17 (.38)
Dummy for hiring tractor service, = 1 if hired tractor is used.	.07 (.25)
Dummy for hiring draft animal service, = 1 if hired animal is used.	.15 (.35)
Independent Variables:	
Hybrid rice adoption Dummy, = 1 if hybrid rice is adopted.	.82 (.39)
Years of schooling of household head	5.49 (2.58)
Age of household head	42.91 (10.80)
Dummy for the gender of household head, = i if female.	.04 (.19)
Household landholding at present time (in hectares)	.43 (.20)
Household landholding at the time of adopting the new farming system	.44 (.20)
Household labor force	3.02 (1.14)
Value of a household's capital stock (in Yuan)	459.22 (653.24)
Wage rate (in Yuan)	7.82 (2.31)
Tractor rent (in Yuan)	15.95 (4.77)
Animal rent (in Yuan)	9.49 (3.07)
County dummy 1 = 1, if Xiangxiang county, 0 otherwise	.20 (.40)
County dummy 2 = 1, if Nanxian county, 0 otherwise	.20 (.40)
County dummy 3 = 1, if Anxiang county, 0 otherwise	.20 (.40)
County dummy 4 = 1, if Zhijiang county, 0 otherwise	.20 (.40)

Table 7: Two-Stage Probit Estimates of the Impact of Hybrid Rice Adoption on Factor Market Transactions

	Labor Market		Land Market		Rental Market	
	Hiring Labor	Hired in Off-farm Agr. Employ.	Lease-Out	Lease-In	Hiring Tractor	Hiring Draft Animal
	(1)	(2)	(3)	(4)	(5)	(6)
Hybrid Rice Adoption Dummy	-3.85	1.34	.33	1.23	1.46	-3.13
	(4.95)***	(1.11)	(.37)	(1.47)	(1.08)	(3.66)***
Ln Labor Force	-.55	.39	-.38	.40	.13	-.34
	(2.23)*	(1.18)	(1.37)	(1.27)	(.30)	(1.24)
Ln Landholding[a]	.73	-.23	1.17	-.81	-.87	.65
	(3.02)**	(.72)	(4.09)***	(3.65)***	(1.98)*	(2.37)*
Ln Capital Stock	-.24	-.02	.06	.12	-.13	-.38
	(4.32)***	(.23)	(.98)	(1.98)*	(1.77)*	(5.93)***
Ln Wage Rate	-.23	-.20	-.25	.47	.55	.32
	(.83)	(.44)	(.89)	(1.63)*	(1.20)	(.89)
Ln Tractor Rent	.48	5.41	-.11	-.48	-.87	.33
	(1.26)	(1.93)*	(.30)	(1.31)	(1.84)*	(.84)
Ln Draft Animal Rent	-.84	.23	.52	.06	2.28	-.68
	(2.70)**	(.31)	(1.47)	(.18)	(3.82)***	(2.00)*
Ln Years of Schooling	.38	-.24	-.39	-.06	.16	.19
	(2.09)*	(1.29)	(2.36)*	(.34)	(.40)	(.91)
Ln Age	.51	-.48	-.01	-.56	.31	.32
	(1.48)	(1.10)	(.03)	(1.65)*	(.54)	(.80)
Female Dummy	1.01	-.38	.64	.27	-4.98	1.13
	(2.98)**	(.61)	(1.63)*	(.65)	(.01)	(3.20)***
Xiangxiang	-.01	1.14	.78	.53	-.26	.63
	(.04)	(1.30)	(1.99)*	(1.77)*	(.44)	(2.00)
Nanxian	-.50	3.57	.82	1.09	2.23	-.51
	(1.29)	(2.29)*	(1.85)*	(2.83)**	(3.86)***	(1.13)
Anxiang	1.09	-4.94	.37	.70	-.35	.96
	(3.07)**	(.02)	(.82)	(1.89)*	(.49)	(2.39)
Zhijiang	.94	3.50	.57	-.06	-5.09	.60
	(2.16)*	(1.87)*	(1.14)	(.16)	(.01)	(1.19)
Constant	-.81	-16.57	-5.84	2.32	-4.46	-.91
	(.39)	(2.10)*	(2.69)**	(1.14)	(1.33)	(.38)
Log-likelihood	-200.24	-121.62	-166.81	-207.47	-74.03	-152.05

Note: Figures in parentheses are absolute values of asymptotic t-statistics. *,**, and *** indicate that the estimates are significantly different from zero at the .1, .01, and .001 level of confidence.

[a] In the labor market and rental market functions, landholding refers to the current operational size, whereas in the land market functions, landholding refers to the initial land size at the time when the household responsibility system was adopted.