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# East Asia Industrialization and Agriculture: Must It be a Prisoner's Dilemma Game?*

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## Abstract

This paper examines the role of land reform in the process of industrialization for East Asian countries. Starting from a prisoner's dilemma game framework between the government and farmers, we show that (i) land reform could suitably modify the payoffs to both the government and farmers in such a way that they not only differ from those in the prisoner's dilemma, but they could change the nature of the game completely, and as a result, a cooperative equilibrium can be reached even in a static setting. (ii) But, because of the physical constraint on the amount limit of land, land reform alone may not necessarily sustain a long-run cooperative outcome between government and farmers. Other elements, such as the government's investment in agriculture *R & D* and better-educated farmers, are required to engage both players in an ongoing cooperative strategy. Only these key elements can possibly mold and sustain the proper payoffs and create additional gateway for the economy to avoid the trap of a prisoner's dilemma game.

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# I. Introduction

East Asia's economic development in the post-war era has been spectacular and attracted tremendous studies in attempting to explain why the region achieved such an outstanding performance. Most notably, common in the three East Asian nations' (Japan, South Korea, and Taiwan) development history is that, in the early stage of development, the states in stead of pursuing a highly discriminatory policies favoring manufacturing relative to agriculture sector, adopted a relatively balanced policies toward agriculture. This is quite contrary to what has been done in other less developed countries.

Among these studies, Grabowski (1993) is probably the first to propose that the tradeoff between industrialization and agriculture growth in less developed countries is essentially a prisoner's dilemma game. Noting that the East Asian governments seemed to successfully avoid the dilemma and bring about rapid economic growth after world war II, he asked why the governments in these nations have such intelligence to adopt favorable policies, as opposed to the ineptness of the governments in the other developing countries? Using a simple prisoner's dilemma game, he suggested that it was successful land reform right after world war II that has helped shaping less exploitative policies in these countries. Land reform, according to him, created a large number of land holding farmers and tilted the power scale relatively toward the benefit of peasant farmers. By redistributing potential power to the agriculture sector, land reform restrained the government from discriminating against agriculture. Knowing it has to play repeatedly against the agriculture sector, and considering an over extractive policy may evoke opposition,

government responded by adopting a long term cooperative strategy and thus helped the rapid growth in post-war East Asia.

Yet two assumptions made by Grabowski are refutable. First, Grabowski's conclusion essentially depends on the power structure of the game. He argued that, because land reform made the power structure more equally distributed, it is more likely that cooperative strategies will be the solution of an indefinite prisoner's dilemma game.[1] In other words, he assumed that land reform increases the potential power of the peasant farmers. Yet there are cases showing just otherwise.[2] We simply do not know a priori whether land reform strengthens or weakens the potential power in the agriculture sector. Even if land reform does endow farmers with greater power, we do not know whether this alone will coerce the government to behave benignly indefinitely.

Second, the government and farmers are assumed to play an infinite game. In a prisoner's dilemma game, a cooperative solution can never be reached in a finite replay. A cooperative solution is possible if and only if the prisoner's dilemma game is played repeatedly and with a not too high discount rate. Thus, given a suitable discount rate, how long the game is played is crucial for Grabowski's conclusion to hold. Suppose we accept Grabowski's claim that the East Asian governments indeed faced a prisoner's dilemma in pursuing economic growth, and that the government and the agriculture sector played against each other indefinitely. Then this naturally leads to the following question: can agriculture in these countries sustain such an infinite game? For if not, there is no point to advocate an infinite play of the cooperative game in these or other less developed countries.

We do not intend to answer why the East Asian governments are so smart as to play cooperative strategies, but instead, we adopt an alternative interpretation on the role of land reform in shaping favorable development policies in the East Asian countries. The land reform contributed perhaps not in endowing farmers with greater political power, but in helping build up a more viable agriculture sector in the early stage of East Asian economic development. Above all, if we view the tradeoff between industrialization and agriculture growth as a prisoner's dilemma game, then land reform may have contributed in that it could change the nature of the game even in a static setting. A simple game framework will illustrate this point in Section II. Section III extends the game into a repeated prisoner's dilemma and examines whether the cooperative solution from the one-shot game can be sustained. Section IV concludes the paper.

## II. Land Reform and the Prisoner's Dilemma Game

### 1. Specification of the Game

Consider two players, the peasant farmers or the land-poor,[3] and the government or the ruling elite including the landlords. Each player faces two strategies. The peasant farmers can choose to play noncooperatively by maximizing his short run profit from production and not adopting new technology (strategy *A*), or he can choose to play cooperatively by adopting new technology (strategy *B*). Likewise, the government can choose to play noncooperatively by only extracting agricultural surplus and not doing extensions on new technology (strategy *a*), or it can choose to play cooperatively by doing otherwise (strategy *b*). As an analogy, Grabowski's

game modeling in his figure 1 can be viewed as one with no land reform and no new technology introduced.

Assume for simplicity that, all farm producers are using a homogeneous Leontief technology.[4] The production functions before and after adopting new technology are the following: Under old technology,

$$Y_a = f(L, K, AL) = \min(\frac{L}{a_1}, \frac{K}{a_2}, \frac{AL}{a_3}), \quad (1)$$

and new technology,

$$Y_b = g(L, K, AL) = \min(\frac{L}{b_1}, \frac{K}{b_2}, \frac{AL}{b_3}) \quad (2)$$

where $L$, $K$, and $AL$ are inputs of labor, capital, and arable land; $a_i$, $b_i$, $i = 1, 2, 3$ are input-output coefficients. Further assume that, $a_1 > b_1$, $a_2 > b_2$, and $a_3 > b_3$. At the optimum, a representative farmer using the old technology will produce at $Y_a^* = \frac{L^*}{a_1} = \frac{K^*}{a_2}$ and those using exact the same amount of inputs under new technology will produce at $Y_b^* = \frac{L^*}{b_1} = \frac{K^*}{b_2}$. Suppose that the government imposes a rent charge of $\beta$ per unit of arable land, or equivalently farmers pay an output tax at a rate of $\alpha$, where $0 < \alpha < 1$, so that

$$\beta \cdot AL = \alpha \cdot Y. \quad (3)$$

All markets are assumed perfect. Any farmer can hire labor at the market wage rate $\omega$ and borrow capital at the ongoing interest rate $\gamma$. Further assume that the new technology requires the peasant farmer to invest an outright fixed amount of capital $R$ at the beginning of period one, e.g., building an irrigation system. If we define $\rho$ as loosely the appropriated (constant) current value of $R$ in each period, then $R$ can

be used for $\frac{R}{\rho}>1$ periods. From (1) and (3) and given $\omega$ and $\gamma$, a price-taking representative farmers' normalized profit under the old technology is

$$\begin{aligned}\pi^{f}_{A,\,a} &= Y-\omega\cdot L-\gamma\cdot K-\beta\cdot AL\\ &= (1-\alpha-\omega\cdot a_1-\gamma\cdot a_2)Y_a \\ &= OT\cdot Y_a,\end{aligned} \tag{1'}$$

which corresponds to the farmer's payoff in cell ($A$, $a$) in Table 1, and obviously $OT\equiv(1-\alpha-\omega\cdot a_1-\gamma\cdot a_2)$. And the government reaps a tax revenue in the amount of $a_1\cdot Y_a$, shown as its payoff in the same cell. Likewise, from (2) and (3) if the same representative farmer adopts new technology on his own, the normalized profit under the new technology becomes

$$\begin{aligned}\pi^{f}_{B,\,a} &= Y-\omega\cdot L-\gamma\cdot K-\beta\cdot AL-R\\ &= (1-\alpha-\omega\cdot b_1-\gamma\cdot b_2)Y_b-R \\ &= NT\cdot Y_b-R,\end{aligned} \tag{2'}$$

which corresponds to his payoff in cell ($B$, $a$) in Table 1. Obviously, we have made the definition of $NT\equiv(1-\alpha-\omega\cdot b_1-\gamma\cdot b_2)$. By definition, we have $NT>OT$. Meanwhile, if the government does nothing and plays noncooperatively, it gains $\alpha\cdot Y_b+EG$, where $EG\equiv R-\rho$. This gain arises from the new output tax paid to the government, plus an extra gain of $EG=R-\rho$. Without land reform the government or landlord at the end of period one can always reap the extra gain of $R-\rho$, for the full cost of the fixed investment in land ($R$) is borne entirely by peasant farmers and depreciates at a rate of $\rho$ each period.

On the other hand, if the farmer plays noncooperatively while the government plays cooperatively, the farmer is assumed gaining $P$ with the government's extension

program. His profit becomes $\pi^f_{A,b} = OT \cdot Y_a + P$ as shown in cell (*A*, *b*) in Table 1. At the same time the government's payoff, $\pi^G_{A,b}$, reduces from $\alpha \cdot Y_a$ to $\alpha \cdot Y_a - GC_1$ as it incurs a cost of $GC_1$ by doing extension.

Finally assume that if both farmers and government play cooperatively, the proportion of farmers adopting new technology increases by *ptr*.[5] Or alternatively, we can think of *ptr* as the increased proportion of one unit of the arable land to which the farmer applies the new technology. Bearing the cost of his own investment in new technology, at the same time receiving a lump sum transfer of *P*, the farmer's profit becomes $\pi^f_{B,b} = NT \cdot Y_b - R + P$. Now that $ptr_1$ more of the one unit of arable land is applied the new technology, the government is thus gaining an extra tax revenue of $ptr_1 \cdot (\alpha \cdot Y_b + EG)$, so that its payoff becomes $\pi^G_{B,b} = (1 + ptr_1) \cdot (\alpha \cdot Y_b + EG) - GC_1$.[6] Now with all the payoffs properly specified, we have completed the 2x2 matrix form in Table 1.

**Table 1 Payoff Function without Land Reform**

| | | Government | |
|---|---|---|---|
| | | a | b |
| Farmer | A | $\pi^f_{A,a}$, $\pi^G_{A,a}$<br>$OT \cdot Y_a$, $\alpha \cdot Y_a$ | $\pi^f_{A,b}$, $\pi^G_{A,b}$<br>$OT \cdot Y_a + P$, $\alpha \cdot Y_a - GC_1$ |
| | B | $\pi^f_{B,a}$, $\pi^G_{B,a}$<br>$NT \cdot Y_b - R$, $\alpha \cdot Y_b + EG$ | $\pi^f_{B,b}$, $\pi^G_{B,b}$<br>$NT \cdot Y_b - R + P$, $(1 + ptr_1) \cdot (\alpha \cdot Y_b + EG) - GC_1$ |

## 2. Necessary Conditions for the Prisoner's Dilemma

For Table 1 to fit the standard definition of a one-shot prisoner's dilemma, it must hold that $\pi^f_{A,b} > \pi^f_{B,b} > \pi^f_{A,a} > \pi^f_{B,a}$ for the farmer and $\pi^G_{B,a} > \pi^G_{B,b} > \pi^G_{A,a} > \pi^G_{A,b}$ for the government.[7] But note that $\pi^f_{A,b} > \pi^f_{A,a}$ and $\pi^f_{B,b} > \pi^f_{B,a}$ as long as $P > 0$ and $R > 0$; $\pi^G_{A,a} > \pi^G_{A,b}$ and $\pi^G_{B,a} > \pi^G_{A,a}$ as long as $GC_1$ and $EG > 0$. The above conditions thus compactly translate into

(i) $NT \cdot Y_b - R < OT \cdot Y_a < NT \cdot Y_b - R + P$ for the farmer, and

(ii) $\alpha \cdot Y_a < (1 + ptr_1) \cdot (\alpha \cdot Y_b + EG) - GC_1 < \alpha \cdot Y_b + EG$ for the government,

which emerge as the two necessary conditions that turn Table 1 into a prisoner's dilemma before land reform.

The first inequality in (i) is key to determine whether the farmer is to cooperate. It says that, if the additional profit from using new technology, $NT \cdot Y_b - OT \cdot Y_a$, does not cover the cost, $R$, it will not pay for the farmer to adopt the new technology. Even if the government plays cooperatively, the farmer will always not cooperate. And given that the farmer does not cooperate, the government is not to cooperate either. The second inequality in (ii) determines whether the government will or will not cooperate.[8] It says that, although the government could take the initiative of doing extension, the mere increase in farmers' participation rate *ptr* induced by extension and thus the extra gain to government's payoff, $ptr_1 \cdot (\alpha \cdot Y_b + EG)$, simply does not suffice to cover the extension cost, $GC_1$. The government apparently will have no incentive to play cooperatively even if the farmer cooperates. So given that the government does not cooperate, the farmer will respond noncooperatively too. Therefore, (non-cooperate, non-cooperate) is the Nash equilibrium of the game.

## 3. Land Reform and Violation of the Necessary Conditions

If both (i) and (ii) break down, the game will no longer be a prisoner's dilemma. The violation of conditions (i) and (ii) could occur without land reform; with land reform, they can become more likely to break down.

Historically land reform all over the world takes a variety of forms. It may include reallocation of land tenure, transferring land ownership from the landlord to the tenant, reducing the output tax that the tenant farmer has to pay, or a combination of various measures. It is through these different measures that land reform may directly or indirectly modify the key variables in such a way that it may lead to the breakdown of the above necessary conditions. Now we will turn to examining some potential measures of land reform in our game framework.

Specifically, we will look at land reform in the form of giving the peasant farmer land tenure or ownership. Endowed with land ownership, the farmer adopting new technology no longer has to forego the entire amount of his investment of $R$ in just one period, so that $R$ drops to $\rho$. His profit becomes $\tilde{\pi}^{f}_{B,a} = NT \cdot Y_b - \rho$, as shown in Table 2.[9] The government or landlord on the other hand loses the extra gain; its payoff is now $\tilde{\pi}^{G}_{B,a} = \alpha \cdot Y_b$ if it plays noncooperatively given that the farmer cooperates. Moreover, by creating a large number of land-holding peasant households, land reform can make income distribution relatively more equal. It has been observed that farmers in the region with more equitable income distribution will be more bound to take advantage of the newly gained wealth by doing more self education and research on new technology (North, P.5). They will also become more willing to participate in the extension program. These efforts on farmers' part could help lower the cost of government's extension program. Therefore, not only *ptr* goes

up from $ptr_1$ to $ptr_2$ but also $GC_1$ reduces to $GC_2$. Given that the farmer uses old technology, the government's payoff will be $\tilde{\pi}^G_{A,\,b} = \alpha \cdot Y_a - GC_2$ if it plays cooperatively; whereas if both cooperate, the government's payoff will be $\tilde{\pi}^G_{B,\,b} = (1 + ptr_2) \cdot (\alpha \cdot Y_b) - GC_2$.

**Table 2 Payoff Function with Land Reform**

| | | Government | |
|---|---|---|---|
| | | a | b |
| Farmer | A | $\tilde{\pi}^f_{A,\,a}$, $\tilde{\pi}^G_{A,\,a}$<br>$OT \cdot Y_a$, $\alpha \cdot Y_a$ | $\tilde{\pi}^f_{A,\,b}$, $\tilde{\pi}^G_{A,\,b}$<br>$OT \cdot Y_a + P$, $\alpha \cdot Y_a - GC_2$ |
| | B | $\tilde{\pi}^f_{B,\,a}$, $\tilde{\pi}^G_{B,\,a}$<br>$NT \cdot Y_b - \rho$, $\alpha \cdot Y_b$ | $\tilde{\pi}^f_{B,\,b}$, $\tilde{\pi}^G_{B,\,b}$<br>$NT \cdot Y_b - \rho + P$, $(1 + ptr_2) \cdot (\alpha \cdot Y_b) - GC_2$ |

The new payoffs in Table 2 show that with land reform the East Asian countries could overcome the trap of prisoner's dilemma and reach a cooperative solution even in a one-shot setting. With land reform, $GC_1 > GC_2$, $ptr_2 > ptr_1$, $\rho > R$, and $EG = 0$, so that both $OT \cdot Y_a < NT \cdot Y_b - \rho$ and $GC_2 < ptr_2 \cdot \alpha \cdot Y_b$ can now possibly hold.[10] Thus the new payoffs will trigger an incentive for both the government and peasant farmers to play cooperative strategies for their own benefits; the nature of the game changes immediately from a prisoner's dilemma to a cooperative one. Now instead of (*A*, *a*), (*B*, *b*) is the dominant strategy. The game reaches the cooperative equilibrium even in one period.

# III. Repeated Prisoner's Dilemma and Growth

But can both players afford to play (*B, b*) indefinitely? We have so far shown that, land reform changes the payoffs to the farmer and to the government and gives both incentives to play cooperatively even in a static game. However, land reform alone is not sufficient to extend the game beyond one period and keep both parties continuously engaging in cooperative strategies.

East Asia is among the regions that have the highest ratio of farmer over arable land in the world. Agriculture production in these countries mostly resemble a Leontief or von-Liebieg type of technology, with arable land being the limiting factor. Under a given fixed technology, when agriculture sector produces below the optimum input ratio, increasing the scarce input, which is normally land or capital in these countries, will raise output. But once production reaches the plateau dictated by a given piece of land, no amount of fertilizers or labor can further increase output. Disguised unemployment usually occurs as a result. In these land-scarce countries, long term output increase and agriculture growth for given land will be eventually confined by existing technology. With no other action taken, this character of East Asian agriculture can severely restrict how long the game will be played. This point can be further demonstrated by considering the above prisoner's dilemma in a repeated game setting.

## 1. Necessary Conditions for a Repeated Prisoner's Dilemma

Assume that the farmer and government have to play against each other repeatedly. And assume that the discount rate is negligible. Extending Table 1 into a repeated prisoner's dilemma, it requires that in addition to (i) and (ii),

$2\pi^f_{B,b} > \pi^f_{B,a} + \pi^f_{A,b} > 2\pi^f_{A,a}$ for the farmer and $2\pi^G_{B,b} > \pi^G_{B,a} + \pi^G_{A,b} > 2\pi^G_{A,a}$ for the government must hold. (See Rasmusen, 1989: 39) These conditions in turn simplify to

(iii) $OT \cdot Y_a < NT \cdot Y_b - R + P$ for the farmer, or equivalently,

(iii') $OT \cdot Y_a - (NT \cdot Y_b - R) < P$, and

(iv) $\alpha \cdot Y_a < (\alpha \cdot Y_b + EG) - GC_1$ for the government, or equivalently,

(iv') $GC_1 < \alpha \cdot (Y_b - Y_a) + EG$.

Condition (iii) is exactly the second inequality in condition (i), meaning that the farmer faces the same incentives in both the one-shot and repeated games. As for the government, (iv') says that, if the additional gain from non-cooperating while the farmer cooperates $(\alpha \cdot (Y_b - Y_a) + EG)$ exceeds the cost of cooperating while the farmer does not cooperate $(GC_1)$, then the government will have no incentive to cooperate in the repeated game.

The breakdown of the repeated prisoner's dilemma requires either (i) or (iii) on the farmer's part, and (ii) or (iv) on the government's part being violated. Note that conditions (iii) and (iv) are weaker requirements than (i) and (ii). Condition (iii) must always hold because the payoffs from (cooperate, cooperate) need to be greater than those from (noncooperate, noncooperate), otherwise the game structure will not be a prisoner's dilemma. Thus we are left to examine the violation of either conditions (i) and (ii) or conditions (i) and (iv). Violation of condition (iv) requires that the government has to at least raise $GC$ to the extent that $GC_1 > \alpha \cdot (Y_b - Y_a) + EG$ (without land reform) or $GC_2 > \alpha \cdot (Y_b - Y_a)$ (with land reform). In a way we can think of government's increasing $GC$ as signaling to the farmer about its

willingness to cooperate.[11] Despite the signalling, it nevertheless cannot trigger the (cooperate, cooperate) solution for the breakdown of condition (i) is still needed.

Either part of violations, condition (i) always stands in the way of reaching a cooperative equilibrium. It implies that breaking down the necessary condition in the repeated game on the farmer's part will require the same mechanism as in the one-shot game. In other words, farmer's willingness to adopt new technology is essential. As we already saw from Table 1 and 2 that, regardless of the extension program, a necessary condition for the farmer to adopt new technology is $NT \cdot Y_b - R > OT \cdot Y_a$ (without land reform) or $NT \cdot Y_b - \rho > OT \cdot Y_a$ (with land reform). That is, either the new technology is profitable or it has to be cheap, otherwise no farmer is going to adopt the new technology that does not raise the production efficiency enough to cover the cost of either $R$ or $\rho$. And we indeed witnessed this lack of incentive on farmers' part where it just did not pay to improve the production efficiency on the farm.[12] So on the farmer's part and regardless of land reform, if he plays non-cooperatively in the one-shot prisoner's dilemma, it is likely that he will keep doing so in the repeated scenario.

On the other hand, we also know that the farmer could play cooperatively in the one-shot game with land reform. Although a previous landless peasant farmer could be given land through land reform and made better off, he still may and may not continue using new technology or participating in the extension program. The cooperative outcome can only last as long as $NT > OT$ and $Y_b > Y_a$. The extent of $NT \cdot Y_b > OT \cdot Y_a$ is always constrained by current limit of the specific factor and technology. So even with land reform, eventually the newly relaxed capital constraint will begin to bind again. Without a continuously lifting technology, $NT$ can be very close to $OT$, and $Y_a$ to $Y_b$. But $NT \cdot Y_b - R < OT \cdot Y_a$ and $NT \cdot Y_b - \rho <$

$OT \cdot Y_a$ always hold as long as $R$ and $r$ are positive. Thus the above mentioned conditions to escape from the prisoner's dilemma will break down immediately in the repeated game mainly because the farmer lacks an incentive to cooperate.

Therefore, although land reform gave the peasant farmer land (asset) ownership, prevented tenants-owners from losing the entire amount of investment and provided a first incentive for farmer to adopt new technology, it alone nevertheless can not make $NT \cdot Y_b$ intricately large. In addition, even if it may make violation of the above necessary conditions feasible, it alone nevertheless cannot sustain the (cooperate, cooperate) outcome. The only way out of the non-cooperative deadlock is that, instead of spending $GC$ on income distribution type of policies as assumed in the above game framework, government invests $GC$ on $R$ & $D$ in agriculture so that raising $GC$ is directly linked to boosting $NT \cdot Y_b$. Only then can both the farmer and government be given the incentives to cooperate in the repeated game and sustain long term economic growth.

## IV. Conclusion

Land reform was important in contributing to East Asia's economic growth, but it may not be important the way Grabowski thought it was. On the merits of land reform, some have argued that land ownership can provide tenants-owners access to credit market or means to obtain capital (Binswanger, Deininger, and Feder, 1993). Gaining land in the short run is also said to boost output on a peasant farm as the binding capital constraint is relaxed and as other abundantly available inputs get employed right away. In addition, by creating a large number of land-holding peasant households, land reform will make income distribution relatively more equal

in these nations. A more egalitarian distribution of land or assets has been shown to stimulate total production (Dasgupta and Raj, 1987). Unlike those of a more conventional economic viewpoint, Grabowski is probably the first to use a simple prisoner's dilemma game to show the role of land reform in the successful economic growth history in East Asia. He focused on the structure of the prisoner's dilemma game and argued that land reforms in these countries mainly increased the peasant farmers' potential power so that their governments were less likely to exploit the agricultural sectors.

In comparison, we consider creating an environment to enhance farmers' awareness in gaining comparative positions may be more likely what the land reforms in East Asia have achieved. Land reform in this paper is regarded as to foster farmers' incentives to adopt new technology and participate in government's extension program. Also starting from a prisoner's dilemma game framework, we show that, land reform could suitably modify the payoffs to both the government and the agriculture sector in such a way that they not only differ from those in the prisoner's dilemma, they could change the nature of the game completely, and as a result, a cooperative equilibrium can be reached even in a static setting. But because of its physical constraint, agriculture in East Asia can not sustain an infinitely replay of the cooperative outcome. In fact, we do not witness a cooperative strategy being played out infinitely in East Asia either.[13] Hence land reform by itself, as contrary to Grabowski's argument, did not coerce the governments in these nations to engage in such a long term play. For land reform alone may not necessarily sustain a cooperative outcome in an infinite replay of the game. Other elements such as government's investment in the research and development (*R&D*) in agriculture, and better educated farmers are required to engage both players in the infinitely played

cooperative strategy. Only these key elements can possibly mold and sustain the proper payoffs and create additional gateway for the economy to avoid the trap of a prisoner's dilemma game.

Thus if the spectacular economic growth in East Asia after world war II can be any lesson, it is this: with no investment on agricultural technology, no government can play a long term strategy even if it has the good intention of doing so. Although land reform did play a significant role in East Asia's economic growth, it was not the driving force to coerce the agriculture sector and government into playing a long term cooperative strategy. More important is government's investment of *R&D* in agriculture and farmers' willingness to adopt new technology. Only with the government's investment in *R&D* on agriculture, and with farmers' adopting new technology, a long term and overall economic growth can be sustained by further industrial and/or trade policies.

The problem with most less developed countries is, they normally look up to developed countries as examples. They too often saw developed countries pouring abundant capital into industrial sector and mis-believed it as the royal way to a rapid economic growth. This is partly why less developed countries tend to sacrifice agriculture while eagerly seeking to industrialize (Hayek, 1960). In the process of economic growth, agriculture sector always has to compete with other sectors for limited capital resources, especially in the land-scarce countries. A zero sum game of the resources usually occurs as a result of this competing. Long term output increase and agriculture growth for given land will be eventually confined within existing resources and technology. Unless the ceiling of production can be lifted by new technology, no one can afford to play a long term cooperative strategy.

## Notes

1 This is based on the assumption that, if government exploits the agriculture sector and makes the peasant farmers worse off, farmers will grow more risk-prone and more likely to get organized to oppose the government. Yet alternatively, if we assume that wealth or material endowment is positively correlated with potential power or the ability of exerting power, then as wealth gets more equally distributed, the power structure also gets more equally distributed in a society.

2 See Chang (1993: 150) for the case in Korea. "The landed class was eliminated through land reform at the time of the Korea War, and the incipient political organizations of the working class and the farmers were also crushed during the war and the subsequent domination of Cold War politics."

3 We do not differentiate the various types of farm producers here. In general they may include tenants, tenant-owners, and owner-operators who have the skill to cultivate and had already farmed the land.

4 Admittedly this is a strong assumption. Other technology of course can be used to demonstrate the discussion, but will not affect the conclusion here.

5 Assume that *ptr*, *GC*, and *P* are determined outside the model.

6 Here for simplicity, we ignore the interaction between *ptr* and *GC* and assume both are exogenously given. Of course, as $R$ and $\rho$, both *ptr* and *GC* can be functions of farmers' income, education, and etc. The possibilities of interactions among all these variables although are potentially rich, they can greatly complicate the subsequent analysis.

7 Here we slightly extend the condition listed in Rasmusen (1989: 39)

8 The second inequality in (i) and the first inequality in (ii) mainly require that the payoffs from (cooperate, cooperate) for both the farmer and government must exceed those from (non-cooperate, non-cooperate), otherwise the game structure will not be a prisoner's dilemma.

9 The number of farmers before and after land reform, n1 and n2, are not explicitly expressed here. Table 1 and 2 are mainly to show that with land reform, a cooperative solution can be reached in a finite game. Although comparing the effects

on the game with and without land reform can be another important issue, we do not attempt the discussion here. Since n1 and n2 will not affect the analysis, they are dropped from Table 1 and Table 2.

10 We implicitly assume that, there always exists some technology such that $NT \cdot Y_b - \rho > OT \cdot Y_a > NT \cdot Y_b - \rho^+$, where $\rho^+ = \rho + \varepsilon$, and $\varepsilon$ is some small positive number.

11 Since both sides of condition (iv) become smaller at the same time, its breakdown may ask for a similar violation condition as that in the case with no land reform. Or if the drop in $GC$ is less than the extra gain, $EG$, land reform may offer a feasible way to violate (iv) on the government's part.

12 For example, in the early 1920s the new and more productive rice variety (Ponlai) was not adopted by most of the tilters in Taiwan. See Myers (1969).

13 For example, as Grabowski (1993: 43) also observed, Korea before 1960's adopted unfavorable policies toward agriculture sector.

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# 東亞的工業化與農業：政府與農民間的兩難賽局？

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## 摘　要

本文首先探討東亞各國在工業化的過程中，土地改革所扮演的角色。從政府與農民間可能為互相不合作的兩難賽局出發，我們證明土地改革可能扭轉賽局的內涵而避免兩者互相不合作的困境，即政府不會一味的放棄農業部門來追求工業化，而農民也會接受政府農業改良的推廣措施。我們進一步證明由於土地有限的天然限制，除非進一步的研究發展與提高農民教育水準，土地改革本身並不足以支撐政府與農民間的長期合作關係。