Two essays on the optimal behavior of a Chinese agricultural production team

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Two essays on the optimal behavior of a Chinese agricultural production team

by

Kim Leslie Norris

A Thesis Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

Major: Economics

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1984

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GENERAL INTRODUCTION

For forty centuries, small-scale peasant farming to supply active local markets typified the agricultural sector in China. But, since the revolution in 1949, the Chinese have experimented with various—and sometimes conflicting—strategies for improving agricultural production and accelerating development of the agricultural sector.

In the early 1950s, the communists carried out a program of land reform that redistributed almost half of China’s cultivated area to poor and landless farmers. This was short lived, however, because Mao and his followers believed continued reliance on private farming would encourage capitalist values and behavior. So, farmers were organized into collectives during the mid-1950s because “collectivized agriculture would mobilize the peasants and 'unleash' the productive powers of socialist agriculture” (Barker and Sinha, 1982, page 71).

The Great Leap Forward (1958-1960), during which all of China's farmers were reorganized into large-scale communes in order to achieve ambitious grain production targets, carried this idea to excess. Although the commune movement ended with a serious agricultural crisis in 1959, the commune structure itself was retained and limited decision-making authority was transferred to the smaller production team.

From the onset of the Cultural Revolution (mid-1960s) to the death of Mao (1976), the left wing of China's communist party successfully stifled right-wing efforts to decentralize decision making and institute material incentives. But, after Mao's death, the communist right wing
seized the opportunity to implement its policies, replacing the "Gang of Four" with the "Four Modernizations." A journal article entitled, "Harshly Criticize the Left; Then We Can Have Speedy Agricultural Development" (Chang and Huang, 1979), reflects the mood at that time.

From 1978 to the present, Chinese agricultural policy has been dominated by the Production Responsibility System, wherein greater freedom from state control is accomplished by granting wider decision-making authority to groups, households, and even individuals within traditional production teams (Tuan and Crook, 1983). Thus, the current situation is much different from the Cultural Revolution or the Great Leap Forward. Agriculture is still collectivized under the commune system and the state still acquires its desired quantities of output through agricultural taxes and imposition of quotas for sale to procurement agencies. Production teams--composed of 30 to 40 households--remain the basic unit of account. Under the Responsibility System, however, teams encourage households to cultivate private plots, market their output in rural trade fairs, and even subcontract a share of the team's quota obligations to the state.

The past ten years suggest that agriculture in China may become even more market oriented. However, events since 1949 also warn that any such trend may be subject to sharp reversal. Because the recent history of Chinese agricultural policy has been characterized by shifts from left to right, the results have been mixed.¹ Out of this experience, the

¹There is an abundance of literature regarding this issue. See, for example, Barker and Sinha (1982), Hsu (1982), and Lardy (1983).
Chinese have perceived a need for more effective agricultural planning and policy making.

Through special access to a set of 1980 records for an agricultural collective (production team) located in north China plain, I have applied an analytical technique that goes some distance in meeting this need. The research here, presented in two essays, uses linear programming to examine the optimal economic behavior of a typical production team under different economic policy environments.

Organization of the Thesis

This research is organized as follows. Part One, "The Optimal Response of a Chinese Agricultural Collective to Alternative Economic Policy Environments," compares the team's optimal economic behavior in five distinct policy environments. The coverage of the theoretical background and testing of the model is applicable to the analysis in both essays. Therefore, the sections of Part One describing the theoretical framework and testing of the model are presented in greater detail than in Part Two and the reader of Part Two may refer to this initial coverage.

Part Two presents the second essay, "The Effect of Shifting Market Structures on a Chinese Collective's Output Supply and Input Demand," where we use the methodology developed in Part One, then introduce parametric programming to compare market supply and demand relationships in three different policy periods.

Each essay contains its own conclusion and overall conclusions from the research are briefly summarized following Part Two.
PART ONE

THE OPTIMAL RESPONSE OF A CHINESE AGRICULTURAL COLLECTIVE TO ALTERNATIVE ECONOMIC POLICY ENVIRONMENTS
INTRODUCTION

Since 1949, leaders of mainland China have experimented with seemingly contradictory strategies for improving agricultural production and accelerating development of the agricultural sector. Out of this experience, the Chinese have perceived a need for more effective agricultural planning and policy making. Because the agricultural production team is a critical link in China's planning process and because it provides a consistent unit of account, the production team is a logical place to begin evaluating this need.

For instance, if a set of records for an actual team was available, it would be possible to investigate the response of the team to the different economic objectives created by different agricultural policy environments. Such a study would be of special interest to Chinese planners in at least two respects. First, the study would indicate how a typical production team might behave in different policy environments. Planners could then use that information to be more effective in setting targets for agricultural production (or income) and in formulating policies conducive to meeting those targets efficiently. Second, for the benefit of the individual team, the study would provide a fresh empirical perspective, putting the team "...in a far better position to resist inappropriate suggestions from higher levels" (Stavis, 1979, p. 50).

Through special access to a set of 1980 records for a production team located in the north China plain, I was able to perform such an analysis. Specifically, in this paper I construct a linear programming
model of the team and then compare the team's optimal response to five distinct policy environments as represented by five economic objective functions (and associated modifications of the constraint set). My objective is to determine the microeconomic impact of the five policy environments on the team's 1) resource allocation, 2) production, and 3) income. From these three indices were drawn hypotheses 2 through 4 below.

In terms of the overall analysis, T. W. Schultz argues that "farmers are not perverse economic men in responding to economic incentives, whether one observes them in China...or the U.S." (Schultz, 1965, p. 31). He further notes: "Although the refrain that farmers in poor countries do not respond to economic incentives is still very popular, it is being interrupted by strong evidence to the contrary" (Schultz, 1965, p. 31). From these assertions we formulate our first hypothesis:

Hypothesis 1--The economic behavior of the production team is rational and, therefore, amenable to microeconomic analysis.

Nonrejection of this hypothesis would set the stage for evaluating the remaining three hypotheses.

Hypothesis 2 (resource allocation)--Because land is a scarce factor in Chinese agriculture, all land will be cultivated, regardless of changing economic objectives.

Hypothesis 3 (production)--Collective foodgrain production will be sacrificed in favor of other commodities as the agricultural economy becomes more market oriented, revealing the team's comparative advantage.
Hypothesis 4 (income)—The team's total income will increase as the agricultural economy becomes more market oriented.
THEORETICAL FRAMEWORK

As a part of the larger Chinese economy, the production team must optimize an objective function based upon the socialist labor theory of value (Lardy, 1978) which provides us with the identity:

\[ P = C + V + M \]

where \( P \) = value or price,
\( C \) = embodied (or past) labor,
\( V \) = present labor, and
\( M \) = Marxian surplus value.

For the Chinese agricultural economy, this relationship may be further disaggregated:

\[ P = C + V_k + V_c + M_f + M_t \]

where \( P \) = price,
\( C \) = nonlabor production costs,
\( V_k \) = in-kind wages to labor,
\( V_c \) = cash wages to labor,
\( M_f \) = collective fund, and
\( M_t \) = taxes.

This relationship may also be illustrated with a diagram, as in Figure 1.

From the socialist labor theory of value can be formulated a set of expressions which represent four periods of policy objectives imposed
upon the production team at various times in post-1949 China. To these may be added a fifth hypothesized case of a market economy. Conceptually, these five cases lie along an ideological continuum (Figure 2).

At the left end of this continuum, we find an environment of centralized economic control which reflects the situation during the Great Leap Forward. At the other end is the decentralized environment of a market economy, similar to the present situation in Taiwan province.¹

¹The period from 1949 to 1958 has been excluded because production teams did not exist for most of that time. Likewise, the Cultural Revolution has been excluded because the objective function is unknown.
Centralized control

Great Leap Forward (1958-1960)

Decentralized control

Five-Year Adjustment (1961-1966)

Four Responsibility Modernizations (1978)

System (1981)

Market Economy (hypothetical)

Figure 2. Continuum of the degree of centralized control in the Chinese agricultural economy

By solving modified versions of a linear programming problem which simulates the team's actual behavior in 1980, we can examine the optimal behavior of the team at the five points highlighted along this continuum. ¹

Case 1: The Great Leap Forward (1958-1960)

Case 1 depicts the production team in an environment where there is state control of productive assets and highly centralized economic planning and decision making. Such was the state of affairs in China during the Great Leap Forward, when

Collectives were not free to allocate resources in such a way as to maximize net income. For example, they could not allocate land between alternative crops according to relative costs and returns. Allocation, instead, was determined theoretically by the state plan, which was not drawn up with the specific purpose of providing collectives with maximum income (Walker, 1968, p. 426).

¹It is critical to understand that these linear programs compare the team's behavior over a series of objective functions, and not over time. In fact, the LP models for all five cases were solved using constant 1980 prices and technology.
Our team was directed to grow wheat, corn, and cotton, exclusively, and production targets were high. Specifically, the team had to grow enough of each crop to meet 1) government quotas and 2) their own subsistence needs. Beyond this, household plot production was strictly forbidden.

During the Great Leap Forward, the actual physical production of grain was considered the overriding criterion of success, and resources were allocated to achieve this aim "regardless of cost, either direct or indirect" (Walker, 1968, p. 427). In other words, the production team's primary objective was to maximize physical output, cost considerations aside. Graphically, the LP problem is illustrated in Figure 3.

![Output maximization](image)

Figure 3. Output maximization

where $X_r$, $X_l$, $X_k$ = land, labor, and capital (less than constraints); $X_s$ = subsistence output levels (greater than or equal to constraint);
\(X_q\) = government procurement quotas (greater than or equal to constraint); and

\(Q_c, Q_w\) = quantities of corn and wheat.

In economic terms, the maximand is not income, but output, and the objective function becomes a ratio not of prices, but of quantities. Output is weighted equally in catties,\(^1\) which is unfair to cotton, but we must keep in mind that "the actual physical production of grain was the overriding criterion of success" (Walker, 1968, p. 427) during the Great Leap Forward. Thus, in case 1, the LP model is used to maximize the objective function:

\[
Q_n = \sum Q_i - M_f(\sum Q_i) - M_t
\]

subject to \(f(X_r, X_1, X_k), X_s), X_q\)

where \(Q_n\) = net output of all crops,

\(Q_i\) = total output of crop \(i\),

\(M_f\) = collective fund (in-kind),

\(M_t\) = taxes (in-kind), and the solution would be analogous to point A in Figure 3.

It is significant that costs (C) and labor income \((V_k + V_c)\) do not appear in this function. As we have seen, these factors were not considerations in the policies of the Great Leap Forward and, therefore, should not be included in the maximization problem.

\(^1\)In China, the standard measure of agricultural output is a catty—a measure of weight equivalent to 0.5 kilograms or 1.1 pounds.
Case 2: The Five-Year Adjustment (1961-1966)

Case 2 represents the economic environment faced by the production team from 1961 to 1966. As during the Great Leap Forward, the central government dictated to the team that it must produce certain crops, sell minimum quotas to the government at procurement prices, and meet its own subsistence needs. But, unlike the Great Leap Forward, up to five percent of cultivated land could be allocated to household plots and importance was attached to improving team prosperity (Hsu, 1982). Indeed, policies of this period allowed the team to focus upon income rather than output.

Graphically, the LP problem can be illustrated in much the same way it was for case 1, with an important exception: The objective function in Figure 3 would become a ratio of prices because the maximand is income and not output. Algebraically, the function maximized in case 2 is:

\[ V_c = \sum P_i Q_i - \sum C_j X_j - M_f (\sum P_i Q_i) - M_t \]

subject to \( f(X_r, X_l, X_k, X_s, X_q) \)

where \( V_c \) = cash income to labor,
\( P_i Q_i \) = total revenue,
\( C_j X_j \) = production costs,
\( M_f \) = collective fund,
\( M_t \) = taxes, and all other terms are the same as in case 1.
Case 3: The Four Modernizations (1978)

Case 3 corresponds to the economic environment at the onset of the Four Modernizations, when policies shifted significantly rightward along the continuum in Figure 3. Teams were granted broader rights of self-management, and economic decision making moved toward decentralization. Although procurement quotas \( (X_q) \) remained in force, the team was free to either produce or purchase commodities to fulfill its subsistence requirement \( (X_s) \). Additionally, household plot allowances were expanded to 15 percent of total cultivated area. Policies at this time also eliminated the collective fund \( (M_f) \) and permitted labor hiring during periods of peak labor demand.

In this new environment, the team's interest in improving its overall profit picture became especially strong (Tuan and Crook, 1983). Assuming profit (i.e., income) maximizing behavior by the team, the objective function becomes:

\[
V_c = \sum P_i q_i - \sum C_j x_j - M_t
\]

subject to \( f(X_r, X_1, X_s, X_q) \)

Case 4: The Responsibility System (1981-Present)

Case 4 considers the behavior of the production team under the Responsibility System. Broadly speaking, the Responsibility System allows brigades to contract with member households or groups of households for fulfillment of production quotas and/or specific labor tasks.
So long as contract obligations are met, the team is free to engage in household plot production.

Because the team is the basic unit of account used throughout this analysis, we have chosen to represent a form of the Responsibility System known as "group contracts" (lian chan dao zu).\(^1\) Under this arrangement, the collective divides its fields into strips and contracts to meet fixed quotas. In effect, this means the only area restriction on household plot production would be the area set aside for contracted crop production.

Other policies of this period, such as elimination of the collective fund and labor hiring, are similar to those in case 3. Since the team is again acting to maximize profits/income, the form of the objective function is duplicated from case 3 and only the constraint set is modified.

Case 5: Market Economy (Hypothetical)

Case 5 postulates the introduction of a market economy into the present-day agricultural organization in China. In fact, this case might be compared with cooperative forms of agricultural organization practiced in Taiwan.

In this case, all quota restrictions \((X_q)\) are removed. Moreover, the team may allocate its land freely between household and collective production. And, although the subsistence requirements \((X_s)\) for wheat,

\(^1\) the actual form of Responsibility System followed by this team is not known.
corn, and cotton are retained, the team may choose either to produce these commodities itself or purchase them in local markets. Labor hiring is, of course, permitted.

To reflect the team's new market-type environment, the objective function becomes:

$$V_c = \sum_{i} p_i q_i - \sum_{j} c_j x_j - m_t$$

subject to \( f(X_r, X_1, X_k | X_e) \)

and the constraint set is adjusted accordingly. A summary of the distinctions between the five cases is presented in Table 1.

<table>
<thead>
<tr>
<th>Case</th>
<th>Quotas/contracts</th>
<th>Subsistence requirement</th>
<th>Labor hiring</th>
<th>Plot area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quotas</td>
<td>Produce</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Quotas</td>
<td>Produce</td>
<td>0</td>
<td>5% maximum</td>
</tr>
<tr>
<td>3</td>
<td>Quotas buy 3</td>
<td>Produce or buy</td>
<td>3 people</td>
<td>10% maximum</td>
</tr>
<tr>
<td>4</td>
<td>Contracts buy 6</td>
<td>Produce or buy</td>
<td>6 people</td>
<td>15% maximum</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>Produce or buy</td>
<td>Unconstrained</td>
<td>100% maximum</td>
</tr>
</tbody>
</table>

Table 1. Key distinctions between the LP models for cases 1 through 5
A generalized version of the LP matrices used to simulate the team's actual economic behavior in 1980, as well as to solve the maximization problems in cases 1 through 5, is illustrated in Figure 4. The practical attractions of this model are best highlighted with a couple of examples. In case 1, for instance, only the quantitative objective function (C row) was maximized. Within the matrix itself, the buying, borrowing, hiring, and private plot activities were dropped; correspondingly, the right-hand sides (RHS) for hiring and plots were set equal to zero.

In case 5, on the other hand, the economic objective function (C row) was maximized and only the collective fund activity was dropped. To eliminate production quotas/contracts, the associated restriction (RHS) was set equal to zero. Furthermore, to activate the plot activity, the RHS was set less than or equal to 20, allowing the plot area of 14.34 mou to come in up to 20 times.

The plot activity also includes a special provision with regard to labor. For each five percent (14.34 mou) of land area allocated to private plots, five percent of the collective's labor supply is

---

1Because no comparable time series of cross-sectional data are available, we were not able to estimate production functions. By implication, the team is limited to producing with a single technology.

2The total collective land area is 20 x 14.34 mou = 286.8 mou. In case 2, where up to five percent of collective land may be allocated to private plots, the plot activity is allowed to come in up to one time for a maximum of 14.34 mou.
<table>
<thead>
<tr>
<th></th>
<th>Produce</th>
<th>Sell</th>
<th>Buy</th>
<th>Consume</th>
<th>Taxes</th>
<th>Fund</th>
<th>Borrow</th>
<th>Hire</th>
<th>Plots</th>
<th>RHS</th>
</tr>
</thead>
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<tr>
<td>C row (economic)</td>
<td>-c_j</td>
<td>c_j</td>
<td>-c_j</td>
<td>-c_j</td>
<td>-c_j</td>
<td>-c_j</td>
<td>-c_j</td>
<td>c_j</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C row (quantitative)</td>
<td>0_j</td>
<td>-0_j</td>
<td>-1</td>
<td>-0_j</td>
<td>-1</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>1/a_i</td>
<td>B_1</td>
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<tr>
<td>Bullocks</td>
<td>a_ij</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>B_1</td>
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<tr>
<td>Capital</td>
<td>a_ij</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>a_i</td>
<td>B_1</td>
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<tr>
<td>Quotas/contracts</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B_1</td>
<td></td>
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<tr>
<td>Subsistence</td>
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<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B_1</td>
<td></td>
</tr>
<tr>
<td>Transfer rows</td>
<td>-a_ij</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Collective accounting</td>
<td>-a_ij</td>
<td>a_ij</td>
<td>-a_ij</td>
<td></td>
<td>-a_ij</td>
<td>-1</td>
<td>-a_ij</td>
<td>a_ij</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
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<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>B_1</td>
<td></td>
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<tr>
<td>Hiring</td>
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<td></td>
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<td>1/a_i</td>
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<td>B_1</td>
<td></td>
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<tr>
<td>Plot transfer</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1/a_i</td>
<td>B_1</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Generalized programming model for a north China production team.
redistributed to the plot activity. Also, because the laborers' incentive to work is heightened significantly by the opportunity to engage in private plot production, additional labor resources, amounting to ten percent of the original collective labor supply, are made available for each five percent of land area that goes into private plot production. Thus, if 770 labor unit hours are available in a typical ten-day period, and if five percent of land area is allocated to private plots, then 1) 38 labor unit hours are redirected from the collective to the plots and 2) another 77 labor unit hours are added to the labor resources available for plot production to reflect the heightened incentive to work.

As demonstrated with these examples, the model is designed so that a few simple manipulations allow us to represent any number of policy environments—including the five cases considered here.

---

1See for example Burki (1969), Mosher (1983), and Walker (1968).

2Consistent with the practice in China, this study has disaggregated labor into ten-day periods, or xún. For example, one month has three xún.

3Because the estimation of a labor supply curve lies beyond the scope of this analysis, labor has been treated as a stock, leaving issues of labor supply to be examined in other studies.
RESULTS

Hypothesis 1: Rational Economic Behavior

This hypothesis lays the foundation for the rest of the analysis. We incorporated actual 1980 data into the generalized model shown in Figure 4, making the modifications necessary to reflect the economic policy environment faced by the team in that year. In terms of the matrix, the collective fund was eliminated; contract obligations were set at 27,700 for corn, 16,620 catties for wheat, and 2,800 catties for cotton. The plot transfer row was set less than or equal to three, meaning that up to 15 percent of collective land area could be used for private plots.

We then conducted a simulation run, forcing the team to act as it had in 1980 when it cultivated 213.1 mou of corn, 173.1 mou of wheat, and 59.4 mou of cotton. The purpose of the simulation was to check the LP matrix for internal consistency and to estimate the level of available production capital. Having done this, we were in a position to test our first hypothesis.

If the LP solution could predict the team's actual behavior in 1980 without being forced, we would be able to accept the LP model as a valid analytical technique. If not, we would have evidence that the economic behavior of the team is not rational and microeconomic analysis would be meaningless. The results of this test are presented in Table 2.

Because the model accurately predicted the response of the production team to the economic environment in 1980, we were able to accept our
Table 2. A comparison of actual and predicted team behavior for 1980

<table>
<thead>
<tr>
<th>Land utilization (mou):</th>
<th>Actual</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>232.5</td>
<td>232</td>
</tr>
<tr>
<td>Late</td>
<td>272.5</td>
<td>272</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Output levels (catties):</th>
<th>Actual</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>74,031</td>
<td>73,860</td>
</tr>
<tr>
<td>Corn</td>
<td>111,001</td>
<td>110,712</td>
</tr>
<tr>
<td>Cotton</td>
<td>3,263</td>
<td>3,277</td>
</tr>
</tbody>
</table>

| Net team income (yuan)        | ¥22,471  | ¥18,233   |

The economic behavior of the team is rational and, therefore, amenable to microeconomic analysis through linear programming. To paraphrase Schultz, these farmers are not perverse economic men (and women) in responding to economic incentives.

We are now in a position to evaluate our remaining hypotheses by comparing the results of the LP runs for cases 1 through 5. These results are summarized in Table 3.

Hypothesis 2: Maximum Land Cultivation

Because Chinese agriculture has developed under conditions of land constraints, and because "nearly all land that can possibly be cultivated is farmed if it can be of any net benefit" (Barker and Sinha, 1982), we would expect the team to cultivate all of its land regardless of the
Table 3. A summary of LP results for cases 1 through 5

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-kind income:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>49,069</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Value</td>
<td>4,941</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cash income</td>
<td>-</td>
<td>8,470</td>
<td>17,766</td>
<td>22,169</td>
<td>28,064</td>
</tr>
<tr>
<td>Collective income</td>
<td>4,941</td>
<td>2,910</td>
<td>5,666</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Household income</td>
<td>0</td>
<td>5,560</td>
<td>12,100</td>
<td>22,169</td>
<td>28,064</td>
</tr>
<tr>
<td>Total income</td>
<td>4,941</td>
<td>8,470</td>
<td>17,766</td>
<td>22,169</td>
<td>28,064</td>
</tr>
<tr>
<td>Net subsistence value</td>
<td>14,475</td>
<td>14,475</td>
<td>8,410</td>
<td>8,410</td>
<td>8,410</td>
</tr>
<tr>
<td>Adjusted total</td>
<td>19,736</td>
<td>23,265</td>
<td>26,176</td>
<td>30,579</td>
<td>36,474</td>
</tr>
<tr>
<td>Output levels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>74,294</td>
<td>74,294</td>
<td>74,294</td>
<td>62,257</td>
<td>64,255</td>
</tr>
<tr>
<td>Corn</td>
<td>111,332</td>
<td>109,216</td>
<td>95,967</td>
<td>75,785</td>
<td>78,217</td>
</tr>
<tr>
<td>Total food grain</td>
<td>185,626</td>
<td>183,510</td>
<td>170,261</td>
<td>138,042</td>
<td>142,472</td>
</tr>
<tr>
<td>Cotton</td>
<td>3,277</td>
<td>3,277</td>
<td>3,277</td>
<td>2,800</td>
<td>2,304</td>
</tr>
<tr>
<td>Vegetables (mou)</td>
<td>0</td>
<td>12</td>
<td>27</td>
<td>65</td>
<td>68</td>
</tr>
<tr>
<td>Pigs (head)</td>
<td>0</td>
<td>27</td>
<td>164</td>
<td>252</td>
<td>261</td>
</tr>
<tr>
<td>Land utilization (286.8 available):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early collective</td>
<td>233</td>
<td>233</td>
<td>233</td>
<td>196</td>
<td>192</td>
</tr>
<tr>
<td>Late collective</td>
<td>273</td>
<td>269</td>
<td>244</td>
<td>196</td>
<td>192</td>
</tr>
<tr>
<td>Household plots</td>
<td>0</td>
<td>14</td>
<td>43</td>
<td>90</td>
<td>95</td>
</tr>
</tbody>
</table>

policy or economic environment. Our results, however, have demonstrated something to the contrary, forcing us to reject our second hypothesis.

The figures in Table 4 indicate the team does not fully utilize all 286.8 mou of its land in cases 1 and 2. This occurs because the team faces a labor constraint in these two cases, which is relieved in cases 3 through 5 when labor hiring is permitted. Similarly, there are particular ten-day periods when labor demand peaks and the team
Table 4. Percentage of total land cultivated in cases 1 through 5

<table>
<thead>
<tr>
<th>Land cultivated</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>81</td>
<td>86</td>
<td>96</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Late</td>
<td>95</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

experiences a labor shortage. During the rest of the season, there is significant surplus labor.

For the team to efficiently utilize all its land, it needs to acquire additional labor for the first 20 days of June (when it plants corn, harvests wheat, and irrigates cotton) and for the first ten days of October (when it plants wheat, harvests corn, and harvests cotton). The value of each additional unit of labor in these periods is reflected by its shadow price. The figures in Table 5, which are specific for collective labor in the first ten days of October, provide an illustration.

Table 5. Shadow prices for collective labor in early October

<table>
<thead>
<tr>
<th>Collective labor hired (hours)(^a)</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadow price per labor hour</td>
<td>n.a.</td>
<td>37.39</td>
<td>.865</td>
<td>.899</td>
<td>12.62</td>
</tr>
</tbody>
</table>

\(^a\)One hundred labor hours are equivalent to one labor unit working ten hours per day for ten days.
In case 2, where labor hiring is not permitted, the value of an additional hour of labor is ¥37.39, well above the going wage of ¥0.865/hour. In cases 3 and 4, however, labor is hired up to the point where the wage paid to labor (price) equals the value of the marginal product (shadow price). In other words, policies which allow the team to hire labor also allow the team to operate efficiently. Thus, once the ban on hiring is lifted, peak period labor shortages are resolved, labor is employed efficiently, and the team uses 100 percent of its land, as shown in Table 4.

Hypothesis 3: Declining Foodgrain Production

There are several reasons for expecting foodgrain production to decline as the economic environment becomes more market oriented. First, we know that combined quota and subsistence levels have traditionally been quite high. Even in 1980, the team fell short of foodgrain production targets. So, as the quota restrictions are lifted, we would expect to see corn and wheat production fall.

Second, Chinese planners have long regarded increased foodgrain production and local self-sufficiency as central objectives for the agricultural economy and the output quotas have been formulated accordingly. Out of this, it sometimes happened that "local knowledge of cropping patterns, soil fertility, and climate were overlooked and teams were forced to grow crops not suited for their area" (Tuan and Crook, 1983, p. 40). As various restrictions upon output are lifted from
cases 1 to 5, the team's comparative advantage is revealed, and we would expect output mixes to move away from lower-priced foodgrain production.

The results appearing in the third section of Table 3 support hypothesis 3. Foodgrain production declines from a high of 185,626 catties in case 1 to 138,042 catties in case 4. Interestingly, foodgrain production takes a slight turn upward in case 5 which can be explained in a single word—prices.

In case 4, the team must meet contract obligations to the government meaning a significant portion of foodgrains are sold at procurement (or contract) prices. In case 5, the quotas are lifted and the team is able to receive market prices for all its foodgrain output. Consequently, the team finds incentive to increase production, lending further evidence to the argument that one possible policy instrument for stimulating agricultural production is higher producer prices.

Predictably, as the team's foodgrain production declines, it is supplanted by production of more profitable agricultural commodities, namely vegetables and pigs, which are sold in local markets at market prices. Table 6 shows the percentage of total land area devoted to vegetable and pig production by households in each of the five cases. In

| Table 6. Land area engaged in household pig and vegetable production |
|-----------------|-------|-------|-------|-------|-------|
| Land for pigs and vegetables | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
| Percent of total | 0 | 14.34 | 43.02 | 90.3 | 94.8 |
| | 0 | 5 | 15 | 31 | 33 |
cases 1 through 3, there are limits on how much land can be used for household production activities and the team uses this land to its upper limit. There are no limits on area allocated to private plot production in cases 4 and 5. However, in case 4, the team must plant enough area in wheat, corn, and cotton to meet contract obligations and, in case 5, foodgrain production becomes an economically lucrative activity due to higher prices.

Hypothesis 4: Increasing Income

As the economic environment becomes more market oriented, we would expect the team’s income to increase. This expectation rests partly on the reasoning presented in hypothesis 3 and partly on the following. Through policy changes from case 1 to case 5, the economic environment faced by the team becomes less restrictive and the team is allowed greater freedom to maximize its "profits" which are in fact distributed as the team's income.

Our results support hypothesis 4. As can be seen in Table 2, the team’s adjusted income nearly doubles as conditions change from case 1 to case 5. For a team of 38 households, this translates into an increase in average per capita income from ¥96.7 in case 1 to ¥178.8 in case 5.

If hypotheses 3 and 4 are considered together, an inverse relationship between foodgrain production and income for this particular team becomes apparent. This relationship is illustrated in Figure 5. This relationship suggests that within the established price structure, there is a trade off between levels of foodgrain production and levels of
income. The state elicits the greatest foodgrain supply response from the team in case 1, but this is also where the team's income is the lowest. As the team is granted greater freedom in its production decisions, it is able to augment its income, but not without sacrificing some foodgrain production.

Within the existing price structure, then, it appears Chinese planners and policy makers must make a choice: Will higher levels of foodgrain production or higher levels of income be the principal objective of agricultural policy?

Our analysis of this team further suggests one possible solution to this unhappy dilemma—higher producer prices. In case 5, when the team
is allowed to receive market prices for its foodgrain, not only does income rise, so does the level of foodgrain output! Allowing for wage increases in the urban sector (currently anathema to Chinese planners) would facilitate such price changes and help to reduce the enormous government subsidies of both producer and consumer prices.
CONCLUDING COMMENTS

This analysis lends support to several observations regarding the Chinese agricultural economy.

First, the results provide further evidence that farmers in developing countries do indeed respond to economic incentives. It further justifies the use of microeconomic analysis—in this case, linear programming—to study problems of agricultural policy in the People’s Republic of China.

Second, even in a labor surplus economy, labor is not necessarily available when and where it is needed. As is so often the case in other agrarian societies, there is marked seasonality of labor demand in China. Averaged over an entire year, there is a surplus of labor. But, during peak periods, there is a shortage which constrains the team’s production potential. A national policy permitting collectives to hire labor is an important first step in relieving this constraint.¹

Finally, we have demonstrated that within the existing price structure, there is a trade off between levels of foodgrain production and levels of income. Such a price structure creates a conflict between national and local priorities because, under this structure, what is optimal for the few (i.e., the team) is not optimal for the many (i.e., the nation). Given the existing price structure, it is in the team’s best interest to cut back foodgrain output in favor of more profitable

¹There are also issues of labor mobility to be addressed, but these lie beyond the authority of this analysis (see, for example, Johnson, 1982).
hog and vegetable production. This, however, is not necessarily in the best interest of a country which has one billion people to feed. On the other hand, the suggested solution to this dilemma--higher producer prices for staple agricultural commodities--is likely to require further increases in already costly government subsidies unless urban wages are allowed to rise. Given this state of affairs, policy makers may continue to ignore the market mechanism in favor of other policy instruments.

The sort of analysis presented here could likewise be used to predict how a team might respond to economic objectives created by policies elsewhere on the continuum of control in Figure 2. With these responses understood, policies could be formulated to encourage the desired behavior from Chinese collectives under future national planning objectives.
PART TWO

THE EFFECT OF SHIFTING MARKET STRUCTURES ON A CHINESE COLLECTIVE'S OUTPUT SUPPLY AND INPUT DEMAND
INTRODUCTION

In the People's Republic of China, unlike most Western economies, the market is only one technique among several for directing the economic activities of firms and households. The centralized nature of the state has tended to prejudice the Chinese in favor of various nonmarket controls until recently. Now, however, a major aspect of economic reform is the integration of state planning with the market mechanism.

Zhou (1982, page 103) states that "the almost unanimous view of Chinese economists on the need to promote commodity economy and act by the law of value provides a theoretical basis for the policy of regulating the economy through the market under the guidance of state planning." This analysis takes this idea one step further by applying a microeconomic planning technique--linear programming--to issues of market supply and demand.

In the first essay, linear programming was used to make a broad comparison of a team's optimal response to changing policy environments, holding all prices and resource levels constant. This second essay uses parametric programming to determine the effect of changing price and resource levels on the team's behavior, with the intent of accomplishing three objectives.

First, I develop output supply and input demand curves for a production team (i.e., collective) in China's nonmarket economy. Second, I use this technique to investigate the effects the Responsibility System has had upon the output supply and input demand of a typical agricultural
production team in comparison to the most liberal of previous planning environments, 1961 to 1966. Finally, I predict the potential future effects upon team supply and demand of shifting from the structure of the Responsibility System to a full market economy.

These objectives gave rise to the three hypotheses tested in this paper. By accomplishing the first objective, we can test whether:

1. The Responsibility System has increased the supply potential of production teams.

2. The Responsibility System has increased the demand for land and labor by production teams.

3. Output supply and input demand relationships will further shift as the agricultural economy becomes more market oriented.

We might expect _a priori_ that the team's supply and demand curves would shift cleanly and consistently from one policy period to the next. This, however, does not take into account the interaction between variables affected by policy changes. For example, the policy periods included in this analysis are marked by significant changes in the team's ability to both hire and allocate labor. This labor factor may alter the shape of a supply or demand curve, or cause it to shift in an unexpected direction, yielding results which are at once more interesting to the analyst, and more useful to the policy maker.

Through an evaluation of the above three hypotheses, combined with this very important caveat, we hope to allow Chinese planners and policymakers to more thoroughly study the effects of shifting market structures on output supply and input demand.
METHODOLOGY

As a part of the larger Chinese economy, the production team must optimize an objective function based upon the socialist labor theory of value (Lardy, 1978) which provides us with the identity:

\[ P = C + V + M \]

where \( P \) = value or price,
\( C \) = embodied (or past) labor,
\( V \) = present labor, and
\( M \) = Marxian surplus value.

For the Chinese agricultural economy, this relationship may be further disaggregated:

\[ P = C + V_k + V_c + M_f + M_t \]

where \( P \) = price,
\( C \) = nonlabor production costs,
\( V_k \) = in-kind wages to labor,
\( V_c \) = cash wages to labor,
\( M_f \) = collective fund, and
\( M_t \) = taxes.

From the components of the socialist labor theory value we can formulate objective functions to be optimized under the various economic policy environments imposed upon production teams since 1949. Objective functions for hypothetical cases—such as a market economy—may also be
formulated from these components. In this analysis, we consider three policy environments: 1

Period 1—the Five-Year Adjustment (1961-1966),
Period 2—the Responsibility System (1981-present), and
Period 3—hypothetical market economy.

These particular policy periods were selected in order to compare the current Responsibility System with the most liberal of previous planning environments (1961 to 1966), and to compare the impact of a market economy with both.

We were able to construct linear programming models for these policy periods by representing the economic environment of each period with a distinct objective function and a unique set of constraints. 2 Once these models were solved, we were able to determine relevant price and resource level ranges through range analysis. Parametric programming was then used to trace out the supply relationship for wheat and the demand relationships for both land and labor.

A generalized version of the LP matrices used to solve the optimization problems associated with the three policy periods is presented in Figure 1. 3 Modifications of the objective function and corresponding

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1 For a description of the objective function associated with these periods, see the Theoretical Framework section of Part One.

2 In Part One, we used a set of 1980 data from an agricultural production team in north China to develop and validate the initial linear programming model of the team's optimal economic behavior.

3 Because no comparable time series or cross-sectional data are available, we were not able to estimate production functions. By implication, the team is limited to producing with a single technology.
<table>
<thead>
<tr>
<th></th>
<th>Produce</th>
<th>Sell</th>
<th>Buy</th>
<th>Consume</th>
<th>Taxes</th>
<th>Fund</th>
<th>Borrow</th>
<th>Hire</th>
<th>Plots</th>
<th>RHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C row (economic)</td>
<td>-Cj</td>
<td>Cj</td>
<td>-Cj</td>
<td>-Cj</td>
<td>-Cj</td>
<td>-Cj</td>
<td>-Cj</td>
<td>Cj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>B₁</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>aij</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1</td>
<td>aij</td>
<td>B₁</td>
<td></td>
</tr>
<tr>
<td>Bullocks</td>
<td>aij</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>aij</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1</td>
<td>aij</td>
<td>aij</td>
<td>B₁</td>
</tr>
<tr>
<td>Quotas/contracts</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
</tr>
<tr>
<td>Subsistence</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
</tr>
<tr>
<td>Transfer rows</td>
<td>-aij</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Collective accounting</td>
<td>-aij</td>
<td>aij</td>
<td>-aij</td>
<td>-aij</td>
<td>-aij</td>
<td>-1</td>
<td></td>
<td>-aij</td>
<td>aij</td>
<td>0</td>
</tr>
<tr>
<td>Taxes</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
</tr>
<tr>
<td>Hiring</td>
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<td>aij</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
</tr>
<tr>
<td>Plot transfer</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B₁</td>
</tr>
</tbody>
</table>

Figure 1. Generalized programming model for a north China production team
LP matrix for each policy period are briefly described in the paragraphs that follow.

**Period 1: The Five-Year Adjustment (1961-1966)**

Policies of this period were marked by centralized government control. The state dictated to the team that it must produce certain crops—wheat, corn, and cotton—sell minimum quotas to the government at procurement prices, and meet its own subsistence needs. Market prices barely influenced the amount of marketed surplus because quotas were set so high that few teams had any surplus to market (Perkins, 1966).

During the adjustment, the state allowed up to five percent of collective land area to be allocated to household plots. In terms of the LP matrix, this meant not more than 1/4 of the total 286.8 mou could be allocated to household plots. Additionally, there was no capital borrowing and no labor hiring during this period.

**Period 2: The Responsibility System (1981-Present)**

We represent this period with a form of the Responsibility System known as "group contracts" (lian chan dao zu). Under this arrangement, the team divides its fields into strips and groups contract to meet fixed production quotas. In effect, this allows the constraint on household plots to increase to the full collective land area or 286.8 mou. However, since contract obligations must be met, the quota restrictions remain in place and in this way limit the extent of household plot cultivation.
Through the Responsibility System, the state is able to direct a significant portion of foodgrain output by enforcing contracts. Aside from this, however, inputs and outputs may be "freely" exchanged. Other policies associated with the Responsibility System allow us to eliminate the collective fund, include capital borrowing, and bring labor hiring into the LP matrix.

Period 3: Hypothetical Market Economy

This case postulates the introduction of a market economy into present-day agricultural organization and might best be compared with cooperative forms of agricultural organization practiced in Taiwan. In terms of the LP matrix, the collective fund is eliminated, all quota restrictions are removed, and the entire 286.8 mou of land area is free to be allocated to household plots.

A summary of the key distinctions between the three policy periods is presented in Figure 2.

<table>
<thead>
<tr>
<th>Period</th>
<th>Quotas/contracts</th>
<th>Subsistence requirement</th>
<th>Labor hiring</th>
<th>Plot area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1</td>
<td>Quotas</td>
<td>Produce</td>
<td>0</td>
<td>5% maximum</td>
</tr>
<tr>
<td>Period 2</td>
<td>Contracts</td>
<td>Produce or buy</td>
<td>6 people</td>
<td>15% maximum</td>
</tr>
<tr>
<td>Period 3</td>
<td>0</td>
<td>Produce or buy</td>
<td>Unconstrained</td>
<td>100% maximum</td>
</tr>
</tbody>
</table>

Figure 2. Key distinctions between the LP matrices for periods 1 through 3
Parametric Programming

Initially, the LP models for the three policy periods were solved for fixed prices and resource levels. Then, through the use of parametric programming, we were able to trace out stepped supply curves for wheat and demand curves for land and labor. Parametric programming is a technique which allows us to change a price (C row) or a resource level by constant increments, *ceteris paribus*, causing the relationships thus traced to be stepped.

To determine the relevant increments of 1) price change in the case of wheat and 2) resource level change in the case of land and labor, range analysis was used. Range analysis is a technique which reveals, for a single LP solution, the range over which a shadow price or opportunity cost is valid. Actual output from one range analysis is presented in Figure 3 to illustrate. This example indicates that a

<table>
<thead>
<tr>
<th>Row</th>
<th>Activity</th>
<th>Lower limit</th>
<th>Lower activity</th>
<th>Unit cost</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor (early June)</td>
<td>1,414</td>
<td>none</td>
<td>1,360.47</td>
<td>.8996</td>
<td>.8996</td>
</tr>
<tr>
<td></td>
<td>1,415</td>
<td>1,510.47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Range analysis for early June labor under the Responsibility System

1The reader may refer to Part One for details regarding changes in output mix, resource use, and income levels.
shadow price (unit cost) of ¥0.90 per hour is relevant over a range of 1,360 to 1,510 labor unit hours per ten-day period. Based upon this information, the RHS for labor was initialized at a level of 500 labor unit hours and increased by increments of 100 until it reached a level of 2,000 unit hours. Using this procedure, we were able to find the shadow price associated with changing levels of labor availability, the shadow price being a measure of how much one additional unit of labor would be worth to the team.

Put another way, the parametric procedure reveals the value of the marginal product (VMP) of labor at different levels of labor availability, making it possible to trace out a stepped VMP—or demand—curve for labor in a particular ten-day period. This was done for early June labor in all three periods. Parametric programming was likewise used to examine the value of the marginal product of land in each period.

Supply curves for wheat were similarly derived. In the case of wheat output, price levels were parameterized and the LP was solved to determine how wheat supply would respond to such price changes. The results were then used to plot stepped supply curves for wheat in each of the three policy periods.
RESULTS

Hypothesis 1: Supply Potential for Wheat

Here, we examine the effect the Responsibility System has had on the team's supply potential for wheat by comparing supply relationships for period 1 to those for period 2. Figure 4 illustrates the market supply curve of wheat over and above 1) procurement quotas in the case of period 1 and 2) contract obligations in the case of period 2.¹

The supply relationships in Figure 4 provide only faint support for our first hypothesis: That the Responsibility System has expanded the supply potential of production teams. Overall, the supply curve shifts outward, but only slightly. Thus, over the price range shown, the team would in total supply only 4.8 percent more wheat to the market under the Responsibility System than under the policies of the Five-Year Adjustment.

Significantly, there is a price range (¥0.26 to ¥0.42) over which the team's marketed wheat supply actually contracts under the Responsibility System. We suspect this occurs because labor hiring is allowed under the Responsibility System, relieving a constraint upon production of more labor-intensive crops--such as corn--relative to wheat. Consequently, the opportunity cost of producing wheat is higher

¹Marketed output should not be confused with produced output which, in the case of wheat, actually declines from period 1 to period 2 (see Table 2, Part One).
Figure 4. Market supply curve for wheat under the Five-Year Adjustment (1) and the Responsibility System (2)
than it was under the labor constraint of period 1.\textsuperscript{1} Corn thereby competes with wheat up to the point where the market price for wheat (¥0.42) overshadows the increased opportunity cost associated with corn in period 2.

These supply curves also reveal important information for price planning. For example, under the policies of the Five Year Adjustment, prices above ¥0.26 were met with virtually no increase in this team's marketed wheat supply of about 52,000 catties. But, under the Responsibility System, a price increase from ¥0.25 to ¥0.30 causes marketed supply to jump from 34,500 catties to 50,000 catties. For any further increase to occur, price must be raised to ¥0.42 per catty.

**Hypothesis 2: Demand for Land and Labor**

By once again comparing parametrics for periods 1 and 2, we were able to investigate the effects of the Responsibility System on the team's demand for land and labor. The results are presented in Figures 5 and 6.

The demand relationship for land in Figure 5 may be interpreted as follows: Say the team has 210 mou of land available for cultivation. Under the Five-Year Adjustment, the shadow price—or VMP—of the last mou would be ¥71. Under the Responsibility System, the shadow price of the last mou would be ¥147. Thus, in the economic environment created by the Responsibility System, the value of the marginal product of land is

\textsuperscript{1}Under the linear programming algorithm, the supply curve is actually a graph of the z-row, or the opportunity cost of not producing the optimal level of a crop.
Figure 5. VMP curve for land under the Five-Year Adjustment (1) and the Responsibility System (2)
Figure 6. VMP curve for labor (early June) under the Five-Year Adjustment (1) and the Responsibility System (2)
doubled at 210 mou. For other levels of land use the VMP curve also shifts, but not by such a dramatic magnitude. This pattern can be attributed to the greater freedom of choice the Responsibility System gives the team in deciding what to produce and how to produce it. As we would expect, the team alters its patterns of production and resource utilization such that the value of land is augmented. Our results, which show the VMP of land increasing from period 1 to period 2, provide support for the hypothesis that input demand has expanded under the Responsibility System.

The demand relationships for labor presented in Figure 6 are interesting because they demonstrate the opposite pattern. Instead of shifting outward, the VMP curve for labor shifts inward under the Responsibility System. In other words, at a given level of labor availability, the value of the last unit of collective labor falls from period 1 to period 2. Alternatively, at a given implicit wage, the quantity of labor demanded falls. This can be explained by the team's ability in period 2 to hire labor at critical times, such as the first ten days of June. (Contrast this with the land resource, which is fixed; the team cannot "hire" additional land.)

Where labor hiring is not permitted, as in period 1, the value of an additional hour of labor during a critical ten days is well above the going wage of ¥0.865/hour.¹ In period 2, however, the team employs labor to the point where the wage paid to labor (price) equals the value

¹This was also demonstrated in Part One. See, for instance, Table 4 on page 23.
of its marginal contribution (shadow price). More succinctly, labor hiring policies of the Responsibility System allow the team to operate efficiently, and reduce the VMP of—or demand for—the team’s own labor.

Hypothesis 3: Supply and Demand Effects of a Market Economy

Here, we compare the effects of a market economy on supply and demand relationships to those of the Five-Year Adjustment and the Responsibility System. In Figures 7, 8, and 9, the results for period 3 are superimposed on those already presented for periods 1 and 2. For the most part, our hypothesis that supply and demand relationships will further shift as the economy becomes more market oriented is supported.

In the case of wheat supply (Figure 7), the trend toward increased output is continued and more pronounced. The team's market supply curve for wheat shifts significantly outward in a market environment, and there is no stage of reversed opportunity costs as seen between periods 1 and 2. In total, marketed output increases 23 percent over period 1, and 17.4 percent over period 2, supporting our expectation that a market economy would further expand the team's supply potential.

Figure 7 also reveals that under the policies of the Five Year Adjustment and the Responsibility System, there is a limit (of about 56,000 catties) beyond which higher market prices do not stimulate additional marketed output. Contrast this to the situation under a market economy, where a price as low as ¥0.25 per catty produces a supply response of 70,000 catties. Such results suggest that for this

1 Again, the reader may refer to Table 4 on page 23.
Figure 7. The effect of a market economy (3) on the supply curve for wheat.
Figure 8. The effect of a market economy (3) on the demand (VMP) for land
Figure 9. The effect of a market economy (3) on the demand (VMP) for labor
team, increased wheat production may be brought about by a liberalization of policies, rather than higher prices.

The effect of a market economy on the team's demand for land is seen in Figure 8\(^1\) where we notice that the VMP curve shifts inward from period 2 to period 3. This interesting result is related to several policy variables.

In period 1, where there is no labor hiring, the marginal value of labor is high relative to land. When labor hiring is allowed, land becomes a more binding constraint, and the relative value of land increases as reflected by the outward movement of the VMP curve in period 2. Moreover, the environment of the Responsibility System—where the team is simultaneously fulfilling government contracts and trying to engage in profitable private plot production—puts pressure on land that further inflates the VMP curve.

Under the market economy of period 3, however, some of this pressure is relieved. In the absence of contract obligations to the state, and given the ability to hire more outside labor, the team has decided upon an output mix that is less land—and more labor—intensive, causing the demand (VMP) curve for land in period 3 to shift downward slightly. Such results demonstrate that a team's demand for inputs is influenced by the interaction among many policy variables.

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\(^1\)The team was limited to a maximum of 286.8 mou in periods 1 and 2, which is consistent with China's policies prohibiting the exchange of land. In period 3, the portion of the VMP curve for land that extends beyond the 286.8 mou limit simply reflects the fact that our parametric model for a market economy allowed the team to acquire additional land.
Finally, in Figure 9, the effect of a market economy on the team's demand for labor is illustrated. From Figure 9 can be discerned three characteristics of downward-shifting labor demand in period 3.

First, the team can hire more outside labor because the 1,500 hour limit does not exist in a pure market environment. Thus, at levels above 1,500 hours, the VMP curve for labor extends beyond the curves for the other two periods.

Second, the team does hire more outside labor due to the more labor intensive nature of the crops--such as plot vegetables--it is now free to produce. Such hiring lowers the VMP of labor, as was seen earlier.

Third, team labor itself is more motivated in a market environment, which increases the effective labor supply and decreases the value of the last hour.

The combination of these three factors causes the team's demand for labor to shift downward and extend outward as it does in period 3. Once again, such results demonstrate the significant influence of interaction among policy variables upon the team's demand for inputs.
This analysis has taken the idea of regulating the economy through the market under the guidance of state planning one step further by using a microeconomic planning technique--LP--to study the effect of shifting market structures. Our parametric programming model, formulated from the labor theory of value, has proven useful to this end in three respects.

First, for a given set of economic policy objectives, parametrics can be used to predict an individual team's market response to changing commodity prices and varying levels of resource availability (ceteris paribus). Moreover, the examples presented in this particular study--wheat supply, VMP of land, and VMP of labor--are by no means exhaustive. Other output supply and input demand relationships could also be examined.

Second, by generating sets of parametrics, as this study has done, it is possible to compare market supply and demand relationships of an individual team under changing economic policy objectives. With such information, planners may be better able to predict the effects of various policies on the economic behavior of teams. Will the team supply more or less wheat to the market? Will the demand for labor rise or fall? And what about the market value of land? Will it be enhanced or diminished?

A final feature of this analysis is although it cannot predict every aspect of a team's behavior, it can be carried out within the framework of China's existing statistical systems. By combining internally
available data with the methodology outlined here, Chinese planners can more thoroughly study the market effects of policy alternatives and policy makers can more thoroughly understand market effects before making their next policy decision.
GENERAL CONCLUSION

These two essays are examples of how linear programming can be used to study the optimal economic behavior of Chinese agricultural production teams under changing policy environments.

The first essay, "The Optimal Response of a Chinese Agricultural Collective to Alternative Economic Policy Environments," examined the microeconomic impact of five policy environments on a typical collective's resource allocation, production, and income. Through the evaluation of four specific hypotheses, we were able to make several observations regarding the Chinese agricultural economy. Our results suggested that:

1. The collective does respond to economic incentives.
2. Labor hiring is necessary for the team to overcome seasonal labor shortages which can act to constrain the team's overall production.
3. There is a trade off between levels of foodgrain production and income under the existing price structure, creating a conflict between local and national priorities.

In the second essay, we took the idea of regulating the Chinese economy through the market under the guidance of state planning one step further by using linear programming (a microeconomic planning technique) to study the effect of shifting market structures on a team's output supply and input demand. We demonstrated how parametric programming—an extension of LP—can be used to predict a team's market response to
changing commodity prices and varying levels of resource availability.

We also generated sets of parametrics to compare market supply and demand relationships of an individual team under changing economic policy objectives.

The sort of analyses presented in these two essays could be used by Chinese planners to predict how a team might respond to the economic objectives created by various policies along the continuum of control developed in Part One (see Figure 2). And, although this analysis cannot predict every aspect of a team's behavior, it can be carried out within the framework of China's existing statistical systems. By combining internally available data with the methodologies offered here, Chinese planners may more thoroughly study the effects of policy alternatives and policies may be formulated to encourage the desired behavior from collectives under future national planning objectives.
BIBLIOGRAPHY


