GRAIN SUPPLY RESPONSE IN CHINA AND INDIA: A COMPARATIVE STUDY[1]

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ABSTRACT

This study estimates grain supply response for China and India. The results show that farmers in both countries seem to be responsive to price changes. However, Chinese farmers care about the price ratios between grain and non-grain crops and adjust their behaviour accordingly, while Indian farmers respond primarily to the grain price signal itself. In China, a significant negative relationship between grain output and input price was identified; such a result could not be obtained for India. Therefore, grain supply in China is affected by the changes in all the relevant prices, while grain supply in India seems to be largely affected by changes in the grain price itself. Weather conditions and technological progress are found to have a significant impact on grain production in both countries.

1. INTRODUCTION

In many developing countries, food self-sufficiency is considered of overwhelming importance. Policies which could encourage greater production of food crops are sought and the formation of these policies necessitates supply response studies on food crops. Many such studies have been carried out for various developing countries including India, e.g., Bauer and Yamey (1959), Krishna (1962; 1963), Falcon (1964), Mubyarto (1965), Behrman (1970), Bardhan (1970), Bardhan and Bardhan (1971), Lim (1975, Chapter 10), and Livingstone (1977). However, studies of this kind for China are not extensive. Few have attempted to carry out such studies with reference to China and India in an international comparative context. This research estimates grain supply responses for China and India. A comparison of the responses is carried out.

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2. TYPES OF SUPPLY RESPONSES OF PRIMARY PRODUCERS[2]

Since the pioneering work by Nerlove (Nerlove 1956), many studies have been carried out on the supply responses of primary producers in both developed and developing countries. Lim (1975) provides a survey on studies done in this area before 1975 while a more recent survey has been given by Rao (1989).

Studies vary greatly in their level of sophistication and choice of supply response models. The availability of reliable statistical data has obviously been an important factor in the choice of the statistical tools and models used. However, the most important determinant has undoubtedly been the type of supply responses studied and the characteristics of the crops analysed. According to Lim (1975, p. 25), there are three types of supply responses. They are the supply response of the agricultural sector as a whole, the supply response for individual crops and the supply response for marketed surpluses. Rao (1989) provides a similar classification. Lim also indicates two kinds of crops in general, annual crops and perennial crops.

At the most aggregative or macro level, there is the supply response of the agricultural sector in which interest is centred on the response of the aggregate agricultural output to movements in the terms of trade for agricultural products. It covers both annual and perennial crops.

The second type of supply response is that for individual crops and covers annual and perennial crops. However, annual and perennial crops have different characteristics and present different conceptual problems. They require therefore the use of different models. For this type of supply response, interest is centred on the allocation of the total acreage between crops in response to movements in their relative prices.

The third type is the response of the marketed surplus of crops to changes in relative price levels. This is concerned basically with subsistence agriculture where a significant proportion of the total output is retained for home consumption. Thus the price elasticities of the total output and the marketed surplus are not the same and must be measured separately. As very few perennial crops are staple foods, the supply response of the marketed surplus is largely concerned with the response of the marketed surplus of annual crops to movements in their relative prices.

For both technological and economic reasons, the supply response will be different for each crop and at each level. An important task of empirical analysis is to identify each of them separately and account for their differences (Rao 1989).

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[2] The discussion of this section is based heavily on Mubyarto (1965), Lim (1975) and Rao (1989).

The first type of supply response, the supply response of aggregate agricultural output, has received relatively less attention although there is an urgent need for such studies for the formulation of an effective price policy for agricultural development. The lack of such studies could be due to technical obstacles or difficulties in the inclusion of some important elements in a model, such as transportation conditions and the population density factor, as pointed out by Lim (1975, p. 25).

The supply response of perennial crops, which belongs to the second type of supply response, has not received much attention either although there has been a move recently towards the study of such crops. The fact that the conceptual problems encountered in such studies were more difficult to solve might have contributed to such a shortage (Lim 1975, p. 26). Most studies in the second category are on annual crops which often are the staple foods of most developing countries. When food self-sufficiency is considered the overriding aim of many developing countries, it was not surprising that emphasis was placed on such crops. Policies which could encourage greater production of these staple crops were required and the formation of these policies necessitated supply response studies on such crops.

The third type, the supply response of the marketed surplus, has received the most attention, especially during the 1960s and the early 1970s. This is due to the extreme importance of the marketed surplus to those developing societies with dominant subsistence agriculture. The literature on it, both theoretically and empirically, can be divided into three groups:

(a) The first group is concerned with the question of farmers' responses to economic incentives in subsistence agriculture (e.g., Boeke 1953; Krishna 1963; Lipton 1967 & 1968; Firth 1970; Mellor 1970; Scott 1976; Ellen 1982; and Massey 1987).

(b) The second group is concerned with measuring the size of the marketed surplus, identifying the factors which determine the level of the marketed surplus of subsistence crops, and finding means to increase the size of the marketed surplus (e.g., Krishna 1962; Bardhan, K. 1970; and Lim 1975, Chapter 10).

(c) The third group emphasises the role of the marketed surplus in economic development, i.e., its role in the early stages of industrialisation and in the move to sustained growth (e.g., Rostow 1960; Kellogg 1962; Bardhan 1964; and Nicholls 1970).

The supply response which this paper is going to estimate belongs to the second category: the supply response of annual crops.

3. MODEL SPECIFICATION

The variables to be included in an econometric model must be determined first. A number of factors affect grain production. Three price factors, namely, grain prices, non-grain farm produce prices, and production input prices, are believed to have more direct and important effects on grain production. Farmers' incomes from grain production and thus farmers' decisions on grain production are critically influenced by these factors. Thus these three factors are considered most important and are to be included in the supply response model. The first two price factors, i.e., prices of grain and non-grain crops, will appear in the model as a ratio.

Furthermore, in societies such as China and India, grain output may not be purely a function of some economic factors. Some non-economic factors, e.g., policy factors and technological progress, may also contribute importantly to grain output. Important also is the weather in such large agricultural countries with insufficient weather-resistant infrastructures. As such, technological progress and weather conditions may need to be included in the model.

Therefore, grain output can be mathematically expressed as a function of the above identified factors, i.e.,

(1) $GO = f(P_g/P_o, P_i, W, T)$

where:

GO: grain output;

P_g: grain prices;

P_o: prices of non-grain farm produce;

P_g/P_o: the ratio of prices of grain and non-grain crops;

P_i: prices of purchased farm inputs;

W: weather factors; and

T: time trend, representing technological progress.

(1) **Ratio of prices of grain and competing crops.** *Ceteris paribus*, the higher the relative price of grain crops, the more profitable it will be to produce them. Thus the higher the price, the greater will be the quantity of grain supplied.

However, the kind of price to be used in the analysis has to be decided. In China and India, there are government grain procurement prices and free market grain prices. In China, the government grain procurement price should be used because during the period of 1957-62 and the period of the Cultural Revolution till 1978, no free market was allowed by the government and thus free market prices were not relevant. Although the free market has been allowed since 1979, only in recent years have data on free market prices become widely available, notably since 1985 when substantial changes were made to the agricultural products marketing arrangements. Thus not enough observations are available to use the free market grain price as the effective price. Given the relative unimportance of the free market in China until recently, this is not thought to be a serious problem for the purpose of this analysis.[3] Relevant government procurement price indexes have been used to construct this price index ratio (See Section 4 for information on all the data used). As procurement prices are normally announced before each sowing season, it allows a certain amount of time for farmers to respond. Therefore, no time lag was used.

For India, the market price is the effective price to use as the government procurement price does not become effective until the free market price drops below it. Relevant wholesale price indexes based on free market prices are used to construct the price index ratio. Such free market prices become known to the producers only when they bring their products to the market for sale. These prices therefore have little effect on the production of the products which are offered for sale at the time by the farmers but they influence the production in the coming cropping season. Therefore a one-year time lag is used.

A positive sign is expected for the price index ratio variable.

(2) **Input prices.** Changes in input prices cause changes in the production costs and, *ceteris paribus*, will influence farm income. Farmers may use less inputs when their prices rise and output will fall. Hence, a negative sign is expected for this variable. The data used are the price index of agricultural inputs. No time lag was considered necessary as farmers can decide whether or not to buy the inputs within a short time.

(3) **Weather conditions.** In China, the statistics frequently used to indicate weather conditions are the sown areas affected by natural disasters which refer to flood, drought, winter damage, damage caused by frost, wind, hail, and so on. Two relevant indicators are "areas affected by natural disasters" and "areas damaged by natural disasters". The latter is a part of the former and includes areas in which the crop yield is 30% or more less than the norm. An index can be constructed by using either of the two "areas" against total sown area in a year to reflect weather conditions. Using "areas affected by natural disasters" is more appropriate because it better reflects the overall impact of natural disasters in a year so this was used to construct the

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[3] See analysis with panel data in Section 5.1.2 for further discussion.

weather index. The higher the index, the more severe the natural disasters. Thus, a negative sign is expected for the weather index.

In India, the availability of monsoon rains is crucial to grain production. Accordingly, an index, which is the total monsoon rainfall as a percentage of normal rainfall, is published regularly. This weather index is used in the analysis and a positive sign is expected for its coefficient. It should be noted that this relationship may not always hold as flooding, which causes damage to crops, will be associated with a large value for the index.

(4) **Technological progress.** Lipsey (1975, p. 88) claims, "The enormous increase in production per worker that has been going on in industrial societies for about 200 years is very largely due to improved methods of production". The enormous contribution from progress in farming technology to agricultural growth in the past decades is also evident even in developing countries such as China and India. This has been clearly indicated by the results of surveys of both experts and farmers. Hence, although the price factor is considered important, "we do not mean to imply that price is <u>quantitatively</u> (the underline added by the author) the most important determinant of supply. Over any long period technology is probably the most important determinant" (Lipsey 1975, p. 89). In each of the following model estimations, a time variable is used as a proxy for technological progress. A positive sign is expected for this variable.

Based on the functional relationship in (1) and the above discussion, the model used for estimating the grain supply response of China is:

$$(2) \qquad GO_t = \beta_0 + \beta_1 PIgrain_t/PIcash_t + \beta_2 PIinput_t + \beta_3 WI_t + \beta_4 T + \mu_t$$

where:

GO: national grain output;
PIgrain: price index of grain;
PIcash: price index of cash crops;
PIgrain/PIcash: the price index ratio of grain over cash crops;
PIinput: price index of agricultural inputs;
WI: weather index; and
T: time trend, representing technological progress.

This model looks similar to the Nerlovian expectations model (Lim 1975, pp. 29-33) in that the procurement prices are known before the sowing season and the farmers respond to "expected" prices rather than the price of the previous period.

However, it is not the Nerlovian expectations model as no expectational lags were intended and the prices the farmers will receive are not the prices they actually "expect" from the market but those determined by the government.

The model used for estimating the grain supply response of India is:

$$(3) \quad GO_t = \beta_0 + \beta_1 PIgrain_{t-1}/PIcash_{t-1} + \beta_2 PIinput_t + \beta_3 WI_t + \beta_4 T + \mu_t$$

Variables in this model are analogous to those in (2), except that the variable PIgrain/PIcash has a one-year lag.

Each of the models for estimating the grain supply response of China and India is a "simple model" as classified by Lim (1975, p. 39). There are no adjustment or expectation lags. It takes into consideration some of the slowly changing factors such as institutional or technological changes over time and the role of unspecified factors by using a time variable. The "simple model" is a one-equation model and its estimating equation is the same as the original supply function. This model has been widely used. Some examples are Stern (1959), Falcon (1964), Dean (1965). Tian (1990) and Chen and Buckwell (1991) provide two recent examples.

4. DATA COLLECTION AND COMPILATION

Data for China have been collected from various sources and presented in Table A.1 in the Appendix. The time series starts from 1950. Although China publishes price indices using different base years, the price indices using 1950 as the base year are the most comprehensive and easily available. The required price index ratios were constructed by using the grain procurement price index and the cash crop procurement price index. The weather index was measured by the "areas affected by natural disasters" over the total sown area. Weather information for the years of 1950-51 and 1967-69 was not available. These years were left out of the analysis as it would be very difficult to estimate meaningful values for them.

In India the time series starts from 1950/51. Grain output is based on the agricultural year which is from July to June. The base year for the price indices was 1970/71 and is based on the financial year which is from April to March. There are no agricultural production data based on the financial year and no price index data based on the agricultural year. Since the price indices are based on the financial year while grain output is based on the agricultural year, there is in fact a lag of 15 and not 12 months with the use of the time lag. In India, the price index for all cash crops is not available. Thus the price index of cotton was used as a proxy for that of cash crops in general as cotton is a major competing crop. The required price index ratios are thus constructed by using the index numbers of grain wholesale prices and cotton wholesale prices. There is also no price index for composite agricultural inputs in India. The price index for fertilisers is used as a proxy because of its importance in crop production. The weather index used is the total monsoon rainfall as a percentage of the normal rainfall, obtained from the India Meteorological Department. The time-series data used for estimating the grain supply response of India are presented in Table A.2 in the Appendix.

5. MODEL ESTIMATION AND THE RESULTS

The estimation was performed using the Econometrics Computer Program, SHAZAM 6.1. The ordinary least squares regression technique was used, unless otherwise indicated. For time-series data, models in both linear and log-linear forms based on the same specifications were estimated. The overall results from the log-linear form were not as satisfactory as those from the linear form. Thus, only the models in linear form are presented.

5.1 China

5.1.1 Time-series data

Thirty five observations were used as those years when the data on the weather were not available were excluded. The correlation matrix of variables based on the model specification (2) is shown in Table A.3. The estimation results were not satisfactory because the signs of two variables (PIgrain/PIcash and PIinput) were contradictory to expectations (Equation 1 in Table A.4). The Durbin-Watson statistic (d) of 0.31 indicates that there is a serious positive autocorrelation problem. This could be due to the following reasons.

(1) In China, political campaigns and drastic policy changes sometimes affect grain production substantially. For example, the Great Leap Forward in the late 1950s damaged agricultural production badly while the rural reform in the late 1970s had the opposite effect. The model (2), however, took little of this into consideration. In addition, the model did not explicitly consider the possible impact of market prices.

(2) Chinese economic data are often poor and cause problems in econometrical analysis. Under the Chinese planned economic system,

> political and administrative decisions often impinge on economic activities. When economic data originate from such a system, they often do not reflect economic movements but rather political and administrative decisions. For example, the procurement prices of grain crops or cash crops may be kept unchanged for many years (Table A.1); or they may be increased with little consideration for the actual market situation. Direct production control (in particular, during the period of collective farming) as well as strict market control may have also meant that the extent to which farmers can respond to price signals is limited. Consequently, this may induce some seemingly "irrational" phenomena. That is, when there are price changes, changes in grain production may not take place because farmers are not allowed to do so. When there are no price changes or even when the earnings from grain production go down, grain production may be increased because farmers are ordered to produce more. In these circumstances, the accepted relationships between output and price signals may be not as strong as expected or, in the extreme, may not exist, <u>not because of the lack of farmers' response but because of government control.</u>

In line with the above argument, two dummy variables were introduced. One represents the impact of changes in politics and policies (D_1). When political campaigns and sharp policy shifts are perceived to have had negative effects, -1 was used; e.g., for 1959-61. If positive effects are perceived, as, e.g., in 1979-84, then +1 was used. In other cases, 0 was used. A positive sign is expected for this dummy variable. The other dummy variable represents the impact of market prices (D_2). When there were market prices, 1 was used; otherwise 0 was used. Also a positive sign is expected. The construction of the two dummy variables and reasons behind them are presented in Table A.5 in the Appendix.

The estimation based on the model (2) with either D_1 or D_2 or both was tried, but the results were little improved (Equations 2-4 in Table A.4). Although the signs of the coefficients of PIgrain/PIcash and PIinput turned out to be as expected in most cases (except the one for PIinput in Equation 2), the positively autocorrelated regression disturbance remained in all three estimations, as the small Durbin-Watson statistics of 0.27-0.37 indicate.

To overcome the serial correlation problem, other estimation techniques have to be used. Several techniques are available (Kmenta 1986, pp. 302-28; Judge, Hill, Griffiths, Lütkepohl and Lee 1988, pp. 388-393). According to Judge et al, however, "the maximum likelihood estimator is best, so, if a suitable computer program is available, this estimator is recommended" (Judge et al 1988, p. 409). Following the recommendation by Judge et al, the maximum likelihood estimation is used with ρ estimated by a grid search.

Estimated first were the first-order models. The results of the four models, corresponding to the specification of Equations 1 to 4, are presented as Equations 5-8 in Table A.4. The signs of the coefficients for PIgrain/PIcash and PIinput for Equations 5 and 7 were still contradictory to expectations. However, it can be seen that the overall model results were improved substantially. All the R-square adjusted and F-statistics became much more significant. But at the 5% significance level, all the Durbin-Watson statistics except for Equation 5 were still in the inconclusive region. For the results of the maximum likelihood values of ρs, t-tests show that they all are statistically different from zero, indicating the disturbances are still positively serially correlated. Thus corresponding second- order autocorrelation models were estimated and the results are presented as Equations 9-12 in Table A.4. The results associated with Equations 5-12 in Table A.4 are asymptotic.

The results of Equations 9-12 in Table A.4, when compared to those from first-order models, show that the R-square adjusted remained almost the same while the F-statistics were only slightly improved. The Durbin-Watson statistics, however, indicate that there are no autocorrelation problems associated with these models: all the ρ2s are not statistically different from zero. Among the four second-order autocorrelation models, the signs of PIgrain/PIcash and PIinput for the two estimated without the policy dummy variable (Equations 9 and 11) are still contradictory to expectations and will not be considered further. The signs of all the coefficients for Equations 10 and 12 are in accordance with expectations. All the magnitudes of the coefficients are also acceptable although those of PIgrain/PIcash, PIinput and D_2 were not statistically significant, which will be explained below. According to the estimation results in Table A.4, it was clear that the policy factor was an important determinant of grain output during the past decades; the free market price factor was not. This has been repeatedly reflected in the model estimation process as is shown in Table A.4. That is, without dummy variables, the model results were far from satisfactory; when the free market price dummy variable was introduced, there was some improvement but this was not very significant. Only when the policy dummy variable was introduced (either with or without the free market dummy variable), were the overall model results satisfactory.

Thus both Equations 10 and 12 in Table A.4 seem appropriate for explaining the relationships between the explanatory variables and grain output. A t-test has shown that the corresponding coefficients in the two models were not statistically different. Nevertheless, Equation 10 is selected for further application because it has a higher F-statistic. Equation 10 of Table A.4 is reproduced below:

(4) $$GO = \underset{(4.02)^{***}}{13717} + \underset{(0.46)}{8.99PIgrain_t/PIcash_t} - \underset{(-0.79)}{24.92PIinput_t} - \underset{(-2.31)^{**}}{83.22WI_t} + \underset{(7.86)^{***}}{756.1T} + \underset{(2.78)^{***}}{1026.5D_1}$$

t-ratio in parentheses;
** and *** indicate statistical significance at 5 and 1 percent level respectively.

Statistically speaking, Chinese farmers do not respond to price signals. The relationships between grain output and the price variables are insignificant. However, the insignificant relationships should not be interpreted as showing that Chinese farmers are not responsive to price signals. The reasons have been spelled out earlier, the major one being the planned economic system practised by the Chinese government. Thus, one important conclusion that can be drawn from the results of the model (4) is that the highly planned economic system did indeed restrict the extent to which the farmers could respond to price signals over the past decades.[4]

In the Chinese social and economic context, drastic shifts in government policy have a significant impact on grain production. This has been verified by the significant coefficient of the policy dummy variable (D_1) and its substantial magnitude. A sharp policy shift would cause a shift in the intercept of the supply curve. The change in grain supply could be as large as 10 million tonnes. This magnitude seems quite realistic when considering changes in Chinese grain production in, for example, 1960, 1979, and 1985. The homogeneity of the Chinese farmers as discovered in a survey by Zhou (1993a) explains why such dramatic changes in grain output could take place in response to a policy change.

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[4] While it is concluded that the rigid planned economic system restricted the extent to which farmers could respond to price signals, it needs to be pointed out that this does not mean that Chinese farmers had no means at all to respond to changes in prices. In fact, as demonstrated by various researches, even under the situation of a direct government plan by which farmers were told to allocate an assigned area to each crop, there was still scope within which farmers could adjust their production activities (Zhong 1985; IGCAAS 1986; Zhao and Ming 1986; Chen and Buckwell 1991, pp. 100-101). Several important ways to do this are as follows: (1) They may allocate a larger or smaller area to grain crops than they declare; (2) They may differentiate between crops in allocating different qualities of land; (3) They may interplant one crop with another in the same piece of land; (4) They may change the allocation of physical and labour inputs for different crops (e.g., discriminating in quantity, quality and timeliness); and (5) They may choose between different new farming technologies for various crops. However, the extent to which farmers can utilise the above ploys is limited. This is reflected by the insignificant relationships between grain output and the price variables.

Technological progress has been shown to have an important effect on grain output over the time period investigated. The value of the coefficient on the time trend variable in the model (4), used as an indicator of technological improvement in grain production, shows that about an extra 7.5 million tonnes of grain is produced annually due to continuing improvements in technology.

Weather conditions are a very important factor affecting grain output. According to the model (4), with every one percent increase in the weather index, there would be a decrease in grain production of about 830 thousand tonnes at the national level. The extent to which other variables in the model, except the policy dummy variable, may change in each year is relatively small. That is, the price indices change slowly over time Therefore, the contribution to grain output brought by changes in these variables would be within a small range. The contribution of technological progress is almost a constant because every year the value of the variable T increases by 1. However, there is little certainty about the weather. The change in WI over a year can be drastic. For example, at the national level according to data in Table A.1, the range over which the WI may change can be from 7% to 35%. The impact of changes over such a range on grain output will be very significant. Therefore, weather conditions affect grain production importantly in China.

5.1.2 Panel data

Equations 10 and 12 in Table A.4 show that PIgrain/PIcash and PIinput were not as strongly related as other variables to grain output. This is because under the rather strict planned economy, the extent to which farmers could respond to price signals was largely restricted by government administrative measures.

The results revealed by the surveys on Chinese farmers and experts show that Chinese farmers do respond to economic incentives (Zhou 1992, 1993a). This suggests that, in an environment where farmers have more autonomy to make their own decisions, as for example, from the reform of the marketing of agricultural products in 1985, it would be reasonable to expect a stronger relationship between the variables PIgrain/PIcash and PIinput and grain output.

However, the time-series is not long enough to capture this relationship. To overcome this problem, panel data (pooled cross-sectional and time-series data) were used. It was possible to collect the needed statistics for various variables at the provincial level from various sources for four years (1987-90) (Tables A.6 to A.9 in the Appendix).

With such panel data, it was possible to carry out an econometric analysis to reveal the structural relationships between grain output and a number of explanatory variables. This analysis was based largely on the functional relationship expressed in (2), with the following exceptions. The variable "market price" was brought into the model, while the time variable was considered less important for such a short time span and was excluded.

The "market price" variable is measured by the "free market grain price index" (MPIgrain) and is lagged a year. A positive sign is expected. The previous arguments for including the variables PIgrain/PIcash, PIinput, and WI as well as those for their signs apply in this analysis. A larger coefficient may be expected of MPIgrain than PIgrain/PIcash, as the results in the previous two chapters, particularly those from the Chinese experts, indicate the importance of market price in recent years in China.

Due to the nature of the panel data, the classical normal linear regression model becomes less applicable. A generalised linear regression model must be adopted (Kmenta 1986, Chapter 12). In this analysis, the cross-sectionally heteroskedastic and timewise autoregressive model, which is a generalised linear regression model, was adopted (Kmenta 1986, pp. 618-22).

In general, the regression equation for panel data is written as:

$$(5) \qquad Y_{it} = \beta_1 X_{it,1} + \beta_2 X_{it,2} + \ldots + \beta_K X_{it,K} + \mu_{it}$$

$$(i = 1,2, \ldots , N; t = 1,2, \ldots , T).$$

That is, the sample data are represented by observations on N cross-sectional units over T periods of time. There are altogether n = N × T observations (Kmenta 1986, pp. 616-18).

The regression equation for this analysis can be thus written as:

$$(6) \qquad GO_{it} = \beta_1 PIgrain/PIcash_{it,1} + \beta_2 MPIgrain_{it-1,2} + \beta_3 PIinput_{it,3} + \beta_4 WI_{it,4} + \mu_{it}$$

$$(i = 1,2, \ldots , N; t = 1,2, \ldots , T).$$

To perform the pooled cross-sectional and time-series estimation, the data presented in Tables A.6 to A.9 were arranged to conform to the Kmenta model as described above. That is, the data were arranged so that

(1) all observations of a particular cross-sectional unit are grouped together in year order. A cross-sectional unit in this case is a province;

(2) a complete time-series for the first (cross-sectional unit) group is followed by a time-series for the second (cross-sectional unit) group, and so on; and

(3) each cross-sectional unit has the same number of observations in the time series.

Those cross-sectional units or provinces with missing values were deleted from the pooled cross-sectional and time-series data. They are Beijing, Tianjin, Shanghai, Tibet, and Hainan, none of which is a major grain-producing area. Since a one-year time lag was required for the variable MPIgrain, all the data for 1987 became useless except the free market grain price index which was lagged to 1988. As a result, there are 25 cross-sectional units and 3 periods of time. The total number of observations was 75, that is, 25 (N) × 3 (T) = 75.

The following was obtained:

$$\begin{array}{llllll} (7) \quad \text{GO} = 1572 & + \ 1.80\text{PIgrain}_{it}/\text{PIcash}_{it} & + \ 4.03\text{MPIgrain}_{it-1} & - \ 4.52\text{PIinput}_{it} & - \ 3.26\text{WI}_{it} \\ \qquad\qquad (6.00)^{***} & (2.89)^{***} & (3.59)^{***} & (-3.53)^{***} & (-2.51)^{***} \end{array}$$

Buse Raw-Moment R-Square = 0.973 F = 13.284
Variance of the estimate - Sigma ** 2 = 0.9428
R-Square between observed and predicted = 0.960
t-ratio in parentheses;
*** indicates statistical significance at 1 percent level.

The results from the above cross-sectional and time-series analysis clearly show that there are strong relationships between grain output and the independent variables under investigation. The relationships are all statistically significant at the 1% level.

According to the model (7), given that the other variables remain unchanged, at the provincial level, the increase by one percent in the ratio of procurement prices of grain over cash crops would increase grain output by about 20 thousand tonnes and the increase by one percent in the input price index would decrease grain supply by about 45 thousand tonnes.

As anticipated, there was a positive relationship between the variables of MPIgrain and grain output, and the coefficient of MPIgrain was larger than that of PIgrain/PIcash. For every one percent increase in its price index, there would be an increase in grain output of about 40 thousand tonnes. This indicates that as more and more elements of the market mechanism have been introduced into the grain economy in China, the market grain price has become a leading indicator to which farmers respond.

Weather conditions are again found to be an important factor affecting grain output. According to the model (7), with every one percent increase in the weather index, there would be a decrease in grain output of some 33 thousand tonnes at the provincial level.

5.2 India

The model estimation for grain supply response for India was based on the time-series data presented in Table A.2 in the Appendix. The time-series covers the period 1950/51-1988/89. Due to the unavailability of two index numbers for fertiliser wholesale prices for 1950/51 and 1951/52, these two years were not included. As a result, there were altogether 37 observations.

The correlation matrix of variables based on the model (3) is shown in Table A.10.[5] The estimation results were not satisfactory because the signs of two variables (PIgrain/PIcotton and PIinput) were contradictory to expectations (Equation 1 in Table A.11).[6]

It was thought that the model using the variable PIgrain/PIcotton might not be appropriate because cotton may not be a good surrogate for competing crops (This is explained later in this section). PIgrain and PIcotton were entered as two separate explanatory variables although one degree of freedom has to be sacrificed and there is an increased risk of multicollinearity because of a similar pattern in the movements of grain and cotton prices. The scatter diagrams of grain output and PIgrain and PIcotton show that there are clear and strong linear relationships between them. Thus the model (3) was modified into the following:

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[5] From now on, PIgrain/PIcash in the model (3) will be replaced by PIgrain/PIcotton in the regression analysis. The data used for PIinput are the price index of fertilisers. See Section 4 for explanations.

[6] It was considered that the index numbers of prices might have caused problems. Their base year was 1970/71 (1970/71=100) and the year before this would normally have a smaller index number. As PIgrain/PIcotton was constructed with two index numbers, so long as the two index numbers are close in size, no matter what their size, their ratio (in percentage) will be around 100. However, the price index number for fertilisers in the same year could be far less than 100. This could have distorted the overall relationships between grain output and the explanatory variables. Therefore it was thought that reconstructing the index numbers with an earlier year as the base might solve the problem.

However, the price index data might not cause much problem so long as they are based on the same base year because the reconstruction of the index numbers would not change the relationships among these numbers. Nevertheless, a trial was carried out to test this. All the price index numbers were reconstructed taking 1952/53 as the base year. The estimation based on (3) was carried out using the newly formed data (36 observations due to a one-year lag for PIgrain/PIcotton). The results were very similar to those based on the original data. This confirmed that any price index data would not cause much problem for the analysis so long as they are based on the same base year.

$$(8) \qquad GO_t = \beta_0 + \beta_1 PIgrain_{t-1} + \beta_2 PIcotton_{t-1} + \beta_3 PIinput_t + \beta_4 WI_t + \beta_5 T + u_t$$

where:

GO: national grain output;
PIgrain: index numbers of grain wholesale prices;
PIcotton: index numbers of cotton wholesale prices;
PIinput: index numbers of agricultural inputs prices (fertilisers);
WI: weather index, monsoon rainfall as a percentage of normal;
T: time trend, representing technological progress

A positive sign is expected for PIgrain and a negative one for PIcotton. All the others are expected to have the same signs as previously discussed.

The results based on (8) revealed a positive relationship between grain output and PIgrain, and a negative one between grain output and PIinput. However, the sign for PIcotton was not as expected (Equation 2 in Table A.11).

The correlation matrix of variables presented in Table A.10 shows that PIcotton is highly correlated with PIgrain. This indicates that the incorrect sign for PIcotton may be attributed to the presence of multicollinearity. One way to avoid or overcome this multicollinearity problem is to construct a new variable using the two variables. This was attempted originally but did not work. Another possible way is to drop the variable PIcotton, which would imply that it is not a very important variable in explaining the variation in grain output.

The results, as indicated in Equation 3 in Table A.11 without PIcotton, were better, showing that the inclusion of PIcotton causes multicollinearity. To test this further, an estimation was carried out which included PIcotton but not PIinput. The results show that while the sign of PIcotton was still against expectation, the magnitude of the coefficient for PIgrain and its significance level were affected significantly (Equation 4 in Table A.11). In addition, the Durbin-Watson statistic was thrown into the inconclusive region (at the 5% significance level) although the F-statistic was slightly improved. This seems to suggest that the prices of cotton were not important in modelling India's grain supply response. The reasons for this will be elaborated later.

Equation 3 in Table A.11 also shows that the relationship between grain output and PIinput was not statistically significant. This indicates that PIinput also was not an important determinant of grain output in India. If that is the case, its absence from the model would not cause a significant change to it. Equation 5 in Table A.11 without PIinput shows that the results were very similar to those when PIinput was present, except that there was a notable improvement in the F-statistic, indicating that PIinput was indeed less relevant to the model.

Thus both Equations 3 and 5 can be used for further empirical application. The latter is selected because, though both the Durbin-Watson statistics fell into the no-autocorrelation region and both R-square adjusted were almost the same, Equation 5 has a higher F-statistic. It is reproduced below:

$$\begin{array}{lcccc} (9) \quad GO = & -56.60 & + 121.64PIgrain_{t-1} & + 523.89WI_t & + 1817.2T \\ & (-0.01) & (4.72)^{***} & (7.83)^{***} & (8.44)^{***} \end{array}$$

t-ratio in parentheses;
*** indicates statistical significance at 1 percent level.

The positive signs of the coefficients for the market grain price index and the time trend show that grain output responds positively to changes in them. Grain output also responds positively to changes in the amount of monsoon rainfall. The relationships between the three variables and grain output are all statistically significant at the 1% level.

The prices of cotton and inputs do not seem to affect grain output significantly. The result for cotton prices should not be surprising, as a similar result was obtained from the survey of Indian experts (Zhou 1993b). According to the survey, although the market prices of non-grain agricultural products were believed to have a positive effect on grain production, such an effect was very small compared to that of the market or government procurement prices. The effect is even less in this analysis because of the following reasons. First, unlike the case in China, the income ratio between grain and non-grain crops is properly balanced in India. Second, the price index used in the model is for cotton only, not the whole group of cash crops. Cotton is a seasonal crop and needs to be irrigated. In India, only about 30% of the arable land are irrigated. As such, the shift between cotton and grain crops is often not feasible (D.P. Chaudhri, personal interview, 6 May 1993) Thus farmers are less responsive to the changes in the price ratio of grain and cotton (PIgrain/PIcotton) or to the changes in the price of cotton itself (PIcotton).

The econometric analysis also shows that the effect of the input price factor on grain production is not significant. The reason for this may be that inputs are so heavily subsidised that minor changes in their prices do not have a significant impact on farmers' returns. If the subsidy policy was abolished resulting in significant increases in input prices, it could be expected that farmers would reduce their usage which would have a negative impact on grain production.

Therefore, among the price factors, the price of grain seems to provide the most important signal to farmers in India. According to the model (9), for every one percent increase in the grain price index, there would be an increase in grain output of about 120 thousand tonnes.

Technological progress also proved to be a very important determinant. The value of the coefficient for the time trend variable shows that technological progress increased output by about 1.8 million tonnes annually.

Weather conditions affect grain output critically. For every one percent increase in the monsoon rainfall index, there would be an increase in grain output of about 520 thousand tonnes.

5.3 Grain Supply Response in China and India: the Results Compared

Farmers in both countries seem to be responsive to price changes. However, there are differences. (1) Chinese farmers care about the price ratios between grain and non-grain crops and adjust their behaviour accordingly (according to the model based on panel data). Indian farmers, however, respond primarily to the grain price signal. (2) In China, a significant negative relationship between grain output and input price was identified (according to the model based on panel data). Such a result could not be obtained for India. Therefore, while grain supply in China is affected by the changes in all the relevant prices, grain supply in India seems to be largely affected by changes in the grain price itself.

The effects of weather conditions and technological progress on grain production were similar in both countries. Weather conditions are critical to grain output but more so in India. For example, in 1989 a one percent change in the weather index would cause total grain output to change by 0.20% (0.83mt/407.55mt x 100%) in China but by 0.31% (0.52mt/169.90mt x 100%) in India. Technological progress contributes to grain production positively and importantly in both countries.

It has also been found that drastic shifts in the Chinese government policy are an important factor affecting grain production.

6. CONCLUSIONS

Prices received by farmers (both procurement and market grain prices and non-grain crop prices) and prices paid by farmers (inputs) are all major factors influencing grain supply in China, but grain supply in India seems to be only affected by the changes in the grain price itself. Weather conditions and technological progress are very important determinants of grain production in both countries.

As weather conditions are still the predominant factor affecting grain production in China and India, it is especially important that a reasonable amount of investment in agriculture be maintained by the central government. Large-scale agricultural capital construction, such as irrigation infrastructure, can only be carried out with the support of government investment. They can increase the grain sector's resistance to weather-related disasters, thus reducing the effect of weather disturbance on production.

It is also important that funds from the central government are allocated to agricultural research and extension so that these activities can be carried out smoothly and effectively to ensure the grain industry fully enjoy the benefits of technological progress.

Chinese farmers are responsive to price signals of both grain and non-grain crops, and they shift resources between grain and non-grain businesses depending on the economic returns. Therefore, with the current situation in China, while attention should be paid to maintaining procurement prices at economic levels, the government should also adopt policy measures to balance returns from grain and non-grain businesses in order to encourage enough farmers in grain production.

The Chinese government does not subsidise the use of agricultural inputs as heavily as the Indian one. This paper is not going to suggest whether the Chinese government should follow a heavy subsidy policy on the use of inputs. However, given the significant negative relationship between input price level and grain production in recent years, the input price level should be kept under check. It should not be allowed to go too high so that it would discourage the farmers to use the inputs.

Because sharp policy shifts by the Chinese government have significant impact on grain production, the Chinese government should maintain a relatively stable grain economic policy and avoid sharp policy changes in order to maintain a steady increase in grain production to meet the country's growing needs.

Appendix

Table A.1 Time-series Data Used for Estimating the Grain Supply Response of China

Year (1)	Grain Output (10,000 tonnes) (2)	Grain procurement price index (1950 =100) (3)	Cash crops procurement price index (1950 =100) (4)	Agricultural input price index (1950 =100) (5)	Total area sown (10,000 <u>mu</u>) (6)	Total area affected by natural disasters (10,000 <u>mu</u>) (7)
1950	13213	100.0	100.0	100.0	-	15571
1951	14369	118.3	118.4	102.5	-	21360
1952	16392	121.4	113.0	108.2	211884	13553
1953	16683	137.1	112.9	113.2	216053	35463
1954	16952	137.1	119.[illegible]	116.2	221889	32126
1955	18394	137.3	120.0	115.4	226622	30081
1956	19275	139.9	122.6	111.0	238759	28294
1957	19505	141.4	126.4	110.8	235866	43723
1958	20000	145.1	127.9	111.2	227992	46444
1959	17000	147.0	129.9	113.9	213607	62198
1960	14350	151.7	133.8	114.3	225863	80374
1961	14750	191.9	140.6	121.9	214821	80346
1962	16000	192.4	145.0	131.7	210343	52050
1963	17000	190.9	152.9	128.3	210327	48822
1964	18750	189.2	152.6	120.4	215297	32764
1965	19453	190.9	152.8	114.7	214936	31206
1966	21400	220.8	152.8	111.0	220243	36311
1967	21782	221.1	154.9	106.9	217414	-
1968	20906	221.1	154.9	103.9	209741	-
1969	21097	221.1	154.9	103.9	211416	-
1970	23996	221.1	154.9	103.9	215231	14961
1971	25014	222.0	161.4	101.7	218526	46576
1972	24048	222.2	164.2	99.9	221878	60867
1973	26494	222.2	164.9	99.9	222821	54740
1974	27527	222.4	165.1	100.1	222953	58019
1975	28452	222.8	165.1	100.0	224318	53029
1976	28631	222.8	165.1	100.1	224584	63749
1977	28273	222.8	165.8	100.2	224000	78032
1978	30477	224.4	174.0	100.1	225156	79667
1979	33212	271.3	200.4	100.5	222715	59051
1980	32056	271.8	210.8	101.5	219570	66789
1981	32502	283.5	215.0	103.2	217735	59679
1982	35450	283.5	215.2	105.2	217132	49700
1983	38728	283.8	215.4	108.4	215990	52100
1984	40731	282.4	212.8	118.0	216332	47831
1985	37911	522.2	277.3	123.7	215439	66512
1986	39151	573.9	287.3	125.1	216306	70703
1987	40298	619.8	296.8	133.9	217435	63135
1988	39408	710.3	330.3	155.6	217303	76305
1989	40755	901.4	385.5	185.0	219831	70485

\- Data not available.

Sources:
1. Columns 2, 3, 4, and 5: SSBa (1992), <u>China Statistics Yearbook 1992</u>, pp. 358, 263, 240.
2. Column 6: MAPRCa (1989), <u>China's Rural Economic Statistics Encyclopedia 1949-86</u>, pp. 130-31, for 1950-86; SSBa (1992), <u>China Statistics Yearbook 1992</u>, p. 352, for 1987-91.
3. Column 7: MAPRCa (1989), <u>China's Rural Economic Statistics Encyclopedia 1949-86</u>, pp. 354-57, for 1950-86; SSBa (1992), <u>China Statistics Yearbook 1992</u>, p. 385, for 1987-91.

Table A.2 Time-series Data Used for Estimating the Grain Supply Response of India

Year (1)	Grain Output (1000 tonnes) (2)	Index numbers of grain wholesale prices (1970/71 =100) (3)	Index numbers of cotton wholesale prices (1970/71 =100) (4)	Index numbers of fertilisers wholesale prices (1970/71 =100) (5)	Monsoon rainfall (percent of normal) (%) (6)
1950/51	50825	51.4	49.7	-	104
1951/52	51996	51.0	52.0	-	81
1952/53	59201	48.2	44.0	77.9	92
1953/54	69821	46.5	45.6	71.5	110
1954/55	68035	36.5	44.9	67.0	103
1955/56	66850	35.2	42.7	67.0	110
1956/57	69855	45.0	48.7	67.2	114
1957/58	64311	47.0	46.7	74.9	98
1958/59	77141	51.2	43.7	74.8	110
1959/60	76672	49.2	46.6	74.8	114
1960/61	82018	49.3	49.2	74.8	101
1961/62	82706	48.4	47.8	73.7	122
1962/63	80151	51.0	49.9	72.4	97
1963/64	80642	55.7	53.3	71.1	98
1964/65	89356	70.4	55.8	69.2	110
1965/66	72347	74.6	56.8	71.6	82
1966/67	74231	88.4	60.9	76.1	87
1967/68	95052	110.4	68.1	91.4	100
1968/69	94013	97.2	73.9	92.7	90
1969/70	99501	100.7	81.7	98.0	100
1970/71	108422	100.0	100.0	100.0	112
1971/72	105168	103.4	107.8	100.6	104
1972/73	97026	119.5	91.6	105.7	76
1973/74	104665	141.9	138.3	113.9	108
1974/75	99826	195.8	168.8	203.0	88
1975/76	121034	174.1	136.4	214.7	115
1976/77	111167	152.7	197.5	186.5	102
1977/78	126407	170.4	193.0	177.4	104
1978/79	131902	172.6	168.6	175.2	109
1979/80	109701	185.4	164.4	167.2	81
1980/81	129589	216.7	182.9	242.7	104
1981/82	133295	237.4	227.3	273.6	100
1982/83	129519	248.8	199.4	277.7	85
1983/84	152374	273.8	221.6	267.5	113
1984/85	145539	276.2	261.0	262.5	96
1985/86	150440	295.7	215.5	266.9	93
1986/87	143418	298.6	184.7	288.8	87
1987/88	140400	331.9	299.1	288.5	91
1988/89	169900	389.9	306.3	288.4	119

- Data not available.

Sources:

1. Column 2: GOIa (1989), Area and Production of Principal Crops in India 1986-88, p. 22, for 1950/51-1986/87; GOIb (1991), Economic Survey 1990-91, p. s-16, for 1987/88-1988/89. Data in Column 1 are in agricultural year, July to June.
2. Columns 3, 4, and 5, Chandhok and the Policy Group (1990), India Database: The Economy (vol. II), pp. 350-51, 356-57. Data in Columns 3, 4, and 5 are in financial year, April to March.
3. Column 6: India Meteorological Department (at the author's request).

Table A.3 Correlation Matrix of Variables Used in China's Time-series Regression Analysis - Corresponding to Variables in Table A.4 (35 Observations)

	GO	PIgrain/PIcash	PIinput	WI	T
GO	1.00000				
PIgrain/ PIcash	0.71098	1.00000			
PIinput	0.25533	0.71445	1.00000		
WI	0.43430	0.45780	0.22899	1.00000	
T	0.95336	0.72607	0.23314	0.57210	1.0000

Source: Calculated from the data in Table A.1.

Table A.4 Results of Regression (China, time-series data, 35 observations)

Equation	Coefficients							R-Square Adjusted	F	d
	Constant	Pigrain$_t$/Picash$_t$	Pfirput$_t$	WI$_t$	T	D$_1$	D$_2$			
Original model specification										
1	10362 (3.51)***	-4.45 (-0.13)	31.21 (0.71)	-185.26 (-2.91)***	800.52 (11.13)***			0.921	99.43	0.31
Dummy variables added										
2	9281.6 (2.62)***	14.24 (0.30)	14.86 (0.28)	-138.75 (-1.63)*	768.49 (8.31)***	558.55 (0.56)		0.918	77.79	0.27
3	11064 (3.86)***	5.98 (0.14)	-1.57 (-0.03)	-116.30 (-1.62)*	747.66 (9.96)***		1916.70 (1.83)**	0.926	86.46	0.36
4	11176 (3.10)***	4.94 (0.08)	-0.14 (-0.00)	-119.55 (-1.33)*	750.60 (8.32)***	-63.671 (-0.06)	1961.6 (1.71)**	0.924	69.58	0.37
First-order autocorrelation model in linear form										
5	14788 (4.20)***	-12.49 (-0.65)	8.17 (0.28)	-138.11 (-3.35)***	765.63 (7.96)***			0.979	468.34	1.86
6	14536 (4.25)***	7.44 (0.38)	-28.57 (-0.45)	-83.99 (-2.50)***	721.91 (7.50)***	971.42 (2.53)***		0.982	455.72	1.66
7	13714 (4.28)***	-13.58 (-0.69)	6.84 (0.24)	-133.78 (-3.63)***	738.41 (8.74)***		676.37 (1.09)	0.979	385.95	1.70
8	14201 (4.28)***	6.03 (0.30)	-26.87 (-0.89)	-94.78 (-2.52)***	776.45 (8.12)***	917.51 (2.31)**	277.80 (0.47)	0.981	372.66	1.68
Second-order autocorrelation model in linear form										
9	13888 (4.16)***	-12.57 (-0.61)	9.62 (0.33)	-135.18 (-3.68)***	763.57 (8.14)***			0.979	468.45	1.88
10	[illegible] (4.52)***	8.44 (0.46)	-24.92 (-0.74)	-80.72 (-2.31)**	756.10 (7.86)***	1026.5 (3.78)***		0.982	459.15	1.92
11	[illegible] [illegible]***	[illegible]	[illegible]	[illegible] [illegible]***	[illegible] [illegible]***		919.15 (1.56)*	0.980	394.23	1.93
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] [illegible]***	[illegible] [illegible]	0.982	387.57	1.92

Note: t-ratio in parentheses; *,**,*** indicate statistical significance at 10, 5, and 1 percent level respectively. Source: Calculated from the data in Table A.1.

Table A.5 Construction of Two Dummy Variables[a]

Year	D_1	D_2	Year	D_1	D_2
1952	1	1	1972	0	0
1953	1	1	1973	0	0
1954	1	1	1974	0	0
1955	1	1	1975	0	0
1956	1	1	1976	0	0
1957	1	0	1977	0	0
1958	1	0	1978	0	0
1959	-1	0	1979	1	1
1960	-1	0	1980	1	1
1961	-1	0	1981	1	1
1962	1	0	1982	1	1
1963	1	1	1983		1
1964	1	1	1984		1
1965	1	1	1985	-1	1
1966	1	1	1986	-1	1
1970	0	0	1987	-1	1
1971	0	0	1988	-1	1
			1989	0	1

[a] D_1 represents the possible impact which political campaigns and sharp policy shifts might have imposed on China's grain production. When such events are perceived to have had negative effects, -1 was used. If positive effects are perceived, then +1 was used. Otherwise 0 was used. Since the early 1950s, the overall political and policy environment encouraged grain production. The Great Leap Forward campaign launched in 1958 would not immediately have had a strong impact on grain production in that year. Thus +1 was used for 1952-58. The Great Leap Forward campaign soon, however, resulted in severe damage to the country's economy including agricultural production. Thus -1 was used for 1959-61. Starting from 1962, the policy emphasis was refocussed on grain production and some positive measures were implemented. Although the Cultural Revolution started in 1966, those positive policy measures on grain production carried out in the previous years would have extended a positive impact, and the Cultural Revolution would not immediately have affected grain production. Thus +1 was used for 1962-66. The Cultural Revolution again threw the country's economy into a chaotic situation. However, agricultural production was relatively less affected due to the need for food. Some policy measures ensuring normal grain production were in place. As a result, grain production did not drop as happened during 1959-61 but increased slowly. Thus 0 was used for 1967-78. The rural economic reform initiated at the end of 1978 cultivated a favourable environment for grain production for the following years. Thus +1 was used for 1979-84. The new grain procurement policy introduced in early 1985 dampened farmers' enthusiasm to produce grain. This situation changed little until 1989 when a significant increase in the procurement price took place. Although the price increase in 1989 could not make grain production as profitable as some other crops, it did improve the income from grain production to some extent. Therefore, -1 was used for 1985-88 and 0 for 1989. The other dummy variable, D_2, represents the impact of market prices. When there were market prices, 1 was used; otherwise 0.

Table A.6 Cross-sectional Data Used for Estimating the Grain Supply Response of China, 1987

Province	Grain Output	Grain procurement price index	Cash crops procurement price index	Free market grain price index	Agricultural input price index	Total area sown	Total area affected by natural disasters
	(10,000 tonnes)	(Last year =100)	(Last year =100)	(Last year =100)	(Last year =100)	(10,000 *mu*)	(10,000 *mu*)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
National Total	40473.3	108.0	103.3	118.1	107.0	217434.8	63102
Beijing	227.0	99.1	99.6	118.9	-	896.5	52
Tianjin	167.7	99.8	104.5	120.0	-	860.4	284
Hebei	1920.0	107.0	103.0	115.1	110.6	13035.2	5131
Shanxi	712.5	107.4	104.8	116.5	105.5	5988.7	4249
Inner Mongolia	607.0	105.8	122.0	120.9	106.5	6710.5	3366
Liaoning	1276.3	111.3	105.5	120.7	109.0	5430.9	1977
Jilin	1675.8	106.4	107.6	118.1	104.1	6055.3	1599
Heilongjiang	1737.6	102.3	118.4	116.9	106.5	12773.0	5433
Shanghai	232.6	116.4	105.2	126.7	-	1005.4	7
Jiangsu	3257.7	105.6	109.2	113.5	109.4	12700.5	2696
Zhejiang	1589.0	110.4	106.2	120.7	111.1	6561.4	1616
Anhui	2428.7	111.0	106.0	120.2	112.8	12557.8	2036
Fujian	839.3	113.0	108.0	113.3	106.8	3915.6	763
Jiangxi	1562.8	114.2	94.9	117.2	108.8	8224.0	1181
Shandong	3393.7	108.1	104.7	113.0	105.8	16331.6	4948
Henan	2948.4	97.8	104.0	112.1	114.4	17929.3	4398
Hubei	2320.7	112.5	97.7	123.6	111.1	11006.2	2108
Hunan	2593.7	121.2	85.0	131.0	114.6	11212.1	3131
Guangdong	1848.2	111.3	108.5	117.9	114.2	9196.3	1958
Guangxi	1210.2	123.3	104.7	117.2	105.5	6917.3	1378
Sichuan	3921.3	108.5	94.7	124.0	106.3	17922.4	4459
Guizhou	673.2	116.6	103.4	119.3	104.3	4869.6	1612
Yunnan	934.8	112.5	108.1	118.2	105.5	6116.0	1779
Tibet	46.7	-	-	-	-	314.4	127
Shaanxi	987.9	106.4	103.9	117.0	108.3	7191.9	3207
Gansu	529.4	110.4	109.1	120.9	104.8	5369.0	2223
Qinghai	104.1	105.1	102.0	100.0	104.1	761.7	170
Ningxia	139.0	105.2	105.5	125.4	107.6	1251.1	637
Xinjiang	588.0	102.0	101.3	110.8	102.3	4380.7	604

\- Data not available.

Sources:
1. Columns 2, 7 and 8: MAPRCb (1988), China Agricultural Statistics 1987, pp. 42, 36, 112.
2. Columns 3, 4 and 5: SSBb (1988), China Price Statistics Yearbook 1988, pp. 97, 74.
3. Column 6: SSBa (1988), China Statistics Yearbook 1988, p. 783.

Table A.7 Cross-sectional Data Used for Estimating the Grain Supply Response of China, 1988

Province (1)	Grain Output (10,000 tonnes) (2)	Grain procurement price index (Last year =100) (3)	Cash crops procurement price index (Last year =100) (4)	Free market grain price index (Last year =100) (5)	Agricultural input price index (Last year =100) (6)	Total area sown (10,000 <u>mu</u>) (7)	Total area affected by natural disasters (10,000 <u>mu</u>) (8)
National Total	39930.0	114.6	111.3	124.2	116.2	217303.8	76311
Beijing	234.6	124.8	137.7	135.0	-	893.2	161
Tianjin	159.8	124.4	106.5	133.9	-	864.8	388
Hebei	2022.6	105.5	101.9	113.7	117.7	13180.3	4482
Shanxi	856.1	116.8	119.0	121.0	118.1	5998.9	1906
Inner Mongolia	744.7	108.2	111.1	115.8	118.0	6839.0	2067
Liaoning	1307.2	103.8	130.9	124.4	118.0	5404.8	2047
Jilin	1693.2	102.5	110.0	121.5	116.8	6052.8	2797
Heilongjiang	1751.2	105.3	106.9	126.0	114.9	12349.4	5997
Shanghai	237.5	117.7	110.9	163.9	-	971.9	5
Jiangsu	3243.4	113.0	107.6	130.3	119.2	12576.9	5483
Zhejiang	1553.6	107.4	106.8	130.5	121.0	6447.7	2009
Anhui	2310.3	126.1	116.9	127.3	118.6	12253.8	4088
Fujian	837.4	127.8	118.5	140.8	121.5	3882.9	880
Jiangxi	1535.4	111.3	111.5	130.3	117.4	8094.6	2075
Shandong	3225.0	121.8	115.3	134.4	114.7	16436.4	7060
Henan	2663.0	119.8	109.6	140.4	121.8	17895.4	6993
Hubei	2252.6	115.5	102.7	127.0	118.1	10843.4	5854
Hunan	2536.2	123.0	99.9	134.1	128.3	11244.2	4647
Guangdong	1649.0	135.7	133.3	143.9	131.0	8063.9	1938
Guangxi	1055.5	135.2	121.3	129.8	126.7	7103.1	2515
Hainan*	119.8	-	-	-	118.9	1101.1	447
Sichuan	3878.3	106.9	115.2	127.5	120.5	18146.2	4828
Guizhou	611.0	123.0	109.3	136.1	116.6	4998.0	1301
Yunnan	940.8	115.8	103.4	129.8	113.9	6338.8	936
Tibet	50.6	-	-	-	-	315.2	41
Shaanxi	983.6	115.1	107.4	129.1	118.5	7165.8	3247
Gansu	596.8	114.0	106.3	115.8	114.3	5351.1	1336
Qinghai	105.8	108.9	120.2	102.8	111.0	771.4	158
Ningxia	164.3	116.4	115.0	113.7	117.1	1309.7	297
Xinjiang	610.7	107.7	117.7	122.2	108.5	4410.1	428

\- Data not available.

* Hainan province was established in 1988.

Sources:
1. Columns 2, 7 and 8: MAPRCb (1989), <u>China Agricultural Statistics 1988</u>, pp. 34, 30, 408.
2. Columns 3, 4 and 5: SSBb (1989), <u>China Price Statistics Yearbook 1989</u>, pp. 149, 126.
3. Column 6: SSBa (1989), <u>China Statistics Yearbook 1989</u>, p. 699.

Table A.8 Cross-sectional Data Used for Estimating the Grain Supply Response of China, 1989

Province (1)	Grain Output (10,000 tonnes) (2)	Grain procurement price index (Last year =100) (3)	Cash crops procurement price index (Last year =100) (4)	Free market grain price index (Last year =100) (5)	Agricultural input price index (Last year =100 (6)	Total area sown (10,000 mu) (7)	Total area affected by natural disasters (10,000 mu) (8)
National Total	41442.2	126.9	116.7	136.6	118.9	219830.3	70486
Beijing	239.2	113.5	121.4	114.2	-	884.1	321
Tianjin	180.5	130.7	126.7	163.5	-	859.5	550
Hebei	2067.7	134.9	130.5	151.6	116.7	13147.4	4702
Shanxi	933.4	149.2	122.1	147.0	114.4	6007.4	1731
Inner Mongolia	688.6	119.4	117.9	140.3	119.9	6863.7	4345
Liaoning	967.3	123.3	118.6	144.1	120.8	5391.7	4127
Jilin	1374.9	128.2	107.6	144.3	112.6	6032.1	4344
Heilongjiang	1668.9	117.9	109.9	137.7	111.9	12679.1	5535
Shanghai	236.5	-	-	142.7	-	954.4	-
Jiangsu	3282.8	126.7	120.9	137.6	123.6	12576.5	4086
Zhejiang	1575.5	141.2	121.0	134.8	117.4	6469.7	1440
Anhui	2424.7	126.8	113.9	126.9	121.7	12358.2	2789
Fujian	909.7	121.2	121.2	140.8	119.5	3984.5	615
Jiangxi	1589.6	125.5	119.3	136.5	121.0	8332.9	1636
Shandong	3250.0	131.3	117.5	137.4	118.2	16199.0	7061
Henan	3233.5	129.1	115.8	134.2	116.8	17999.2	3783
Hubei	2416.2	129.1	118.7	134.7	121.5	10891.4	1984
Hunan	2675.5	130.2	82.5	126.4	124.4	11623.2	3425
Guangdong	1830.5	131.4	145.5	143.3	120.0	8322.7	1374
Guangxi	1301.7	92.7	105.4	128.0	125.8	7424.6	1857
Hainan	151.7	-	-	141.8	124.6	1184.4	576
Sichuan	4083.5	141.0	109.9	142.1	116.2	18443.5	6325
Guizhou	670.8	117.7	113.4	137.5	119.7	5211.1	1970
Yunnan	998.4	131.9	109.9	143.9	120 4	6540.3	1839
Tibet	54.9	-	-	-	-	317.5	75
Shaanxi	1082.6	115.2	113.1	128.3	122.4	7250.8	2400
Gansu	639.2	117.5	106.1	136.5	113.7	5366.1	1330
Qinghai	110.8	128.8	109.0	151.1	116.4	798.3	144
Ningxia	177.2	133.7	112.3	149.5	118.4	1314.8	183
Xinjiang	626.4	111.3	115.2	122.8	111.4	4402.2	939

- Data not available.

Sources:
1. Columns 2, 7 and 8: MAPRCb (1990), China Agricultural Statistics 1989, pp. 68, 34, 386.
2. Columns 3, 4 and 5: SSBb (1990), China Price Statistics Yearbook 1990, pp. 117, 94.
3. Column 6: SSBa (1990), China Statistics Yearbook 1990, p. 266.

Table A.9 Cross-sectional Data Used for Estimating the Grain Supply Response of China, 1990

Province	Grain Output	Grain procurement price index	Cash crops procurement price index	Free market grain price index	Agricultural input price index	Total area sown	Total area affected by natural disasters
	(10,000 tonnes)	(Last year =100)	(Last year =100)	(Last year =100)	(Last year =100)	(10,000 mu)	(10,000 mu)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
National Total	45184.1	93.2	111.9	81.4	105.5	222543.4	57711
Beijing	264.6	99.6	108.9	68.4	-	885.4	267
Tianjin	188.9	90.8	118.2	78.5	-	859.8	129
Hebei	2276.9	93.2	123.5	81.9	103.5	13180.1	[illegible]
Shanxi	969.0	81.5	114.4	86.5	106.2	6024.5	[illegible]
Inner Mongolia	973.0	107.2	109.9	81.7	110.8	7083.6	[illegible]
Liaoning	1494.7	104.1	107.5	85.1	107.7	5428.4	[illegible]
Jilin	2046.5	105.1	118.0	91.6	106.2	6059.7	[illegible]
Heilongjiang	2443.8	107.0	112.2	96.4	104.3	12837.7	[illegible]
Shanghai	244.4	95.6	120.8	90.1	-	946.7	[illegible]
Jiangsu	3264.2	92.7	116.3	85.1	102.2	12388.8	[illegible]
Zhejiang	1586.1	95.8	97.0	84.0	104.0	6577.1	[illegible]
Anhui	2457.2	89.5	111.4	80.8	103.9	12470.4	[illegible]
Fujian	922.3	88.5	105.3	73.0	100.3	4118.9	[illegible]
Jiangxi	1679.1	96.6	112.6	78.9	104.8	8637.2	[illegible]
Shandong	3570.9	92.8	106.7	78.7	103.2	16323.9	[illegible]
Henan	3303.7	81.0	115.8	79.5	98.3	17834.6	[illegible]
Hubei	2475.0	90.1	113.7	84.6	102.9	11041.7	[illegible]
Hunan	2692.7	88.1	117.0	83.7	99.9	11927.7	[illegible]
Guangdong	1910.2	95.4	98.3	73.0	94.8	8507.3	[illegible]
Guangxi	1402.6	90.6	105.2	77.8	99.2	7711.9	[illegible]
Hainan	169.6	-	-	79.7	109.1	1231.9	[illegible]
Sichuan	4266.3	89.4	115.4	80.9	104.7	18713.0	[illegible]
Guizhou	721.0	91.7	112.0	78.3	101.7	5368.2	[illegible]
Yunnan	1061.2	96.8	117.1	78.8	103.5	6738.1	[illegible]
Tibet	55.5	-	-	-	-	320.3	[illegible]
Shaanxi	1070.7	97.3	121.1	87.6	103.9	7289.7	[illegible]
Gansu	686.7	95.8	126.9	93.9	111.2	5417.0	[illegible]
Qinghai	114.6	99.4	119.2	-	108.7	817.1	[illegible]
Ningxia	193.3	99.0	112.3	86.7	105.6	1333.4	[illegible]
Xinjiang	680.3	105.2	125.0	91.4	108.3	4469.7	[illegible]

\- Data not available.

Sources:
1. Columns 2, 7 and 8: MAPRCb (1991), China Agricultural Statistics 1990, pp. 74, 46, 370.
2. Columns 3, 4 and 5: SSBb (1991), China Price Statistics Yearbook 1991, pp. 119, 96.
3. Column 6: SSBa (1991), China Statistics Yearbook 1991, p. 246.

Table A.10 Correlation Matrix of Variables Used in India's Time-series Regression Analysis - Corresponding to Variables in Table A.11 (37 Observations)

	CD	PIgrain	PIcotton	PIgrain/ PIcotton	PIinput	WI	T
CD	1.00000						
PIgrain	0.95282	1.00000					
PIcotton	0.94824	0.95665	1.00000				
PIgrain/ PIcotton	0.26786	0.34559	0.98453E-01	1.00000			
PIinput	0.92254	0.97213	0.84461	0.25125	1.00000		
WI	-0.21692E-01	-0.18561	-0.12777	-0.27622	-0.16739	1.00000	
T	0.95767	0.94572	0.92192	0.34603	0.95379	-0.24264	1.00000

Source: Calculated from the data in Table A.2.

Table A.11 Results of Regression (India, time-series data, 37 observations)

Equation	Coefficients							R-Square Adjusted	F	d
	Constant	$PIgrain_{t-1}/PIcotton_{t-1}$	$PIgrain_{t-1}$	$PIcotton_{t-1}$	$PIinput_{t-1}$	WI	T			
Original model specification										
1	-2232.5 (0.18)	-15.58 (-0.32)			76.30 (2.93)***	529.66 (6.70)***	2232.5 (10.58)***	0.969	288.33	1.32
PIgrain/PIcotton extended as two separate variables										
2	3661 (0.51)		105.05 (2.41)**	97.80 (2.19)**	-36.24 (-0.99)	491.96 (7.01)***	1698.3 (7.97)***	0.979	331.89	1.81
3	220.12 (0.11)		117.56 (3.17)***		-17.23 (-0.46)	524.47 (7.75)***	1816.3 (8.33)***	0.976	369.91	1.89
4	[illegible] (0.38)		76.97 (2.32)**	69.46 (2.01)**		494.37 (7.52)***	1713.3 (8.66)***	0.979	414.75	1.67
5	-56.61 (-0.01)		121.64 (4.72)***			513.89 (7.89)***	1817.2 (8.44)***	0.977	505.20	1.83

Note: t-ratio in parentheses; **,*** indicate statistical significance at 5 and 1 percent level respectively.

Source: Calculated from the data in Table A.2.

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