ESTIMATING GRAIN SUPPLY RESPONSE FOR CHINA WITH PANEL DATA[1]

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ABSTRACT

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. While many such studies have been carried out for various developing countries, studies of this kind for China are limited. This research estimates grain supply response for China using pooled cross-sectional and time-series data. The empirical evidence indicates that, besides weather conditions and technological progress, prices are important determinants of grain supply in China. Policy implications are discussed.

Keywords: grain supply response, panel data, China.

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1. INTRODUCTION

Policies which could encourage greater production of food crops are often sought by developing countries. Supply response studies on food crops can do much to help the formation of such policies. Many studies of this kind have been carried out for various developing countries, for example, Bauer and Yamey (1959), Krishna (1963), Falcon (1964), Manghas, Recto, and Ruttan (1966), Behrman (1970), Parikh (1971), Livingstone (1977), Flinn, Kalirajan, and Castillo (1982), Alam (1992), and Ghosh and Neogi (1995). Lim (1975) and Askari and Cummings (1976) both contain surveys of such studies before 1976 while a more recent survey has been given by Rao (1989).

In marked contrast, however, studies of this kind for China are not extensive. Two attempts worth-mentioning are Tian (1990) and Chen and Buckwell (1991).

The primary objective of Tian's study is to examine the effects of the grain procurement system on grain production in China. Time-series data are used. The initial year of the time series starts from 1952 but the end year was not indicated. Tian (1990) finds that the influence of prices (i.e., grain procurement prices and market grain prices, prices of non-grain farming produce, and input prices) on farmers' production decisions has become stronger since the rural economic reform in late 1970s, with the effect of market grain prices being the strongest.

As a part of their detailed study on the Chinese grain economy and policy, Chen and Buckwell (1991) also investigate whether Chinese farmers are responsive to price signals. They estimated a series of grain supply response models both at the national aggregate sector level and regionally. Time-series data are used (1952-84). They conclude that while "self-subsistence is a fundamental issue ...., beyond the motivation of self-subsistence, profitability is a factor which influences producer's supply response behaviour" (Chen and Buckwell 1991, p. 97). However, the sign of the independent variable, the ratio of procurement prices of grain over cotton (representing competing crops), is unexpectedly negative. Theoretically, a positive sign for this variable is expected. The same criticism applies to the result for another price ratio independent variable, i.e., the ratio of grain procurement price over fertiliser price, where a negative sign is also found.

Given the importance of grain to China, there is a strong need for more supply response research for China. This research estimates grain supply responses for China using pooled cross-sectional and time-series data at the provincial level (1987-93). Its primary objective is to identify those major factors which affect the supply of grain. The cross-sectionally heteroskedastic and timewise autoregressive model is used.

The next section addresses model specification issues. Section 3 discusses data collection and compilation. Results are given in Section 4. The final section offers conclusions and policy implications of the study.

2. MODEL SPECIFICATION

The variables to be included in an econometric model must be determined first. A number of factors affect grain production. Several price factors, namely, government procurement prices for grain and non-grain farm products, free market grain 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 factors are considered most important and are to be included in the supply response model. The first two price factors, i.e., procurement prices of grain and non-grain crops, will appear in the model as a ratio.

Furthermore, in societies such as China, grain output may not be purely a function of some economic factors. Some non-economic factors, e.g., technological progress may also contribute importantly to grain output. Important also is the weather in such a large agricultural country with insufficient weather-resistant infrastructures. As such, technological progress and weather conditions may need to be included in the model.[2]

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

(1) $GO = f(P_g/P_o, P_{gm}, P_i, W, TT)$

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_{gm}: market grain prices;
- P_i: prices of purchased farm inputs;
- W: weather factors; and
- TT: time trend, representing technological progress.

[2] Policy factor can often be an important determinant affecting grain production in countries like China. There were no drastic policy shifts during the time period covered in this study (1987-93). Hence, there was no need to include this factor in the model.

(1) Ratio of procurement 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.

Considering the special situation in the Chinese grain economy, the government procurement prices are also included in the analysis. This is because the majority of the surplus grain of most Chinese farmers is sold to the government under the quota regime (Zhou 1992). In most cases, the level of the procurement price is more important in determining the level of farmers' income from grain. Without the inclusion of the procurement price variable, many variations in the grain output may not be explained. Admittedly, there could be a relationship between the government procurement price and the market price; e.g., a high market price may lead to an increase in the announced government procurement price. This problem should have been alleviated to a large extent as the procurement price is not included in the model itself but is used to construct the price ratio in conjunction with the cash crop procurement price. Government grain procurement price index and cash crops procurement price index were used to construct the price index ratio.

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

(2) Market grain price. Although grain has been allowed to be traded on the free market 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. This makes it possible to include the market price as a variable in the supply response estimation. Market grain price index was used in this study.

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 that 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. The higher the market price, the greater will be the incentives to encourage the production of more grain. A positive sign is expected for the free market price variable.

(3) 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 were 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.

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

(5) 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. Hence, although the price factor is considered important, "we do not mean to imply that price is quantitatively (the underline added by the authors) the most important determinant of supply. Over any long period technology is probably the most important determinant" (Lipsey 1975, p. 89). A time variable was used as a proxy for technological progress. A positive sign is expected for this variable.

Because panel data are used, covering a number of provinces over the 1987-93 period, a generalised linear regression model must be adopted. In this study, the cross-sectionally heteroskedastic and timewise autoregressive model was used (Kmenta 1986, pp. 618-22).

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

$$(2) \qquad Y_{it} = \beta_1 X_{it,1} + \beta_2 X_{it,2} + \dots + \beta_K X_{it,K} + \mu_{it}$$
$$(i = 1,2, \dots, N;\ t = 1,2, \dots, T).$$

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

Hence, the regression equation for this analysis, based on the functional relationship in (1) and the above discussion, can be written as:

$$(3) \qquad GO_{it} = \beta_1 PIgrain/PIcash_{it,1} + \beta_2 MPIgrain_{it-1,2} + \beta_3 PIinput_{it,3} + \beta_4 WI_{it,4} + \beta_5 TT_{it,5} + \mu_{it}$$
$$(i = 1,2, \dots, N;\ t = 1,2, \dots, T).$$

where:

GO: grain output;

PIgrain: procurement price index of grain;

PIcash: procurement price index of cash crops;

PIgrain/PIcash: the procurement price index ratio of grain over cash crops;

MPIgrain: market grain price index;

PIinput: price index of agricultural inputs;

WI: weather index; and

TT: time trend, representing technological progress.

3. DATA COLLECTION AND COMPILATION

The relevant price indexes (i.e., grain procurement price index, cash crops procurement price index, market grain price index, and agricultural input price index) were obtained from SSB, *China Price Statistics Yearbook (1988-1994)*. This yearbook was not published in 1993 and hence the needed data for 1992 was obtained from Editing Committee of *China Commerce Yearbook*, *China Commerce Yearbook 1993*. All the price indexes originally took the previous year as the base year. They were reconstructed taking 1987 as the base year.

Grain output, total area sown and total area affected by natural disasters were obtained from MAPRC, *China Agricultural Statistics (1987-1993)*.

To perform the pooled cross-sectional and time-series estimation, the data were arranged to conform to the Kmenta model (Kmenta 1986, pp. 616-22). 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, Qinghai, and Hainan, none of which is a major grain-producing area. The sum of their grain output accounts only for about 2.5% of national output. 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 that was lagged to 1988. As a result, there were 24 cross-sectional units (N) and 6 periods of time (T). The total number of observations was 144.

An intuitive observation of the compiled data provided the following insights.

(1) Grain procurement price index, taking 1987 as the base year, was increasing in general over the years under investigation. However, this increase was not smooth at all. In most cases, there was an increase over the previous year but a decrease in the next, sometimes substantially.

(2) Cash crop procurement price index increased steadily in most cases.

(3) Given (1) and (2) in the above, the index ratios of the two procurement prices showed many ups and downs. Among all the 144 ratios, 78 were below 100 (54%). The lowest ratio was 73.2.

(4) Market grain price index showed many ups and downs, often abruptly.

(5) Input price index increased most steadily and faster than any other index series in most cases.

(6) As would be expected, the weather index ("areas affected by natural disasters" against "total sown area") varied frequently over years. A higher weather index is often associated with a lower grain output.

The above seems to suggest that, besides the varying impact of weather conditions on grain output, varying index ratios of grain and cash crop procurement prices and market grain prices would also contribute to fluctuations in grain output should Chinese farmers be responsive to price changes at all. On the other hand, input prices would have had a consistent negative impact on grain production.

4. RESULTS AND DISCUSSION

Applying the "pool" command of Shazam to the pooled data, the following was obtained:

(4) $$\underset{(9.05)^{***}}{GO = 1630} + \underset{(2.29)^{**}}{2.53PIgrain/PIcash} + \underset{(3.51)^{***}}{1.92MPIgrain} - \underset{(-3.43)^{***}}{5.70PIinput} - \underset{(-5.64)^{***}}{4.55WI} + \underset{(4.80)^{***}}{102TT}$$

Buse Raw-Moment R-Square = 0.944

F = 15.075

R-Square between observed and predicted = 0.909

The results 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 except for PIgrain/PIcash being 5%.

According to the model (4), given that other variables remain unchanged, at the provincial level, the increase by one percent in the ratio of procurement price index of grain over that of cash crops would increase grain output by about 25 thousand tonnes. For every one percent increase in the market grain price index, there would be an increase in grain output of about 19 thousand tonnes. The increase by one percent in the input price index however, would decrease grain supply by about 57 thousand tonnes.

Technological progress contributes to the increase in grain output importantly. The value of the coefficient on the time trend variable shows that about one extra million tonnes of grain is produced annually due to continuing improvements in technology.

Weather conditions are found to be 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 output of some 46 thousand tonnes at the provincial level. The extent to which other variables in the model may change in each year is relatively small. That is, the price indexes change slowly over time. Therefore, the contribution to grain output brought by changes in them would be within a small range. The contribution of technological progress is almost a constant because every year the value of the variable TT increases by 1. However, there is little certainty about the weather. The change in WI over a year can be drastic. For example, according to the data used in this study, the range over which the WI may change can be from 6% to 28% (in Xinjiang) or 12% to 72% (in Jilin). 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. CONCLUSIONS AND IMPLICATIONS

According to the econometric analysis, farmers in China seem to be responsive to price changes. 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. Weather conditions and technological progress are found to be very important determinants of grain production in China.

Based on the findings of this research, some policy implications can be drawn, given that greater grain production is a major policy objective.

Farmers in China care about the price ratios between grain and non-grain crops and adjust their behaviour accordingly. Given this, the Chinese government should adopt various policy measures to balance returns from grain and non-grain business. The returns should also be kept balanced over time (without abrupt ups and downs as in the past several years) or slightly in favour of grain production.

The above, however, should be based on the prerequisite that farmers can gain a normal rate of return from grain production. To ensure a normal rate of return to grain producers, attention should be given to the following two aspects. (1) Grain procurement prices in real terms should not be allowed to be lower than their previous year's level and should be maintained at economic levels. (2) An effective minimum support price policy should be implemented to protect farmers' interest when a precipitous price fall takes place, such as in 1990 and 1991. This removes market uncertainty and enables farmers to pursue their production efforts with the assurance that a temporary glut in the market caused by either supply or demand factors will not be allowed to depress their incomes unduly.

Input prices have increased exceptionally quickly in China over the past several years. The significant negative relationship between grain output and input price identified suggests that input price level must be kept under control to prevent farmers' returns from being taken away.

As weather conditions are a very important determinant of grain production, it is especially important that a reasonable amount of investment in agriculture be maintained by the 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. Such investment should be carried out smoothly and steadily. While a sharp increase in investment may not produce immediate results, a sharp decrease may quickly reduce the efficacy of previous investments.

Given that technological progress contributes significantly to grain production, funds should be allocated from government sources to ensure regular on-going agricultural research, extension and education activities. In the longer term, technological progress is most likely to be the most determining contributor to the increase in the country's grain output. Hence extra attention to ensure continuous technological progress is needed and the country will be certainly rewarded by doing this. Due to very limited arable land, efforts should be made to the development of such new techniques as yield-increasing farming methods and land-augmenting measures.

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