FACTORS AFFECTING THE VARIABILITY OF CHINESE FOODGRAIN PRODUCTION[1]

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ABSTRACT

China has been basically self-sufficient in foodgrain production. Because of its large population and increasing roles in the world market, the variability of Chinese foodgrain production has important implications to both the Chinese government and other national governments. While the variance decomposition technique has been widely used to study variability, its shortcomings have proven difficult to overcome. An alternative approach to decompose production variability is discussed in the paper and subsequently applied to the case of foodgrain production in China. The results show that the most of the production variability can be attributed to environmental factors. Among the controllable inputs, variations in fertilizer application asserts the greatest impact on the foodgrain production variability.

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1 Introduction

The variance decomposition technique is widely used in variability analysis. It has been applied to both estimated econometric equations (Houck 1973, Firch 1977, Piggott 1978),and to identities (Burt and Finley 1968, Hazell 1982, 1984, Anderson et.al. 1988). To attribute production variability to various relevant factors, a regression model can be estimated as follows:

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \hat{\mu}, \tag{1}$$

where Y denotes production, X_i, i-th input, β_i, i-th estimated parameter and $\hat{\mu}$ the residual. By taking variance on both sides of equation (1), we can obtain

$$Var(Y) = \sum_{i=1}^{k} \beta_i^2 Var(X_i) + 2\sum_{i=1}^{k-1} \sum_{j=i+1}^{k} \beta_i \beta_j Cov(X_i, X_j) + Var(\hat{\mu}). \tag{2}$$

Where Var is the variance operator and Cov the covariance operator. It is interpreted that $\beta_i^2 Var(X_i)$ represents the contribution to production variability $Var(Y)$ made by X_i.

This approach suffers from several drawbacks. First, variations in X_i ($i = 1 \cdots k$) are always positively related to production variability, which does not necessarily hold in all cases. Second, interpretation of covariances possesses difficulties in terms of policy implication. In particular, when the covariance terms dominate the total variability of production the decomposition is of limited significance. Perhaps, partitions of covariances in the right way(!) could eliminate these problems, though it is not a easy task. For example, Houch (1973) simply havles $2\beta_i\beta_j Cov(X_i, X_j)$ and then added to $\beta_i^2 Var(X_i)$ and $\beta_j^2 Var(X_j)$. This is obviously not justified on any grounds. Instead of halving the covariance terms, $Var(X_i)$ and $Var(X_j)$ can be used as weights to break down them (Wan, 1987). However, the centre issue is whether there is a right way at all to separate covariances.

An alternative approach adopted in this study is to regress variability of production on the variabilities of $X_i (i = 1, \cdots, k)$. The variability is defined as the absolute deviation of observed values of a variable from its trend. Essentially, this definition is consistent with the definition which uses variances to indicate variability. By summing up both sides of the estimated equation, the total production variability is shown to be composed of variabilities of the included independent variables.

This alternative approach is proposed in the next section. Its application to the case of foodgrain production in China is discussed in section 3, followed by a conclusion.

2 Method and Data

Let Q denote production, X_i, i-th input, $\hat{Q}$ and $\hat{X}_i$ their trend values. Then, the equation of the form

$$|Q_t - \hat{Q}_t| = f\left(|X_{it} - \hat{X}_{it}| \right) + \mu \tag{3}$$

can be estimated. Where t is the time subscript and $|\ |$ is the operator for absolute values, μ is the disturbance. Linear relationship is assumed in this paper, though this is not a necessary assumption. By doing so, equation (3) can be written as

$$\left|Q_t - \hat{Q}_t\right| = \beta_0 + \sum_{i=1}^{k} \beta_i \left|X_{it} - \hat{X}_i\right| + \hat{\mu}. \qquad (4)$$

According to equation (4), we have

$$\sum_{t=1}^{T} \left|Q_t - \hat{Q}_t\right| = \beta_0 + \sum_{i=1}^{k} \sum_{t=1}^{T} \beta_i \left|X_{it} - \hat{X}_i\right|. \qquad (5)$$

In words, production variability consists of variabilities of Xs. Dividing equation (5) by $\sum_{t=1}^{T} \left|Q_t - \hat{Q}_t\right|$, components of production variability in percentage terms can be derived. The value of $\frac{\beta_0}{\sum_{t=1}^{T} \left|Q_t - \hat{Q}_t\right|}$ can be interpreted as the contribution of variables excluded from the equation (See Rao and Miller 1971). We will call this value 'residual variability'.

It's clear that variabilities of Xs is not restricted to be positively related to production variability and no interaction terms have to appear in equation (5). If necessary, interaction terms should be included in equation (4).

For convenience,the above approach can be called absolute deviation decomposition.

Provincial information on inputs and total foodgrain production are available for 1980-1985. In order to obtain reasonable estimations, the provincial data are pooled to form regional data. Bearing in mind the division of agriculture district, China can be separated into four regions, namely, South-east region(region 1), North-east region (region 2), Middle region (region 3) and South-west region (region 4).

Table 1: Division of Agricultural Regions

Region	Provinces Included
1	Jiangsu, Anhui, Hubei, Hunan, Shanghai, Jiangxi, Fujian, Guangdong, Zhejiang
2	Liaoling, Jilin, Heilongjiang, Leimen, Beijing, Tianjing, Hebei, Shandong.
3	Shanxi, Shaanxi, Gansu, Henan, Qinghai, Ninxia.
4	Sichuan, Yunnan, Qinhai, Guangxi, Xingjiang, Xizhang, Gansu.

As presented in Table 1 some province are included in both region 3 and region 4. This results from overlaps of district division and also from the deliberate intention to increase sample size for region 3.

It is believed that as far as foodgrain production is concerned, provinces in each region have similar environmental and socio-economic conditions. However, the condition are remarkably different across regions and generally improve from region 4 to region 1 (Yu 1984).

The available inputs data comprise of area sown in 10^4 *mu* (A), electricity in 10^8 kWh (EL), area ploughed by machines in 10^4 *mu* (JG), area harvested by machines in 10^4 *mu* (JS), area irrigated in 10^4 *mu* (IRRI), drainage capacity in 10^4 hp (JP) and chemical fertilizer application in 10^4 Mt (FER).

3 Empirical Results and Interpretation

Foodgrain production is of the utmost importance in China, not only because over one billion population needs to be fed, but also because about 80 per cent of the population depend on agriculture, which is dominanated by foodgrain production (MAAF[3] 1984). This importance is reinforced by the fact that China is not doing much better than self-sufficiency in food in terms of food energy requirement (CAAS[4] 1985). China's foodgrain production also has a very strong and increasing influence on the world grain market (Stone and Zhong 1985, Tang 1981, Bodin 1985).

If, in the future, China could maintain self-sufficiency in foodgrain, as the Chinese government desires, with acceptable levels of imports, it would be the fluctuations in foodgrain production rather than production itself, that are of greater concern to the Chinese, other national governments and economists.

Historically, foodgrain production variability in China has been of considerable importance. In the early 1960s, the shortage of food caused at least 12 million deaths (SSB[5] 1984). On the other hand, large amount of raw grains were decayed when total production suddenly increased in 1983. Foodgrain production continues to be the centre issue to Chinese politicians and economists, particularly since the decrease in national foodgrain out-

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[3] Ministry of Agriculture, Animal husbandry and Fishery.

[4] Chinese Academy of Agricultural Sciences.

[5] State Statistics Bureau.

puts after 1984. Currently, a great deal of effort is being directed towards finding causes of foodgrain production variability in China.

Before applying the combined cross-section and time series data to estimate equation (4), trends have to be removed from both dependent and independent variables for each province. Differences in the basic level of provincial variability, however, can not be ignored. Since there are only 6 observations for each province and there is no strong evidence to suggest the existence of a long-run trend , instead of trend values are used in equation (4). To take into account the inter-provincial differences in the basic level of variability within a region, dummy variables can be defined for β_0 in each equation. The proportion of production variability associated with these dummies is of the same property as β_0, and thus considered as part of the residual variability components.

In fitting equation (4) to the regional data, insignificant variables, say, with T ratio less than 1.0 ,are dropped. The final results are summarized in Table 2 with T ratios in the brackets.

The composition of production variability can be readily computed and is presented in Table 3.

It comes as no surprise that production variabilities in different regions are affected by different factors, because of different production structure, environment and socio-economic conditions. For example,irrigation is generally a stabilizing factor of foodgrain production. However, it become a destabilizing source in region 2. This probably is the outcome of an unreliable irrigation system in the region. The unreliability may result from

Table 2: Estimated Coefficients of Regional Functions

Region	1	2	3	4
Constant				4.69 (1.85)
A			0.02(1.44)	
EL				3.42 (1.57)
JG			0.02 (1.50)	
JB	0.40 (4.7)		0.08 (3.61)	
JS	-0.74 (-2.5)		-0.21 (-3.99)	
IRRI		0.21(2.43)		-0.18(-3.79)
FER	2.42(7.1)			2.98(3.55)
JP	0.61(1.3)	0.22(4.5)	0.33(2.89)	0.51(2.06)
D1	14.74(2.3)		59.08(11.71)	35.95(5.53)
D2	14.24(2.5)			5.95(1.30)
D3				-6.33(-1.18)
D4		21.13(2.6)		
D5	6.36(1.2)	46.40(5.9)		
D6		22.70(2.8)		
D7	19.77(3.8)			
R^2	0.91	0.78	0.95	0.77

Note: D_i represents dummy variables.

Table 3: Components of Foodgrain Production Variability

Region	Factor	Percentage Contribution
1	1. JB	20.6
	2. JS	-18.0
	3. FER	68.3
	4. JP	8.3
	5. Other Sources	21.8
2	1. IRRI	25.4
	2. JP	32.2
	3. Other Sources	42.4
3	1. A	8.5
	2. JG	13.6
	3. JB	27.3
	4. JS	-40.4
	5. JP	29.5
	6. Other Sources	62.1
4	1. EL	21.0
	2. IRRI	-43.9
	3. FER	80.0
	4. JP	10.0
	5. Other Sources	67.1

shortage of water resources and poor management.

Although it's difficult to generalize the decomposition results, several points are worthy of mention: (a) fertilizer fluctuations appear to be the most influential factor causing production variations. The percentage contributions of fertilizer are 68.3 in region 1 and 80.0 in region 4; (b) drainage and irrigation capacity plays an important role in the determination of production variability in all regions. This may reflect the fact that foodgrain production in China is largely dependent on weather. In reality , flooding and draught are the most important factors in controlling the fluctuations of foodgrain production in China; (c) changes in area sown do not assert a significant impact on production variability. To certain extent , this finding is consistent with that given by Stone and Zhong (1985). Put it another way, changes in yields dominate the total production variability; (d) variations in area harvested by machines help stabilize the production. This is more important in region 4, where the labor force may be in shortage during harvest, and in region 1, where triple-cropping often caused tight labor supplies; (e) other sources account for some 50 percent of total foodgrain variability. It is noted that the residual contribution increases from areas with better production conditions to less developed regions. This is plausible because the other sources include management skills and environmental factors, e.g., soil condition, weather, etc.

4 Conclusion

Instead of applying variance decomposition technique to variability studies , absolute deviation decomposition is proposed. Although this approach is not without deficiency, it is better than variance decomposition in two aspects: (a) no restriction on the signs of coefficients when establishing the relationship between production variability and variations in explanatory variables; (b) no interaction terms being necessarily present which leads to easier interpretation of decomposition results.

The results suggest that production variability in China is mainly attributed to environmental conditions. Among the controllable inputs fluctuation of usage fertilizer created the greatest impact on production variability. Any policy aiming at reducing production variability should be region- or province-specific, as the decomposition results indicate that production variability has different components. Also the same factor has a different impact on production variability in different regions.

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