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SOURCES OF PRODUCTIVITY DISPARITIES IN REGIONAL GRAIN PRODUCTION IN CHINA

Yang Hong

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About the author

Yang Hong is at the

Centre for Asian Studies
Chinese Economy Research Unit
The University of Adelaide
ADELAIDE SA 5005
Australia

Copies of Working Papers are available from:

Chinese Economy Research Unit
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email jholmes@economics.adelaide.edu.au
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ABSTRACT

The study utilises survey data on 1000 households in rural China to investigate sources of disparities in factor productivities for rice, wheat and maize in different provinces. The effects of natural endowments are emphasised. It is found that for respective crops, the level of factor productivities is generally higher in their major producing areas than that in the non-major producing areas due partly to more suitable natural conditions and more specialised production. Meanwhile, farmers' production efforts, in particular land input also tend to be in favour of major crops. This biased behaviour rises factor productivities for major crops and lowers them for non-major crops in different regions. The finding of this study underlines the efficiency of specialisation of crop production in areas where natural conditions are favourable and where farmers are more experienced in producing them.

1. INTRODUCTION

China's vast size has created great disparities in grain production among regions. These disparities are reflected in various aspects. Variation in factor productivities among regions is one of them. Given a certain level of inputs, output varies in different regions. This feature suggests a significance of analysing productivities from a regional perspective.

The aim of this study is two-fold. One is to examine productivity disparities in regional grain production and the other is to investigate the major causes of these disparities. The analysis draws particular attention to the effect of natural endowments on the level of productivities in different regions. Insights into these issues are of significance for helping to explore regional comparative advantages. Through a more rational spatial distribution of grain production, the nationwide efficiency of resource utilisation can be improved.

Many factors can cause regional variations in productivities, and according to sources, they may be grouped into four categories.

First, the genetic characteristics of different crops can strongly influence their yield potential. Experiments have shown that with a given level of inputs, output can vary among different crops due to their specific genetic characteristics. This means variations in their productivities. Determined primarily by natural conditions, the spatial distributions of respective crops are different. In China, rice production is mainly concentrated in south, and wheat and maize in north. The spatial pattern of crop distribution results in different average yields, and accordingly varying productivities across regions. In view of the effect of genetic characteristics, the crop compositions should be taken into consideration in comparing regional productivities. This study, therefore, pursues a disaggragated analysis, which examines productivities for different crops separately. Since wheat, rice and maize are the three major grain crops in China, the analysis focuses on them.

The second category is related to human capital endowment. Many previous studies have found a positive relationship between human capital endowment and the level of production efficiency. Farmers' educational status and farming experience have

been the most commonly considered elements in human capital endowment (Fleisher and Liu, 1992; Wu and Meng, 1995; and Sharif and Dar, 1996).

The third category comprises factors relating to natural endowments. These include the availability of arable land and relative suitability of natural conditions, such as soil quality, weather conditions, water supply and so on. Among various factors in this category, the availability of arable land and associated farm size and plot size have attracted much attention in the literature for their links with economies of scale. Studies of the effect of natural conditions on regional variations in productivities have, however, been few. Yet, empirical observations can easily verify this effect. In the areas where natural conditions are favourable, the level of productivity is high, and vice versa.

The last category includes socio-economic factors which influence farmers' production decisions and capacity to apply their decisions at the household level (Kalirajan, 1991). Land ownership and off-farm incomes are the core issues in this category. In China's case, however, the type of land ownership is more or less homogenous. Household farm land is owned by and contracted from collectives. Although this type of land ownership may influence the overall level of productivities, it is unlikely to be a major cause of regional disparities.[1] In terms of off-farm incomes, regional variations are significant due to the uneven development of rural economy. Farmers' production decisions are influenced by the relative importance of off-farm incomes in their total incomes. Since different production decisions can alter household resource allocation, the level of productivity in grain production may also change.

The following analysis focuses on examining the impact of the above factors on productivities in regional grain production. Data used in the analysis are from a joint household survey conducted by the Chinese Economy Research Unit of the University of Adelaide in Australia and the Ministry of Agriculture in China. The survey targeted the five large grain producing provinces of Guangdong, Jilin, Jiangxi, Sichuan and Shandong. About 200 households were selected from four counties in each province. The total number of households surveyed is slightly over 1000. The survey covers three production years from 1993 to 1995. For further details of the survey, see Wu (1995).

The study is organised as follows: Section 2 overviews regional specialisation in producing respective crops and examines provincial disparities in land and labour productivities. Relationships between regional specialisation in crop production and natural conditions are discussed. Section 3 estimates production functions and constructs total factor productivity indices for wheat, rice and maize. Analyses of sources of regional disparities in productivities are conducted in Section 4. The effect of natural endowments on provincial productivities is emphasised. The final section summarises the conclusions drawn from the analyses.

2. REGIONAL GRAIN PRODUCTION SPECIALISATION AND LAND AND LABOUR PRODUCTIVITIES

2.1 The Degree of Regional Specialisation and Natural Conditions

In the provinces surveyed, the crop compositions in grain production vary significantly. As shown in Table 1, Guangdong and Jiangxi are dominated by rice and Jilin by maize. Shandong is the largest wheat producer in China, while maize is also important. Grain production in Sichuan is relatively diversified. Although rice is a major crop in this province, wheat and maize respectively account for about 30 percent and 10 percent of its total grain sown areas. The relative share of respective crops reflects the degree of specialisation of provinces in producing them.

Table 1 Shares of Respective Crop Sown Areas in Total Household Grain Sown Areas in the Surveyed Provinces

	Total grain sown areas	Wheat	Rice	Maize	Others
	mu	%	%	%	%
Guangdong	2815.75		93.69	0.67	5.64
Jilin	4221.70	2.53	14.66	69.15	13.65
Jiangxi	2327.10		98.90		1.10
Sichuan	1089.44	29.02	45.83	10.29	14.86
Shandong	1767.40	48.80		44.90	6.24

[1] Land sub-contracting among farm households has emerged in some relatively developed areas such as Guangdong. However, the survey shows that the number of households involved and the quantity of land sub-contracted are still small. Their effect on provincial productivity would thus be minor.

It should be pointed out that for individual regions, the degree of specialisation in crop production is closely related to their natural conditions. Wheat and maize are concentrated in north China because there has relatively suitable ecological environment for these crops to grow. Rice production is limited in northern China due mainly to the constraints of low temperature and inadequate water. Soil conditions may also set some constraints.

Apart from natural conditions, however, farmers' choice in crop production is also influenced by many other factors, including for example, relative prices for different crops, risk aversion, dietary habit and so on. Fleisher and Liu (1992) argued that in China, multiple crops are the best available means for households to avert risk of crop failure, even though aggregate output is reduced. Given the fact that Chinese farmers are semi-autarkical producers and integrated national markets are far from established due to political, economic and technical barriers (Li Qingzeng, et al, 1991; Cheng Enjiang and Wu Yanrui, 1994), multiple crops would have been necessary for many households.

A question, however, should be asked here is whether or not the crops which regions and farmers are specialised match the relative level of productivity or comparative advantage. If so, then producing crops which they are not specialised would mean a loss of production or an additional use of inputs for a given amount of output. For individual farmers, the lost production may be a measure of the gains that could be obtained from introducing a market for insurance against crop failures (Fleisher and Liu, 1992). However, for the country as a whole, this would mean an inefficiency in terms of resource utilisation. For policy makers, therefore, the issue becomes how to stipulate appropriate measure to remove various barriers and to encourage provinces and farmers to pursue their comparative advantage in grain production so that national resources can be used more efficiently.

Another issue should be raised is the possibility of crop substitution. Whenever the substitution is feasible, for regions or households, producing crops which they have comparative advantage can lead to a more efficient use of resources. However, in reality, substitutions are not always feasible due to various reasons, including multiple-cropping

and inter-planting in many areas. In the survey, little information about the feasibility of substitution is available. Moreover, this study only considers three grain crops, it is difficult to justify the feasibility of substitution among all crops regions or farmers produce. The lack of sufficient information constrains a further discussion on this issue. Nevertheless, this will not affect the justification to be made in this study of the relative level of productivities among regions in producing the three major grain crops considered.

2.2 Regional Disparities in Land and Labour Productivities

According to the definition, land productivity or yield is the output per unit of land. It reflects the output capacity of land with a given set of inputs. Similarly, labour productivity is the output achieved by a labourer or per labour day or hour with all associated inputs (Blandy, et al, 1984). Table 2 shows the average levels of land and labour productivities in the surveyed provinces for wheat, rice and maize.

Table 2 Land and Labour Productivities for Respective Grain Crops in the Surveyed Provinces

Yield: kg/mu;
Q/L*: kg/labour day

	Wheat		**Rice**		**Maize**	
	Yield	Q/L*	Yield	Q/L	Yield	Q/L
Guangdong						
1993			382.01	33.35	291.26	18.35
1994			376.73	27.00	263.25	14.46
1995			403.31	35.26	281.77	16.94
Average			**387.35**	**31.87**	**278.76**	**16.58**
Jilin						
1993	154.83	19.61			517.26	81.88
1994	168.85	19.28			512.97	64.17
1995	211.54	14.93			565.29	81.44
Average	**178.41**	**17.94**			**531.84**	**75.83**
Jiangxi						
1993			382.20	26.57		
1994			366.86	23.59		
1995			370.26	28.12		
Average			**373.11**	**26.09**		
Sichuan						
1993	229.64	10.58	491.29	24.59	214.48	7.77

1994	246.19	12.10	557.54	22.47	254.31	11.38
1995	265.04	13.93	508.63	25.17	279.19	11.24
Average	**246.96**	**12.20**	**519.15**	**24.08**	**249.33**	**10.13**
Shandong						
1993	371.69	28.92			369.45	35.29
1994	375.84	29.81			348.55	32.74
1995	390.88	33.51			351.24	31.99
Average	**379.47**	**30.75**			**356.41**	**33.34**

* Q/L is the labour productivity.

Average yields vary significantly among crops. In general, wheat has a lower average yield, and the yields of rice and maize are higher. This result partly reflects their different genetic characteristics.

For a respective crop, the yield varies among provinces. For example, the average yield of wheat in Shandong is more than twice the average in Jilin. In contrast, maize yield in Jilin is much higher than that in other provinces, including Shandong. Variations in rice yield are also substantial. Bearing in mind that Jilin is the largest maize producing province in China and Shandong is the largest producer for wheat, a positive relationship seems to exist between the level of yield and the degree of production specialisation.

For a province where more than one crop is produced, the relative levels of yields with reference to other provinces involved are often different. Jilin has the highest maize yield and the lowest wheat yield in comparison with other provinces. In Sichuan, maize yield is the lowest whereas rice yield is the highest. This feature suggests that for individual provinces, the relative levels of yields for respective crops coincide with the relative degree of specialisation in producing them.

Similar to the situation in land productivity, variations in labour productivity for respective crops are significant among provinces as well as between crops. Meanwhile, for provinces where more than one crop is produced, the relative levels of labour productivity also vary. The level of labour productivity for maize is much higher in Jilin than elsewhere. Whereas for wheat, Jilin has a relatively low level. In Shandong, the yield levels of these two crops are reversed. Again, this is consistent with the degree of specialisation of these provinces in producing respective crops.

Fluctuations in land and labour productivities are significant over the three years the survey covered. This is particularly so for rice and maize. In 1994, rice yield in Sichuan was 11 percent higher than that in the previous year. In 1995, the yield dropped

by 8.5 percent. In Jilin, maize yield increased by 10 percent in 1995 compared with the preceding year. Although changes in inputs and other factors could cause fluctuations, the excessive range also leads to a consideration of the effect of weather conditions. It would be, therefore, necessary to incorporate weather factors in the analysis of productivity changes.

To sum up, variations in land and labour productivities among regions and for respective crops are significant. A general impression is that the levels of both land and labour productivities for respective crops tend to be high in their major producing provinces. Before examining total factor productivity, however, there remains a question as to whether these high levels are associated with a more efficient production or simply the result of a more intensive use of all associated inputs.

3. PRODUCTION FUNCTIONS AND TOTAL FACTOR PRODUCTIVITIES

3.1 Estimation of Production Functions for Wheat, Rice and Maize

Total factor productivity is defined as the output achieved from all associated inputs. In studies of total factor productivity, the Cobb-Douglas production function has been commonly used. This is because of its simplicity as well as its suitability for use with real measures of inputs (Fleisher and Liu, 1992). In view of its merits, the Cobb-Douglas production function is also used in this study. The functional form contains four conventional input variables: sown areas, labour, chemical fertiliser and other capital inputs. Several non-input variables are designed to capture the effects of human capital endowment, natural endowment and the development of rural non-grain sectors on grain production. The final form of production function for the i^{th} household can be specified as follows:

$$Log(Q_i) = a_0 + a_1 Log(S_i) + a_2 Log(L_i) + a_3 Log(CF_i) + a_4 Log(K_i) \quad (1)$$
$$+ a_5 Log(P_i) + a_6 SC_i + a_7 EXP_i + a_8 M_i + a_9 I_i + \sum b_j D_j + \sum b_t D_t$$

where

Q = household crop output measured in jin (1 jin = 0.5 kg);

S = household crop sown areas measured in mu (1 mu=1/15 ha);

L = household labour input measured in adult labour days;[2]

CF = household chemical fertiliser measured in yuan (in constant prices);

K = household other capital inputs (except for chemical fertiliser) measured in yuan (in constant prices);

P = household average size of crop plot measured in mu;

SC = schooling years of household heads;

EXP = farming experience of household heads in years;

M = proportion of sown areas of respective crops in household total grain sown areas;

I = share of non-grain incomes in total household incomes;

D_j = provincial dummy;

D_t = year dummy;

i = the i^{th} household.

In the model, variables *SC* and *EXP* represent household human capital endowment. Here, only household heads are considered due to their dominant role in household production decision-making.

Variable *P* is the average size of plot on which crops are produced. Many empirical observations have found that average plot size is positively related to land endowment. In general, the more the arable land is available, the larger is the average plot size. It has been argued that in agricultural production, not only is small farm size a cause of low marginal productivity, but there is an additional constraint imposed by the division of land assigned to each household into subplots (Fleisher, et al., 1992). Since household plots are scattered around villages, it requires travel time that could otherwise be used for production. Meanwhile, small plot size can constrain the effective use of agricultural machinery and irrigation facilities. It can also lower the effectiveness of pest control.

M is the proportion of sown areas of respective crops in total household grain sown areas. This variable is included to capture the effect of the relative degree of crop specialisation in household production on the level of productivity.

[2] Labour contributed by labourers below 16 years old is converted into full adult labour based on the ratio of 1 to 0.7. This ratio is the usual practice in Chinese official statistics.

Variable *I* reflects the degree of farmers' involvement in non-grain activities. The higher the share is, the more household incomes are reliant on non-grain activities. Since the relative importance of non-grain incomes can influence household resource allocation, different shares are expected to impact on productivities in household grain production.

Two dummy variables are included in the model. The provincial dummy D_j is designed to capture the specific provincial effects that are not reflected by other variables in the model. The coefficient of the provincial dummy, to a large extent, represents the effect of natural conditions on provincial productivities, though effects of social-economic factors may also be involved. In estimating production functions for respective crops, one province is taken as reference. The coefficients of dummy variables for other provinces can be viewed as their specific effects (particularly the effect of natural conditions) on the level of productivities in comparison with the reference province.

The year dummy D_t captures the effect of time related factors, including weather fluctuations, on annual productivities.

Since wheat, rice and maize are concentrated in different areas, the provinces included in estimating production functions for each crop are different. For wheat, Jilin, Sichuan and Shandong are involved. The production function for rice includes Guangdong, Jiangxi and Sichuan. For maize, Guangdong, Jilin, Sichuan and Shandong are included. The total number of households involved in producing respective crops is around 400-600. The estimation uses pooled data over the three years the survey covered. The total observations in each production function thus amounts to 1300-1600. Table 3 presents the estimates of the production functions for wheat, rice and maize.

Table 3 Estimates of Production Functions for Wheat, Rice and Maize

	Wheat	Rice	Maize
Constant	5.281	6.222	5.560
	(50.998)*	(74.886)	(54.481)

Log(S)	0.561	0.819	0.641
	(26.390)	(42.965)	(21.323)
Log(L)	0.073	0.009	0.109
	(1.499)	(0.665)	(5.425)
Log(CF)	0.149	0.081	0.125
	(2.805)	(4.085)	(7.642)
Log(K)	0.178	0.070	0.127
	(10.591)	(4.400)	(6.790)
Log(P)	0.118	0.040	0.039
	(7.193)	(4.325)	(1.795)
SC	0.012	0.004	0.009
	(4.118)	(1.953)	(2.094)
EXP	0.001	0.002	0.0003
	(1.171)	(1.396)	(0.241)
M	0.006	0.001	0.005
	(5.381)	(0.912)	(4.651)
I	-0.010	-0.001	0.0001
	(-9.921)	(-4.104)	(0.038)
D_{94}	0.447	-0.012	-0.021
	(2.272)	(-0.975)	(-0.744)
D_{95}	0.101	0.004	0.102
	(5.103)	(0.263)	(3.571)
D_{GD}		*reference*	-0.222
			(-2.938)
D_{JL}	-0.310		0.302
	(-7.138)		(8.305)
D_{JX}		0.019	
		(1.321)	
D_{SC}	*reference*	0.304	-0.550
		(14.317)	(-13.721)
D_{SD}	0.782		*reference*
	(2.415)		
Adjusted-R^2	0.912	0.952	0.920
Number of observations	1306	1549	1596

* Values in brackets are the T-ratios.

The estimation result shows significant differences in coefficient values of respective inputs for wheat, rice and maize, demonstrating the different production functions for these crops.

The coefficient of sown areas is large for all the three crops, indicating the crucial role of land input in determining grain output. This result, however, also implies a

constraint to the further increase in household output, since the amount of their land is generally fixed, if not declining.[3]

The coefficients of chemical fertiliser and other capital inputs are significant for all the crops. In contrast, the coefficient of labour input is either small (for maize) or statistically insignificant (for rice and wheat). It implies that at present, increasing household grain output has been reliant primarily on material inputs rather than labour input.

It is worth pointing out that the estimated coefficients of factor inputs in this study are highly consistent with the author's another study of grain productivity using a different source of household survey (Yang, 1994). This consistency implies a relatively high stability and reliability of the estimates. However, the statistically insignificant coefficient of labour input in this study is different from some previous studies of Chinese agricultural productivity, such as the studies by Fan (1990) and Lin (1992), in which the coefficient of labour input is positive and significant. For a detailed discussion on this difference, see Yang (1994, 1995).

The coefficients of non-input variables are statistically significant (except for rice where a few coefficients are statistically insignificant), reflecting their effects on productivities. Since different provinces have specific characteristics in regard to the aspects these variables involve, their productivities will vary.

3.2 Provincial Total Factor Productivities for Wheat, Rice and Maize

The calculation of provincial average total factor productivity index is based on the following formula:

$$TFP = Q/(S^{a}K^{b}L^{g}CF^{d})^{4} \qquad (2)$$

[3]In fact, the decline in arable land has been a trend evident since the 1970s. The decline, however, has been accelerated during the reform period.

TFP is the total factor productivity index. Other abbreviations are the same as the definitions in form (1). Table 4 gives provincial average total factor productivity index for wheat, rice and maize. The figure for the reference provinces is taken as 100.

Table 4 Average Total Factor Productivity Indices for Wheat, Rice and Maize

	Wheat	Rice	Maize
Guangdong		100	76
Jilin	73		125
Jiangxi		103	
Sichuan	100	114	65
Shandong	111		100

For respective crops, the level of total factor productivity varies among provinces. For wheat, the level in Shandong is the highest. For maize, a substantially higher level is achieved in Jilin. The higher level of productivity for these crops generally appears in their major producing areas. This is consistent with land and labour productivities in these provinces. The consistency indicates a close relationship between natural conditions, production specialisation and the level of factor productivities. It is, however, noted that for rice production this relationship is relatively complicated. Sichuan has the highest level in yield and total factor productivity. However, as shown in Table 1, in terms of the degree of specialisation, the level in Guangdong and Jiangxi is higher than that in Sichuan. This feature will be analysed in the next section.

4. SOURCES OF REGIONAL DISPARITIES IN PRODUCTIVITIES

The above examination reveals great variations in factor productivities for different crops among provinces. This section analyses sources of regional variations in productivities by looking at specific provincial characteristics in human capital

[4] Here only the number of physical labourers is included as labour input. Human capital is separated from physical labour input. This is to assume that physical labour input is homogenous and human capital is an element influencing the level of total factor productivity.

endowment, natural endowment and the rural economic development. Particular attention is drawn to the effect of natural conditions and household land use behaviour on the level of total factor productivity in different provinces.

4.1 Human Capital Endowment

As shown in Table 3, the coefficient of schooling is positive and significant, whereas the coefficient of farming experience is either very small or statistically insignificant. The result suggests that the educational level of household heads is an important factor in determining household production efficiency. This is particularly so for wheat and maize where the values of the coefficients are relatively high. The smaller value for rice may imply that less schooling is necessary for farmers to manage their rice plot efficiently. The statistically insignificant coefficient of farming experience is, however, different from the finding in many previous studies, such as Fleisher and Liu (1992) and Sharif and Dar (1996). This may be related to the fact that Chinese farmers generally have sufficient farming experience.

Table 5 Average Schooling and Farming Experience of Household Heads

(years)

	Farming Experience	Schooling
Guangdong	33.06	6.66
Jilin	29.71	7.20
Jiangxi	28.44	7.40
Sichuan	31.60	6.14
Shandong	29.48	7.81

As shown in Table 5, the average farming experience of household heads is around 30 years, with a slightly higher figure in Guangdong and Sichuan. In terms of average schooling, however, Guangdong and Sichuan have a lower figure. This situation may be related to the fact that in the former province, the rapid development of rural off-farm activities has attracted many young people with higher level of education to those sectors and in the later province, a large number of rural young labourers have flowed outside their home towns to seek employment opportunities elsewhere. As a result, the

relatively older farmers with more farming experience but a lower level of education are left on farm land.

Overall, the survey shows that differences in terms of farming experience among household heads are relatively small and the coefficient of this variable in the estimation is statistically insignificant. Its effect on provincial productivity disparities would have been minor. As for the level of education, the survey shows that the range of regional variations is 1-2 years. The statistically significant coefficient of years of schooling suggests that this variable has contributed to regional variations in productivities.

4.2 Natural Endowments and Household Land Use Behaviour

The estimation of production functions shows a positive and significant coefficient of proportion of sown areas of respective crops in total household grain sown areas. This result corroborates the close relationship between the relative degree of specialisation in household grain production and the level of productivities. In other words, productivities tend to be higher for major crops in a region and lower for the non-major crops. Since the degree of specialisation in producing respective crops are different among regions, productivities will also vary.

The coefficient of average plot size is positive and significant for all the three crops. This means that the bigger the plot size is, the more productive is the plot. The result indicates that there are potential gains from land consolidation. It also implies that a further fragmentation of household land will cause a decline in productivity. This point has also been addressed by Nguyen et al (1995) in their study of land fragmentation and farm productivity using the same household survey data.

Table 6 shows the household average contracted land and average plot size for different crops. The largest figures appear in Jilin and the smallest in Sichuan. This result reflects their different land resource endowment.

Table 6 Household Average Contracted Land, Crop Sown Areas and Plot Size

(mu)

	Total* contracted land	Total grain sown area	Maize sown area	Average plot size of maize	Wheat sown area	Average plot size of wheat	Rice sown area	Average plot size of rice

Guangdong	10.63	13.40	1.07	0.91			12.78	3.04
Jilin	21.15	19.77	15.87	5.63	2.16	1.01		
Jiangxi	7.39	13.58					12.37	1.19
Sichuan	3.71	5.32	0.84	0.30	1.58	0.54	2.52	0.63
Shandong	6.77	7.24	3.94	2.19	4.22	2.05		

* In some provinces, the sum of sown areas of crops is larger than the amount of household contracted land. This is caused by the multiple-cropping system practiced in the provinces.

A positive relationship can be seen between the farm size, sown areas and the average plot size. The bigger farm size is associated with the larger sown areas and plot size. Since the farm size and plot size is related to economies of scale and hence production efficiency, their variations can be a source of productivity disparities among provinces. The large average farm size and thus plot size in Jilin would have contributed to the high level of factor productivity for maize production. By the same token, the extremely small farm size and thus tiny plot size in Sichuan would have lowered its productivity.

An interesting feature shown in Table 6 is that for a province where more than one grain crop is produced, the average plot size varies for different crops. For example, in Jilin, the plot size for maize production is much larger than that for wheat, being 5.63 mu and 1.01 mu respectively. In Guangdong, the average plot size for maize is less than 1 mu, whereas for rice, it is over 3 mu. In Sichuan, although the average plot size is extremely small, the difference can still be seen. Rice plots tend to be larger than those for maize and wheat. This situation seems to suggest that the larger plot size is associated with the major crops in provinces. In other words, farmers tend to devote larger plots to their major crops, leaving non-major crops to smaller plots.[5] This differential land use behaviour gives rises to factor productivities for major crops and lowers them for non-major crops in respective provinces.

The coefficients of provincial dummies are significant, indicating the effect of natural conditions on the level of provincial productivities. Taking Sichuan as reference for wheat production, the coefficient is positive for Shandong and negative for Jilin. This means that holding other conditions constant and given a certain level of inputs, a smaller amount of wheat can be obtained in Jilin and a larger amount in Shandong with reference to Sichuan. Similarly, rice output is larger in Sichuan and Jiangxi in comparison with

[5] Empirical observations show that smaller plots are often marginal land with poorer quality.

Guangdong. Maize output is substantially larger in Jilin and much smaller in Sichuan in comparison with Shandong. The coefficients of provincial dummies reflect the relative suitability of provincial natural conditions for the crops to grow. Shandong has relatively good natural conditions for wheat production and Jilin is superb for maize production. In Sichuan, natural conditions for rice production seems to be better than that in Guangdong and Jiangxi, despite the fact that rice is the dominant grain crop in the latter two provinces. This result implies that the positive effect of natural conditions on rice production in Sichuan exceeds the benefit achieved from production specialisation in Guangdong and Jiangxi.

4.3 Rural Economic Development and Sources of Household Incomes

The coefficient of the share of non-grain incomes in household total incomes is negative for wheat and rice, and statistically insignificant for maize. This result seems to indicate a negative relationship between non-grain incomes and productivities of household grain production.

In China, the development of the rural economy has been fuelled by the rapid growth of rural non-grain sectors. A large part of the increase in household income is generated from non-grain sectors. As a result, the share of non-grain incomes in household total incomes has expanded over the years. The negative coefficient of the share in the estimation indicates that its increase has lowered productivity of grain production. This result is, however, more or less expected. For years, grain production has been disadvantaged due to the state control and the low purchase prices. With the increase in the share of non-grain incomes, farmers are expected to pay less attention to grain production.

The progress of rural development has, nevertheless, been uneven among provinces. The share of non-grain incomes in total household incomes also varies. This has become one of the sources of regional disparities in productivities.

Table 7 Share of Non-grain Incomes in Total Household Incomes

Province	Total household	Share of non-grain

	incomes (yuan)	incomes %
Guangdong	26931.51	69.06
Jilin	13565.72	18.81
Jiangxi	12159.78	49.40
Sichuan	8200.23	62.84
Shandong	11891.79	60.33

Table 7 shows that Guangdong has the highest figure for the share of non-grain incomes in total household incomes and Jilin has the lowest figure. The negative coefficient of the share means that the level of productivity in Guangdong has been lowered. In contrast, the small share of non-grain incomes in Jilin gives greater importance to grain production in total household incomes. This may have made farmers to be more dedicated to grain production, in particular the major crop - maize, contributing to the high level of total factor productivity of maize production in this province.

5. CONCLUSIONS AND IMPLICATIONS

The study examined factor productivities for wheat, rice and maize and investigated sources of productivity disparities in regional grain production. The major findings can be summarised as follows:

First, different genetic characteristics of respective grain crops cause variations in their production functions. It is necessary to distinguish these differences in comparing regional productivities.

Second, there is a close relationship between the suitability of natural conditions and the degree of specialisation of crop production. Provinces are more specialised in producing crops which local areas have relatively suitable natural conditions. The study found that the suitability of natural conditions and the associated degree of production specialisation are the important factors influencing the level of productivities of respective crops among regions.

Third, the estimation of the production functions reveals that the average plot size has a significant effect on the level of productivity. It is also found that in a province where more than one crop is produced, farmers tend to use different plots in producing respective crops. Major crops are usually produced on larger plots and non-major crops on smaller plots. This differential land use behaviour increases economies of scale and thus factor productivity for major crops and lowers them for non-major crops.

Overall, the study found that for individual provinces, productivities are high for their major crops, due partly to more suitable natural conditions and thus more specialised production. This finding indicates a significance of concentrating production of respective crops to the areas where natural conditions are favourable and where farmers are specialised in producing them. In this respect, appropriate policies which can encourage and facilitate the concentration are needed.

REFERENCES:

Kalirajan, K. P. 1991. "An analysis of production efficiency differentials in the Philippines". *Applied Economics*, Vol.23, pp.631-638.

Blandy, Richard, Peter Dawkins, Ken Gannicott, Peter Kain, Wolfgang Kasper and Roy Kriegler, 1984. "Structured Chaos: the process of productivity advance". Working paper, No.73, National Institute of Labour Studies, Inc, the Flinders University of South Australia.

Cheng Enjiang and Wu Yanrui, 1994. "Market reform and integration in China in the early 1990s - the case of maize. Paper presented to the workshop "China's Grain Marketing System", organised by Chinese Economy Research Unit, the University of Adelaide, 14 December, 1994.

Fleisher, Belton and Liu Yunhua, 1992. "Economies of Scale, Plot Size, Human Capital and Productivity in Chinese Agriculture". *Quarterly Review of Economics and Finance*. Vol, 32, No.3, Autumn 1992, pp.112-123.

Li Qingzeng, Andrew Watson and Christopher Findlay, 1991. "Grain production and regional economic change in China". Working paper of the Chinese Economy Research Unit, the University of Adelaide, No.91/13.

Lin, Justin Yifu, 1992. "Rural Reforms and Agricultural Growth in China". *The American Economic Review*, Vol.82, No.1, pp.34-51.

Nguyen, Tin, Cheng Enjiang and Christopher Findlay, 1995. "Land fragmentation and farm productivity in China in the 1990s". Paper presented to the Conference on "Grain Market Reform in China and Its Implications", East-West Centre, Honolulu, September, 16-19, 1995.

Sharif, Majma and Atul Dar, 1996. "An empirical study of the patterns and sources of technical inefficiency in traditional and HYV rice cultivation in Bangladesh". *The Journal of Development Studies*, Vol.32, No.4, 1996, pp.612-629.

Wu, X. Harry, 1995. "A note on the CERU-MoA grain farm household survey in China". A Collection of Papers Applying the CERU/MoA Survey Data. Chinese Economy Research Unit, the University of Adelaide.

Wu, X. Harry and Meng Xin 1995. "The Direct Impact of the Relocation of Farm Labour on Chinese Grain Production". Paper presented to the Conference on "Grain Market Reform in China and Its Implications", East-West Centre, Honolulu, September, 16-19, 1995.

Yang Hong, 1994. Grain Production in China: Productivity changes and provincial disparities, 1978-1990. Unpublished Ph.D dissertation, the University of Adelaide, Australia.

Yang Hong, 1995. "Grain output response to changes in labour input in China - production function analysis of household survey data". Paper presented to the Conference on "Grain Market Reform in China and Its Implications", East-West Centre, Honolulu, September, 16-19, 1995.

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