ABSTRACT

Title of thesis: Factors That Influence The Regional Agricultural Production Structure In China

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An analysis of the regional specialization trend in China since the beginning of its economic reform in 1979, and the determinants of this trend. The indices of regional specialization are calculated for years 1985 to 2006. Important policy changes during this period, mainly agricultural policy changes, are discussed. After applying the fixed effect regression on a modified Heckscher-Ohlin model, it is found that: (a) among scale, natural resource and human investment variables, only human investment are significant; (b) WTO membership has had a positive total effect on regional specialization of China's agricultural production; (c) Regions that produce a larger portion of exportable products have become more specialized since entering WTO; (d) Center region of China is the one with the least specialization.

FACTORS THAT INFLUENCE THE REGIONAL AGRICULTURAL PRODUCTION STRUCTURE IN CHINA

by

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I. Introduction and Literature

Regional specialization is often used by economists to measure the degree of free trade or the economic openness of a country. Why do we care about regional specialization? The prevailing wisdom is that the two main reasons for trade are comparative advantage and increasing returns. Comparative advantage means that trade exists because different geographical places take advantage of inherent differences to maximize production in a narrow area of expertise. Increasing returns says that, trade arises to take advantage of scale and variety gains from specialization. Both these two reasons mean that there is a relationship between trade and the regional structure of production. Therefore, studying regional specialization in production enables us to evaluate if a country or a region is taking full advantage of their comparative advantage and increasing returns of production. That is, it allows us to investigate whether a country or region is realizing its full potential gain from trade. Furthermore, understanding the determinants of regional specialization enables people to effectively influence the regional structure of production by affecting the determinant factors. In this way, the government would be able to design policy improvements for both trade and production.

There is no theoretical basis for a certain relationship between freer international trade and the regional specialization within a country. Therefore the question needs to be answered, case by case, with empirical analysis. In the case of China, there would be one major reason, the distinct natural condition in different areas of the country, for people to expect that agriculture production in China be relatively more specialized. Agricultural production usually relies significantly on the natural characteristics of an area, especially in less developed countries. China is one of the world's largest developing countries in terms of geographical territory. As a result, conditions such as climate, topography, precipitation and soil vary dramatically among different regions in China. However, empirical studies of regional specialization in China's agricultural production have arrived at different conclusions.

In Carter and Zhong (1991), it is claimed that past Chinese governmental policies resulted in low levels of differentiation between the agricultural productions of China's various regions. The authors argue that the major reason is central regulation, and provide empirical evidences to support their argument that deregulation of the market would lead to increased regional specialization. Carter and Lohmar (2002) examine the extent of regional specialization in agriculture in China and identified trends in specialization from 1981 to 1999. The index of regional specialization for

China's agricultural production for 1981, 1986, 1991, 1996 and 1999 are found to be 1.08, 1.11, 1.10, 0.93 and 0.91. It means that regional specialization in 1999 is less than that in 1981, suggesting an overall shift towards despecialization. No satisfactory reason for such a seemingly contradictory trend was provided in this paper. The authors predicted that WTO membership would have a significant impact on the structural transformation of China's agriculture.

It is not impossible to find an explanation for despecialization in China. Pingali and Rosegrant (1995) claims that specialization in agricultural production is accompanied by economic growth, urbanization and withdrawal of labor from the agricultural sector. It may be the withdrawal of labor that explains the apparent contradiction between China's development and its decrease in regional specialization. As is well known, China has the world's largest population, a large part of which is working in the agricultural sector. A withdrawal of labor from agriculture could result in serious consequences, such as an increased rate of unemployment or mass migration into urban areas, all of which have the potential to pose problems for China's development. Although the Chinese government seeks to absorb surplus labor in the countryside by developing rural industries, the government still has to make a tradeoff between these two opposing goals.

There are also some other relative studies on regional specialization, though not specifically about agricultural production in China. Bai, Du, Tao and Tong (2004) use a dynamic panel estimation method to investigate the determinants of regional specialization in China's industries. Less geographic concentration is found in industries where the past tax-plus-profit margins and the shares of state ownership are high, reflecting stronger local government protection of these industries. The evidence also supports the scale-economies theory of regional specialization. Finally, the overall time trend of regional specialization of China's industries is found to have reversed an early drop in the mid-1980s, and registered a significant increase in the later years. Kim (1995) and Kim (1999) study the trends in U.S. regional manufacturing structure from late 1800's to 1987. The author finds the index of regional specialization in U.S. manufacturing industries to be over 0.8 in 1880, but only about 0.6 in 1987. It is concluded that factor endowments explain a large amount of the geographic variation, and that the historical trends in U.S. regional specialization can be explained jointly by models based on scale economies and resources. In addition, David and Weinstein (1999) empirically compare the relative importance of comparative advantage and increasing returns to scale on regional specialization with Japanese data, and find support for the existence of economic geography effects in eight of nineteen manufacturing sectors. Although there are differences between agriculture and other

industries, these papers provide guidelines on how to and where to look for determinants of the trends in regional specialization.

This paper tends to answer the following questions. What is the trend of regional specialization of agricultural production in China? What are the key factors that determine this trend? What is the effect of WTO membership to the regional specialization? It proceeds as follows: Section II discusses important changes within China during the studied period; Section III presents preliminary results based on available data, which enable us to identify the trend and eyeball the impact of WTO membership on agricultural production structure in China; finally in section IV, regressions are run on a modified form of Heckscher-Olin Model to test the effect of resource and scale, and also to test the effect of WTO membership.

II. Analysis of the Changes

In this section, we will discuss the important policy changes during the studied period that may have had an effect on the degree of regional specialization in China's agricultural production. Our analysis will be roughly divided into three periods: 1980's, 1990-2000 and post 2001.

2.1 1980's

Before the economic reform of China in 1978, Chinese leaders implemented a central planning policy, in the belief that markets should play a minimal role. A large portion of trade was carried out through state channels in accordance with economic plans. Starting from 1978, policies were shifted to encourage markets to develop together with state-planned commerce. As a result, a mixed system of trade emerged. In agriculture, state planned quotas of agricultural products, which were to be delivered to the state, were gradually reduced during the period of 1978 to 1985 for most products. Local and long-distance market exchanges were allowed and even encouraged to develop. Negotiable state trade was introduced and expanded. However, various problems accompanied the early stage of economic reform.
In Sicular (1988), four major problems were mentioned. First, the higher profitability encouraged evasion of remaining quotas. Second, the existing procurement system was ill suited to handle emerging agricultural surpluses. Third, growth in production led to increasing selectivity of demand. Finally, the procurement system created inequities.

In order to deal with these problems, the Chinese government carried out further

commercial reforms in 1985. Except for a few products, procurement quotas were no longer sent down to farmers. The state no longer promised to buy as much as farmers wished to sell. Planned procurement of most agricultural products was gradually eliminated and replaced by free-market allocation. All the policies above indicate a gradual move towards deregulation over the agricultural trade market, a trend generally regarded as helpful to establishing a freer environment for agricultural trade.

On the other hand, the total investment in farming and rural development was decreased during this period. The three major components of the total investment were state investment, private investment and collective investment. State agricultural investment fell continuously after 1979. According to Lardy (1986), it dropped to only 5% of the state investment in 1984, which was the lowest in the entire history of post 1949 China. Most of the rural areas did not receive allocation of agricultural products. The only rural areas which did receive were primarily those well suited for production of commercial crops. Although state agricultural policy sought to compensate for the decrease of state investment by encouraging private farm investment, it turned out that people were far less willing to invest in farming than expected. Evidence shows that they invested in private housing three times as much as in farming. The reason might be that, private housing was the only asset whose ownership would not alter very often at the time. Moreover, as the level of decollectivization increased during the economic reform, collective investment in agriculture also decreased. Lardy (1986) says that collective investment in agriculture decreased from 8.7 billion in 1980 to only 4.39 billion in 1983.

Another very important factor was the change in policy that accompanied the development of the transportation system in China. Since the late 1970's, transportation development was a major focus of the Chinese government. Unfortunately, rural areas did not see much benefit, because transportation development during that period was concentrated on railways rather than the roads. At that time, the role of the transportation sector was not to serve the entire economy, but only to serve "heavy industries" (Lyons 1985). Figure 1 shows the development of railroads and roads in China from 1962 to 2006. In the figure, there is an obvious slow down of road development starting from the late 1970s. It was almost at the same time, when China started to direct more effort towards electrified railways. By the time of middle 1980's, there were still no roads passing through one third of China's villages. The nonparallel development of the transportation industry with agriculture greatly slowed down the increase of mobility of agricultural input factors and outputs. As a result, regions could not rely on the supply from others to satisfy their own needs, but had to try to produce a large part of their own demand for most agricultural products.

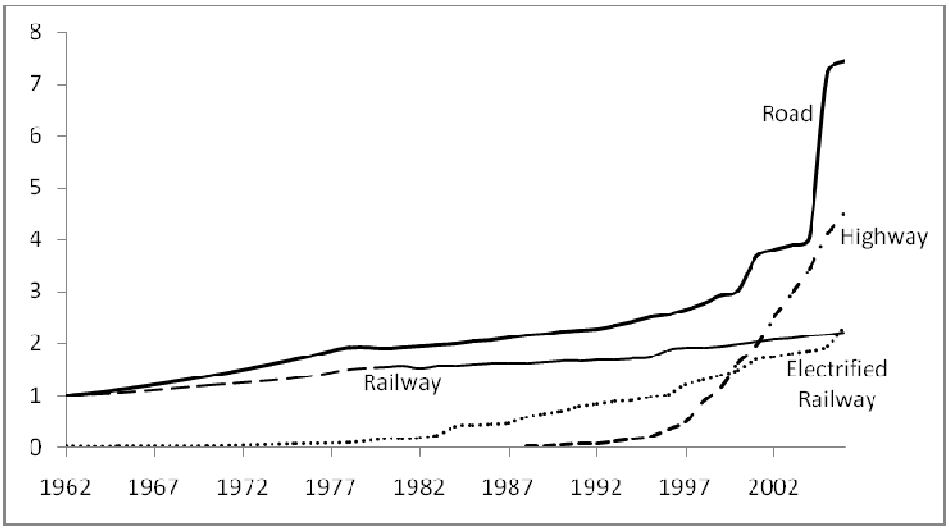

Figure 1. Road an Railway Development in China

For road and railway, the figure indicates the index of length in each year, with the mileages in 1962 being 1 for both. For highway and electrified railway, the figure indicates the real number of mileage in each year, with the unit being 10,000 kilometers. Road is the total of highway and local roads, while railway includes both electrified and non-electrified railways. (Source of data: Statistic Yearbook of China, 2007)

Finally, "self-sufficiency" was the policy of pre-reform Chinese government in almost all kinds of production. By the mid 1960s, China began a conscious attempt to develop duplicate sets of industries in each region and province, so as to be better able to sustain economic activity in the event of a foreign invasion (Young 2000). Although there was much less emphasis on this policy after 1978, it would take some time for both the administration and production sector to get used of it. The period preceding the reform, when local officials were gradually freed from the central government, saw new and costly distortions that were created by local officials for reasons of rent-seeking. According to Young (2000), such distortions included barriers to trade such as tariff barriers, physical barriers, outright prohibition, low interest loans, or even subversion of the legal system.

2.2 1990-2000

The change in China's agricultural policy in the 1990s can be roughly divided in to two periods: more free trade in early 1990s and more government intervention in mid and late 1990s.

Following the pace of reform in 1980s, the agricultural market became more liberalized and grew rapidly in the early 1990s. By the end of 1993, the Chinese

government abandoned the urban grain rationing system and stopped the fixed price for contracted government purchases. Although famers still needed to sell to the government a certain amount of their products, the prices were to be determined at the market level. By this time, China's agricultural market had reached the most flourishing point they had ever been since the 1950's. However, the country's economy started to suffer from another round of inflation, which increased expected prices in the future. As farmers were much more free to make their own production decisions, many of them decided to withhold their production in the fall and winter of 1993-1994, in order to get the highest expected price in the future. Not only individual farmers but also local governments in surplus areas implemented prohibitions on outward shipment, for the purpose of maximizing revenue. All these contributed to a sharp increase in agricultural products prices, which can be seen in figure 2.

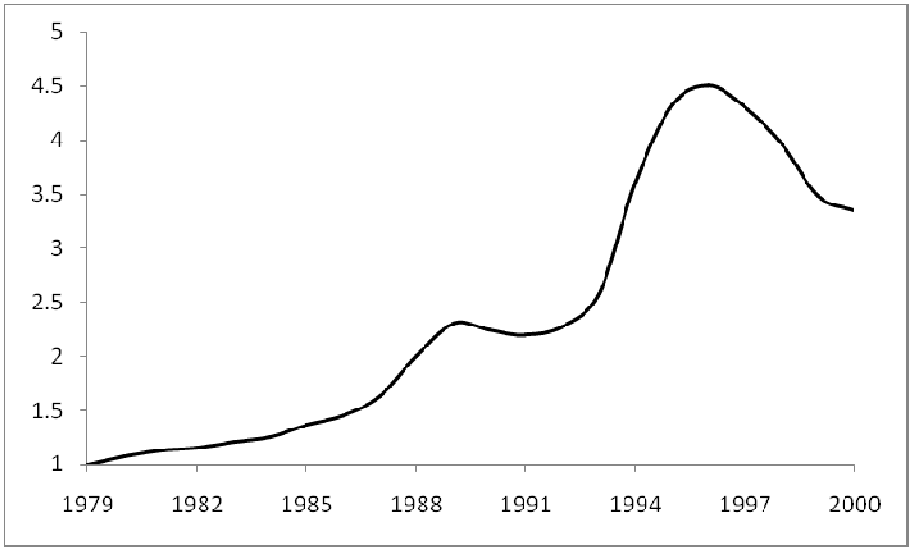

Figure 2. Price Indexes for Agricultural Products Purchase Price in China

The figure indicates purchase price indexes for agricultural products in China, with that in the year of 1979 being 1. (Source: USDA Economic Research Services, China Agricultural and Economy data, National Data Results)

Viewing the price increase in 1993 and production decrease in late 1994, the Chinese government considered them to be a signal for the need of more government intervention. According to Carter (1997), policies were introduced during late 1994 and 1995 to reduce the importance of the market in agricultural product trade. First, non government agencies were again prohibited to buy grain directly from the farmers, especially before government quotas were fulfilled. Second, the Chinese government established a blockade on rice and corn exports. Third and most importantly, the Governors Green Bag Responsibility System policy was implemented, which required provincial governors to be responsible for grain supply in each province regardless of comparative advantage in grain production. Based on 1995, 1996 and preliminary 1997

data, Crook (1997) examined the effect of these policies and argued that the grain bag responsibility system was effective to the central government of China, because it raised the sown area in most provinces, increased production and reduced imports. This can explain the decrease of price in the late 1990s in figure 2, and the reason for the Chinese government to maintain this policy until the end of the twentieth century. However, these policies have a negative impact on geographic concentration of agricultural production in China.

Conversely, the development of transportation sector became faster and more balanced in the 1990s, as shown in figure 1. A highway system emerged in China by the end of the 1980s and expanded rapidly during the following decade, especially in the late 1990s. Although the total length of railway did not increase much during this period, the portion of electrified railway increased tremendously. During the same period, the aviation sector matured and became another major part in transportation. The total length of civil aviation routes in China increased from 506.8 thousand kilometers in 1990 to 1522.2 thousand kilometers in 1999, and more than tripled.

2.3 Post 2001

Important agricultural policy changes in China after 2000 were mostly due to the accession of the WTO in December 2001. In entering the WTO, China had to show to the world its willingness to be more open to international trade and to continue its drive for domestic reform. Even before China's accession to the WTO, many economists predicted that China's agricultural sector would struggle to survive when exposed to the world market, because it was considered to be the most vulnerable segment of China's economy. Therefore, China's policy changes after 2000 were not only aimed to fulfill its WTO commitments, but also to prevent its agricultural sector from being destroyed. Such policy changes can be differentiated into two areas: international trade policy changes and domestic agricultural policy changes.

The initial international trade policy changes were aimed at reducing trade barriers and discrimination against imports, as well as increasing the transparency of trade. To some extent, China liberalized agricultural trade. Table 1 shows the tariff rates and quota levels for tariff rate quota (TRQ) commodities[1]. Products listed in table 1 are major commodities in China's international agricultural trade. It is clear that for all of these commodities, in-quota tariff rates were far below that in 2001. Out-quota tariff rates were all decreased or expected to decrease in the future. The quota level for each commodity was increased immediately and continuously after 2001. China also

[1] Source: Fuller, F., J. Beghin, et al. (2003). "China's Accession to the World Trade Organization: What Is at Stake for Agricultural Markets?" Review of Agricultural Economics 25(2): 399-414.

Table 1 Tariff rates and quota levels for TRQ commodities (percent)

	2002/03	2003/04	2004/05	2005/06	2006/07	2010/11
Wheat						
Baseline 2001	14.13	14.13	14.13	14.13	14.13	14.13
Scenario in-quota tariff	1.00	1.00	1.00	1.00	1.00	1.00
Scenario out-quota tariff	76.00	74.00	72.00	68.00	65.00	65.00
Scenario quota (mmt)	8.47	9.05	9.64	9.64	9.64	9.64
Corn						
Baseline 2001	14.13	14.13	14.13	14.13	14.13	14.13
Scenario in-quota tariff	1.00	1.00	1.00	1.00	1.00	1.00
Scenario out-quota tariff	76.00	74.00	72.00	68.00	65.00	65.00
Scenario quota(mmt)	5.85	6.53	7.20	7.20	7.20	7.20
Rice						
Baseline 2001	14.13	14.13	14.13	14.13	14.13	14.13
Scenario in-quota tariff	1.00	1.00	1.00	1.00	1.00	1.00
Scenario out-quota tariff	76.00	74.00	72.00	68.00	65.00	65.00
Scenario quota(mmt)	3.99	4.66	5.32	5.32	5.32	5.32
Cotton						
Baseline 2001	3.00	3.00	3.00	3.00	3.00	3.00
Scenario in-quota tariff	1.00	1.00	1.00	1.00	1.00	1.00
Scenario out-quota tariff	76.00	67.00	58.00	49.00	40.00	40.00
Scenario quota(mmt)	0.82	0.86	0.89	0.89	0.89	0.89
Soybean Oil						
Baseline 2001	13.00	13.00	13.00	13.00	13.00	13.00
Scenario in-quota tariff	9.00	9.00	9.00	9.00	9.00	9.00
Scenario out-quota tariff	74.00	74.00	74.00	74.00	74.00	9.00
Scenario quota (mmt)	2.52	2.82	3.12	3.59	3.59	no TRQ
Rapeseed Oil						
Baseline 2001	20.00	20.00	20.00	20.00	20.00	20.00
Scenario in-quota tariff	9.00	9.00	9.00	9.00	9.00	9.00
Scenario out-quota tariff	74.00	74.00	74.00	74.00	74.00	9.00
Scenario quota (mmt)	0.88	1.02	1.13	1.24	1.13	no TRQ

Source: Fuller, F., J. Beghin, et al. (2003). "China's Accession to the World Trade Organization: What Is at Stake for Agricultural Markets?" Review of Agricultural Economics 25(2): 399-414.

granted "zero tariff" status for some foreign agricultural products, announcing certain agricultural products imported from these countries would enjoy zero tariffs in China after a certain time. Moreover, China introduced private trading quotas to break the monopoly of the state trading companies. All these policy changes were supposed to liberalize China's agricultural trade market.

But in reality, these policy changes were not as effective as expected in introducing free trade. As we mentioned above, China's agricultural sector was still in need of

protection. First, also from table 1 we can see that, although out-quota tariff rates were decreasing, the rate level was incomparably high, some even more that 20 times higher than in 2001. It shot up the price of out-quota imports, and dramatically reduced their competitiveness in China's domestic market. Second, the "zero tariff" status was only granted to a few countries whose trade with China consisted of only a tiny part of China's total agricultural trade. For example, according to Han (2005), China signed such a protocol with Cambodia, Laos and Burma in 2002, but the overall value of China's trade with them was less than one billion U.S. dollars per year, compared with $621 billion of its total international trade in 2002. Finally, a large part of China's private trading quota was still held by state companies. Due these circumstances, the pace of China's development towards freer trade was slower than expected.

Many domestic agricultural policies also changed after 2001. First, China increased government budgetary expenditure for agriculture. Agriculture was identified as a priority sector for the first time in the last decade in 2002. In practice, the governments of 29 provinces made direct payments to grain producers for a total of 11.6 billion yuan in 2004. Second, by May 2004, all 31 provinces of China had implemented a reform of rural taxation. The core of the reforms was: (1) removing of fees and funds that used to be collected from the farmers; (2) adjustment of taxes in order to prohibit duplication; (3) reform of collection and use of village levies. It was claimed that the tax burden of peasants was decreased by 30%-80% by the reforms (Han 2005). In addition, other related reforms were carried out to render the rural taxation reform sustainable, such as the reform to reduce bureaucracy and enhance accountability for rural governance, the reform to redefine the role and responsibility of each level of government, and the increase in transfer payments from the upper level government to support lower-level rural taxation reform.

III. Data and Preliminary Results

The empirical analysis in this paper relies solely on the data of twenty major agricultural products in China, which are apple, banana, beef, cigarette, corn, cotton, egg, fresh water products, grape, milk, mutton, orange, pear, pork, rapeseed, rice, salt water products, soybeans, tea and wheat. Monthly provincial quantity of production data and price index data of each product is drawn from statistical yearbooks published by the National Bureau of Statistics of China[2]. National average prices for each product in 2006 are from the 2007 statistical yearbook. National average prices of each product in 1985-2005 are calculated using the prices in 2006 and the price indices. For the

[2] Statistical yearbooks of China from 1986 to 2007. The data set includes all 31 provinces in mainland China.

regression in section IV, annual provincial data of sown area, employment in agricultural production, total machinery power, precipitation, temporary, highway and railway mileage are also drawn from statistical yearbooks of China.

It is true that this is not a perfect data set. First, our results could be more accurate if we had a record of the prices for each product in each year, rather than calculating with indices. Second, provincial price data, rather than national average price data, would also be a big improvement. Unfortunately, these short comings are due to the unavailability of data. However, considering the assumption in trade theories that prices are equalized in free trade, the national average prices may not be that bad. Also, as we are more interested in the trends rather than the exact degree of regional specialization, the bias from using this data will not cause significant deviation from the overall picture.

Following general practice, the thirty-one provinces in mainland China are aggregated into six different regions[3]: northeast (NE), north (N), northwest (NW), east (E), center (C) and south (S). This regionalization is the same as that used by Carter and Lohmar (2002), which was also used by the U.S. Department of Agriculture's "Economic Research Service in the China" component of its baseline model (used to predict agricultural production, consumption, and trade). These six regions represent separate agro-climatic regions.

According to Krugman, an index valuing between zero and two can be calculated to measure the degree of regional specialization. The closer the index is to two, the more divergently specialized the two regions are; the closer it is to zero, the more similar the two regions are. Following Krugman, the equation for calculating the index is:

$$RI_{jk} = \sum_{i=1}^{n} \left| \left(\frac{V_{ij}}{V_j}\right) - \left(\frac{V_{ik}}{V_k}\right) \right|$$

where, V_{ij} is the value of production in the agricultural sector i for region j, V_j is the total value of agricultural production for region j, and similarly for V_{ik} and V_k. RI_{jk} measures the index of specialization of region j with respect to region k. The aggregate level of specialization in a country is then the unweighted average of the two-region indices for all pair wise combinations of regions. For the case of China, there are six regions, so 15 different pair wise combinations.

[3] The provinces are aggregated into the six regions as follows: NE includes Heilongjiang, Liaoning and Jilin provinces; N includes Beijing, Tianjin, Hebei, Shanxi, Shandong and Henan provinces; NW includes Inner Mongolia, Xinjiang, Gansu, Ningxia, Shaanxi, Qinghai, and Tibet; E includes, Shanghai, Jiangsu, Zhejiang, and Anhui; C includes Jiangxi, Hubei, Hunan, Sichuan, and Chongqing; and S includes Fujian, Guangdong, Guangxi, Hainan, Guizhou, and Yunnan.

Applying this method to our data set, aggregate indices of regional specialization for China's agricultural production are calculated for each year from 1985 to 2006. Figure 3 shows the trend of shift in the structure of regional production. Table 2 through table 6 report the digital results for both two-region and aggregate indices for the year of 1985, 1990, 1995, 2000 and 2006.

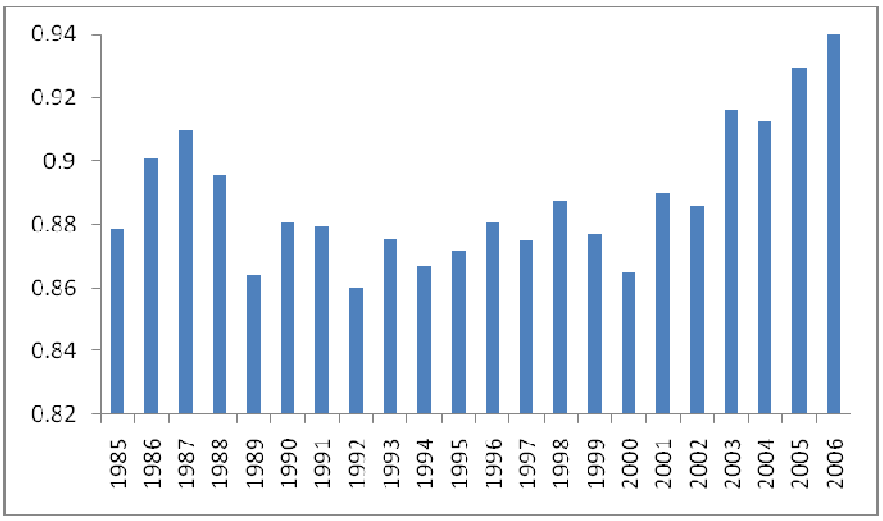

Figure 3. Index of Regional Specialization, 1985-2006

From figure 3 we can see that, there seems to be a trend of despecialization in China from late 1980s till mid 1990s, followed by a series of upward movements until 2006, which brought the degree of regional specialization up to 0.94. There is also a very obvious upward jump from 2000 to 2001, when China entered WTO. This may be a good evidence to support the prediction in Carter and Lohmar (2002), that WTO membership has a strong effect.

From table 2 to 6, there are obvious patterns of the change of indices. In the same year, the two-region indices vary a lot. For example, the indices range from 0.50 to 1.51 in 2006, and from 0.41 to 1.35 in 1985. Across the years from 1985 to 2006, the relative magnitudes of the two-region indices are somewhat constant. For instance, the indices between South and Northwest are always the largest among the fifteen pair wise combinations, while those between South and East are usually the smallest.

Table 2 Index of Regional Specialization, 1985

1985	N	NW	E	C	S

NE	0.70	0.85	0.84	1.09	0.96
N	-	0.42	1.02	1.28	1.19
NW	-	-	1.09	1.20	1.35
E	-	-	-	0.43	0.36
C	-	-	-	-	0.41
Average	0.88				

Table 3 Index of Regional Specialization, 1990

1990	N	NW	E	C	S
NE	0.66	0.86	0.85	1.16	0.95
N	-	0.42	0.90	1.25	1.09
NW	-	-	1.12	1.23	1.36
E	-	-	-	0.47	0.37
C	-	-	-	-	0.52
Average	0.88				

Table 4 Index of Regional Specialization, 1995

1995	N	NW	E	C	S
NE	0.57	0.82	0.79	1.14	0.88
N	-	0.45	0.87	1.23	1.05
NW	-	-	1.14	1.23	1.36
E	-	-	-	0.56	0.36
C	-	-	-	-	0.63
Average	0.87				

Table 5 Index of Regional Specialization, 2000

2000	N	NW	E	C	S
NE	0.55	0.90	0.54	1.05	0.64
N	-	0.67	0.76	1.20	0.91
NW	-	-	1.18	1.21	1.38
E	-	-	-	0.66	0.45
C	-	-	-	-	0.87
Average	0.86				

Table 6 Index of Regional Specialization, 2006

2006	N	NW	E	C	S

NE	0.60	1.02	0.67	1.10	0.77
N	-	0.79	0.83	1.19	0.98
NW	-	-	1.30	1.38	1.51
E	-	-	-	0.63	0.50
C	-	-	-	-	0.86
Average	0.94				

Table 7
Average Regional Specialization in South and North

	1985	1990	1995	2000	2006
South	0.40	0.45	0.51	0.66	0.66
North	0.66	0.65	0.61	0.7	0.8
Across North and South	1.11	1.1	1.08	0.98	1.08

If we further aggregate the six regions into two parts of China: northern part of China, which includes north, northeast and northwest, and southern part of China, which includes east, center and south, it is interesting to see that the degree of specialization is relatively lower within each of the two parts and larger across them, which can be seen more clearly from table 7. This means agricultural production in China is more differentiated between the northern and southern part. Also, it is noticeable that the average degree of specialization in the south is always lower than in the north. This tells us that the degree of similarity among the regions in southern part of China is higher than that in northern part. These results are reasonable considering the real situation in China. First, northern China differs from the south in many aspects, including capital, human and natural resources. Secondly, regions in south China are more equalized in economic development, and have more similar natural conditions. Some of the descriptive information is shown in table 8.

The net import and export data of China in 2006 allocates the twenty agricultural products into three groups: exportable, importable and non-tradable goods. Exportable goods include eleven products, which are apple, beef, cigarette, corn, eggs, fresh water product, orange, pork, rice, salt water product and tea. Importable goods are cotton, soybean and wheat. The remaining products are classified as non- tradable. The net export value of the exportable goods was 7.32 billion US dollars, while the

Table 8
Natural, Capital and Human Resource in Each Region for Selected Years

	North China			South China		
	N	NW	NE	C	E	S
1985						
Temperature (C^o)	12.12	8.19	5.37	16.53	15.63	18.48
Precipitation (1000mm)	3.73	2.71	2.38	5.7	4.97	7.71
Ag Population (million)	73.84	26.41	15.91	84.74	48.97	64
Farmed Land (Hectare/capita)	0.49	0.65	1.03	0.39	0.45	0.31
Machinery Power (kw/capita)	0.99	0.8	1.42	0.39	0.73	0.38
Highway (1000km)	156.9	174.99	102.76	222.24	74.92	210.57
Railway (1000km)	10.18	11.74	12.04	8.18	3.34	6.65
1995						
Temperature (C^o)	13.29	8.87	6.53	17.31	16.55	19.93
Precipitation (1000mm)	3.33	2.66	1.8	6.42	4.74	8.04
Ag Population (million)	78.54	30.13	17.66	86.74	47.4	69.71
Farmed Land (Hectare/capita)	0.47	0.6	0.92	0.39	0.44	0.34
Machinery Power (kw/capita)	1.76	1.19	1.64	0.57	1.24	0.71
Highway (1000km)	205.28	197.92	123.57	243.49	99.06	287.58
Railway (1000km)	11.37	12.5	11.99	8.45	3.7	6.61
2006						
Temperature (C^o)	14.02	9.7	6.73	18.3	17.5	20.43
Precipitation (1000mm)	2.91	2.06	1.7	5.47	4.41	8.8
Ag Population (million)	75.02	29.39	18.85	70.98	36.71	68.8
Farmed Land (Hectare/capita)	0.53	0.68	1.04	0.49	0.58	0.38
Machinery Power (kw/capita)	4.12	2.55	3.25	1.59	2.85	1.2
Highway (1000km)	729.78	593.89	321.57	746.86	380.29	684.62
Railway (1000km)	17.17	17.76	13.41	12.1	5.59	11.06

Annual data for each region from 1985 to 2006 is used in the regression.

net import value of the importable goods was 12.31 billion US dollars in 2006. Following the above definition, the portions of the value of exportable goods produced in each region in each year are calculated and shown in table 9. The percentages range from 0.51 to 0.97, with the south region producing the most and the northwest region producing the least exportable goods.

IV. Empirical Analysis

Within this section, data will be applied to a modified Heckscher-Ohlin model to estimate the determinants of the trend of regional specialization in agricultural production of China.

Table 9 Percentage of Exportable Goods Produced in Each Region

Year	NE	N	NW	E	C	S
1985	0.81	0.62	0.51	0.82	0.90	0.97
1986	0.82	0.62	0.51	0.83	0.91	0.96
1987	0.84	0.66	0.55	0.84	0.91	0.96
1988	0.86	0.70	0.56	0.86	0.93	0.96
1989	0.85	0.69	0.55	0.86	0.93	0.97
1990	0.86	0.70	0.55	0.86	0.92	0.97
1991	0.86	0.70	0.56	0.87	0.91	0.96
1992	0.85	0.73	0.57	0.85	0.91	0.96
1993	0.85	0.76	0.58	0.87	0.92	0.97
1994	0.87	0.76	0.60	0.87	0.92	0.97
1995	0.89	0.76	0.61	0.87	0.92	0.97
1996	0.89	0.78	0.62	0.87	0.92	0.97
1997	0.87	0.76	0.59	0.86	0.91	0.97
1998	0.90	0.79	0.60	0.89	0.92	0.97
1999	0.91	0.79	0.62	0.87	0.92	0.97
2000	0.89	0.81	0.61	0.89	0.92	0.97
2001	0.89	0.80	0.60	0.88	0.92	0.97
2002	0.88	0.80	0.60	0.88	0.93	0.97
2003	0.86	0.79	0.55	0.87	0.91	0.96
2004	0.85	0.76	0.54	0.86	0.92	0.96
2005	0.86	0.78	0.52	0.87	0.93	0.97
2006	0.86	0.77	0.51	0.87	0.92	0.96

4.1 Model Setup

The Heckscher-Ohlin model predicts that regional specialization is affected by resource and scale economy. According to Kim (1995), in a study of the manufacturing industry, raw material intensity (cost of raw materials divided by value added) can be used to measure the importance of resource, and average plant size by production workers can be used as a measure of scale economies.

Because agriculture is different from manufacturing, we modify the model by using three categories of variables: scale, natural resources and human investment. Specifically, we use sown land per working capital to represent the scale of the economy (scale), we use precipitation and temperature to represent the natural resource

of a region, and we use per capita power of agricultural machinery in each region[4] (machinery), mileage of road (Road) and railway (Railway) to represent the human investment of a region[5].

Also, following Kim (1995), regional dummies are included in our model as the regional-specific effect. Instead of time dummies, a year series variable is included in this model. In order to test the effect of WTO membership, a dummy variable WTO is included by interacting with the year variable. The value of the dummy is 0 in the year 2000 and before, and 1 afterwards. Another important variable in our model is the portion of exportable goods produced in each region. Therefore, our econometric model is specified as:

(1)

$$Regional\ Specialization = \beta_0 + \beta_1 scale + \beta_2 machinery + \beta_3 precipitation + \beta_4 temperature + \beta_5 road + \beta_6 railway + \beta_7 year + \beta_8 (year * WTO) + \beta_9 portion + \beta_{10}\alpha_{it} + \varepsilon$$

All other variables are either self-explanatory or explained above, except that portion representing exportable goods produced in a region. North, Northwest, Northeast, South and East are regional dummies.

(2)

$$Regional\ Specialization = \beta_0 + \beta_1 scale + \beta_2 \log(machinery) + \beta_3 precipitation + \beta_4 temperature + \beta_5 \log(road) + \beta_6 \log(railway) + \beta_7 year + \beta_8 (year * WTO) + \beta_9 portion + \beta_{10}\alpha_{it} + \varepsilon$$

Model (2) is a modification of (1) by taking the log of machinery, road and railway. A fixed effect model is used on both (1) and (2) to account for effects specific to each region, which stays constant over time and for effects specific to each year that stay constant for all regions.

4.2 Hypotheses to Test

The first job of this model is to identify the determinant factors of regional

[4] Power of agricultural machinery is a statistics in China's statistic yearbook. It is the sum of the total power of major machineries that are used in agricultural production, such as tractors, seeding machines, reaping machines and so on. Its unit is kilowatt.

[5] Unfortunately, not all these data are available for all provinces. By the assumption that provinces within each region are similar, we ignore the provinces whose data are unavailable, and use only available data to calculate regional averages.

specialization in China's agricultural production. According to our set up, there are three groups of factors in the model: natural resource, human investment resource and scale. Trade theories predict that at least one of these factors should have a significant effect.

Second, we want to test whether WTO membership has an effect on the degree of regional specialization. It is generally believed that the WTO makes trade much freer within its membership countries. And trade theories always relate the degree of free trade to the degree of regional specialization. Therefore, it is reasonable to believe that there is a strong relationship between WTO membership and the degree of regional specialization. Moreover, if there is a significant effect, we want to go one step further to do two more tests.

First, when did the effect take place? Was it in, before or after the year when China entered the WTO? By doing this test, we will be able to answer the question of whether China had effectively prepared for the entering the WTO previous to its entrance. As discussed in section 2.2 and 2.3, China made many policy changes before entering the WTO, and it is obvious that China was trying to prepare for their entrance. These preparations would only be considered effective if they had a similar effect as WTO membership. That means, the policy changes before entering the WTO set China more in line with what is expected of a WTO member country. On the other hand, if the preparations were not effective, it would mean that China only started to change toward a WTO member country after its entrance of WTO. In order to do the test, we alter the WTO dummy variable to 1_WTO and WTO_1. 1_WTO equals zero on and before 1999, which means effective preparations if significant. WTO_1 equals zero on and before 2001, which means ineffective preparations if significant. Regression results for both function forms and all alternatives are shown in tables 10 and 11.

Second, we want to test whether entering the WTO had different effects on regions that are producing different portions of exportable goods. Regions producing a larger portion of exportable goods have comparative advantage on resources that are intensive in producing such goods. According to the Heckscher-Ohlin model, a country or a region exports the goods that they have a comparative advantage on in free trade. As discussed in section II, there used to be different sources of trade barriers in China before its entrance into the WTO, which prevented each region from making full use of their comparative advantage. After 2001 or even earlier, those barriers were gradually removed. Trade became freer for each region both inside and outside China, which allowed them to make better use of their comparative advantage for revenue enhancement. On the other hand, before entering WTO, the major competitors of each

region were other regions within China. The central control of the Chinese government guaranteed that competition would not escalate to an extent that any region was badly hurt. Also, the government was able to apply barriers to protect its agricultural sector from the challenges of the world market. After entering the WTO, China entered the world market. Each region has to compete not only with other regions in China, but the rest of the world, which the Chinese government has very little control over. Therefore, regions have to specialize on products that they have comparative advantages on, so as to survive. The above discussion means that it is both necessary and sufficient for each region to become more specialized after China entering WTO. In order to test the WTO effect on regions producing different

Table 10 Estimate Results for the Linear Model

	WTO	1_WTO	WTO_1
Scale	0.035	0.046	0.054
	(0.12)	(0.12)	(0.12)
Machinery	0.021	0.020	0.019
	(0.018)	(0.018)	(0.019)
Precipitation	-0.0080	-0.0063	-0.0099
	(0.0066)	(0.0065)	(0.0067)
Temperature	-0.0064	-0.00054	-0.0068
	(0.010)	(0.010)	(0.010)
Road	-0.000020	-0.000020	-0.000039
	(0.000081)	(0.000079)	(0.000082)
Railway	-0.0057	-0.0030	0.0011
	(0.0064)	(0.0056)	(0.0059)
Year	0.0035**	0.0021	0.0044***
	(0.0017)	(0.0018)	(0.0017)
Year*WTO	0.000029***	0.000032***	0.000014
	(0.000011)	(9.0e-6)	(0.00001)
Portion	0.23	0.19	0.15
	(0.10)	(0.19)	(0.21)
Regional Dummies	All positively significant		
R-Square	0.93	0.94	0.93
No. of Observation	132	132	132

Numbers in parentheses below each estimate is the standard error for that estimate. A three star indicates a statistically significant estimate at 1% level. A double star indicates a statistically significant estimate at 5% level. A single star indicates a statistically significant estimate at 10% level.

Table 11 Estimate Results for the Log Model

	WTO	1_WTO	WTO_1

Scale	0.033	0.057	0.031
	(0.13)	(0.13)	(0.13)
Log(Machinery)	-0.018	-0.034	-0.022
	(0.052)	(0.051)	(0.052)
Precipitation	-0.0083	-0.0061	-0.0087
	(0.0065)	(0.0064)	(0.0065)
Temperature	-0.0078	-0.0019	-0.0086
	(0.010)	(0.010)	(0.010)
Log(Road)	0.013	0.012	0.015
	(0.035)	(0.034)	(0.035)
Log(Railway)	0.16**	0.14**	0.19***
	(0.075)	(0.063)	(0.067)
Year	0.0032	0.0021	0.0035
	(0.0023)	(0.0023)	(0.0023)
Year*WTO	7.9e-6	0.000023**	1.4e-6
	(0.000011)	(8.9e-6)	(9.6e-6)
Portion	0.25	0.31*	0.22
	(0.19)	(0.18)	(0.19)
Regional Dummies	All positively significant		
R-Square	0.94	0.94	0.94
No. of Observation	132	132	132

Numbers in parentheses below each estimate is the standard error for that estimate. A three star indicates a statistically significant estimate at 1% level. A double star indicates a statistically significant estimate at 5% level. A single star indicates a statistically significant estimate at 10% level.

portions of exportable goods, we altered model (1) and (2) by adding an interaction term between portion and WTO*year. Regression results for this model are shown in table 12.

4.3 Analysis of Results

There are four major findings from the regression results:

(a) The scale variable, natural resource variables and Road variable are not significant in determining the regional agricultural production structure. The only exceptions may be Railway and Machinery, which are both human investment resources.

According to tables 11 and 12, the effects of railway and machinery on regional specialization were both positive. More specifically, a one percent railway increase led to about 0.16 unit increase in the degree of specialization; a one unit increase in

machinery led to a 0.055 unit increase in the degree of specialization. The result means that only human investment matters in determining the regional specialization of agricultural production in China.

Table 12
Test for Reaction to WTO membership from Different Regions

	(1)	(2)
Scale	-0.10	-0.085
	(0.11)	(0.13)
Machinery	0.055***	0.024
	(0.018)	(0.051)
Precipitation	-0.0066	-0.0076
	(0.0061)	(0.0062)
Temperature	-0.0060	-0.012
	(0.0094)	(0.0097)
Road	-0.00012	0.017
	(0.000077)	(0.033)
Railway	0.0064	0.13*
	(0.0064)	(0.071)
Year	0.0033**	0.0025
	(0.0015)	(0.0022)
Year*WTO	-0.00015***	-0.000094***
	(0.000037)	(0.000029)
Portion	-0.21	0.095
	(0.20)	(0.18)
Portion*Year*WTO	0.00019***	0.00012***
	(0.000038)	(0.000033)
Regional Dummies	All positively significant, except N	
R-Square	0.94	0.94
No. of Observation	132	132

Numbers in parentheses below each estimate is the standard error for that estimate. A three star indicates a statistically significant estimate at 1% level. A double star indicates a statistically significant estimate at 5% level. A single star indicates a statistically significant estimate at 10% level. Column (1) shows the results for the linear model, while column (2) shows those for the log model.

One of the important inferences from this result is that, China's agricultural production has been developed to a relatively higher level. It is generally believed that in less agriculturally developed countries, agricultural production should largely depend on natural conditions, such as weather and terrain. Although the aim of this paper is not to study the productivity of agriculture, the regression results show a decrease in the

dependency of agricultural production on weather variables. Instead, we see a significantly positive relationship between human investment and production. It tells us that the importance of capital is increasing, which is a sign for the development of China's agricultural production.

Another possible explanation of this result may not be as optimistic as the one above. Although the economy in China is mostly market oriented today, their infrastructure investments, such as the building of railways, are still highly dependent on central government policies. Therefore, this result may also be a sign that government policy is still a very important factor in determining agricultural production in China. The government still has some controlling power over the structure of regional agricultural production, intentionally or unintentionally, through the direction of government investment. The influence is so strong that people even ignore their regional comparative advantage on natural resources and other factors. In the case when all policies are appropriate, this would not be a problem, because appropriate policies should have already taken every factor into consideration. However, it is usually not the case in reality. When policies are biased and production follows the policies so closely, production may diverge away from its comparative advantage. As a result, the competitiveness of the country in the world would decrease in free trade.

It is most likely that (a) is the result of the combination of the above two reasons. That is, agricultural production in China has developed, while it is still under the control of government policies to some extent.

(b) The empirical results support the prediction of Carter and Lohmar (2002), that the total effect of WTO membership is significantly positive on the regional specialization of China's agricultural production. China's preparations for entering the WTO were effective.

According to Table 10, the index of regional specialization increases by about 0.00003 a year starting from at least one year before China entering WTO. A Chow test of structure break in 2000 rejects the null hypothesis that the parameters are the same before and after 2000, which is consistent with our regression result. This result is also consistent with theories. Entering the WTO has the effect of freeing trade, which makes countries or regions produce according to their comparative advantage.

As a result, countries or regions become specialized on products that they have a comparative advantage on.

Also, this result tells us that the policy changes the Chinese government made before entering the WTO were effective in reducing trade barriers and freeing trade in agricultural products. Unlike many pessimistic predictions, this goal was achieved without the agricultural sector being destroyed by free trade. This is useful in providing successful examples for other developing countries which share similar situations with pre-WTO China and are willing to open their agricultural market to the rest of the world.

(c) Regions that produce a larger portion of exportable products become more specialized after entering the WTO, than those that produce a smaller portion of exportable products.

According to table 12, after entering the WTO, every one percent increase in the production of exportable goods would increase the region's degree of specialization by about 0.0002. This result means that all else equal, regions producing a larger portion of exportable goods would not only be more specialized, but also become specialized faster.

By controlling for the portion of exportable goods in each region, we are able to separate the total effect of WTO membership into two parts: the effect on regions with different portions of exportable goods and other effects. Tables 10 and 12 show that, although the overall effect of WTO membership is positive, its two components have different signs. WTO membership increases the degree of specialization for regions with higher portions of exportable goods, while the net outcome of all other WTO effects is negative. The positive effect is large enough, so that it overcomes all negative effects and make the net total effect of WTO membership positive.

According to our previous analysis, regions producing a larger portion of exportable goods should have a comparative advantage in producing them. Therefore, this result is actually saying that comparative advantage becomes a determinant factor in agricultural production after China entered the WTO. Although it is impossible to separate important factors of comparative advantage from this result, it shows that entering the WTO does have the effect of making a country to produce according to its comparative advantage. In combination with result (a), it also tells us that China's agriculture was not producing effectively before entering the WTO.

(d) The center region is the one with the least specialization among all six regions.

This finding is somewhat surprising at first glance. According to table 9, the center

region produces the second largest portion of exportable goods among the six regions. It means that the center region has a comparative advantage in producing exportable goods. Considering result (c), this region should be relatively more specialized, especially after 2001.

One possible explanation may be that, the value of per capita power of agricultural machinery (Machinery) and the mileage of railway (Railway) are relatively low in this region. According to table 8, the mileage of railway in center region always ranked 4th among the six regions from 1985 to 2006; while the per capita power of agricultural machinery ranked the last most of the time. From result (a), these two factors are the only ones that have positively significant effect on regional specialization during the whole period of our study, regardless of WTO membership. The estimated parameters for these two variables are much larger than that for "Portion*Year*WTO". Therefore, it may be reasonable to argue that, the low level of Machinery and Railway prevented the center region from becoming more specialized in the long-run, while the high portion of exportable goods production has effect only after China entered the WTO.

A further look into the data may find the large agricultural population to be the primary cause. Also from table 8, the agricultural population in the center region is always among the top two from 1985 to 2006. Actually, it was only after1999 that the agricultural population in the north region exceeded that in center region. The agriculture population in center in 2006 is still twice as much as that in northwest and east regions, and more than three times that in northeast. Although the total level of machinery power in the center region is always far above the national average, sometimes even ranking the top among the six regions, the per capita level is almost always the lowest, because of its huge agricultural population. In addition, a decreasing trend in the agricultural population in the center region can be identified from table 8. So, it may be possible that the center region becomes more specialized than others in the future.

The location of the center region may also be one of the reasonable explanations for the center region being the list specialized, though not the most important one. The center region borders on four of the other regions except the northeast, which means it is the one that has the most neighbor regions. Therefore, the center region may share some characteristics with each of the bordered regions, and consequently, may be

suitable for producing more kinds of agricultural products than any other region. As a result, the production of this region ends up less specialized than others.

V. Conclusion

After 30 years of economic reform, the competitiveness of China in the world agricultural market has increased a lot. However, the degree of regional specialization in China's agricultural production did not increase as predicted by many theories. Instead, it fluctuated in the last two decades of late 20th century, and only started to increase steadily after China entered the WTO. Considering the real situation, becoming more specialized may not be the best outcome for China in the early stages of economic reform. During the 30 years of this study, China's economic system changed from purely planning, to a mix of planning and market, and finally to a market oriented system. China's agricultural policy varied during this period. Although all these policies are aimed at the development of China, they have mixed impacts on the geographical concentration of agricultural production.

With a modified Heckscher-Ohlin model, we estimated the determinants of regional specialization in China's agricultural production. Scale and natural resource are found to be not significant. Railway and machinery, which are human investment resources, are positively significant. It may indicate that agricultural production in China is less dependent on natural resources and more dependent on human investment, which means a development of agricultural production in China. However, it may also be possible that China's agricultural production is still under the control of the central government. WTO membership is found to have a positive total effect on the regional structure of agricultural production in China. It is also proved that China effectively prepared to enter the WTO beforehand. The total WTO effect can be separated into two parts: a large positive effect on regions with higher exportable goods production and a negative net effect on all others. The positive WTO effect on regions with higher exportable goods production is a signal for the increasing importance of comparative advantage. Our regressions also find that the center region is the one with the least specialization, which may be a result of large agriculture population in the region and/or the location of the region.

The most important limitation in this paper is the lack of a complete data set. The results can be greatly improved if we had more years of data, more kinds of agricultural products, more detailed provincial data and so on. Most importantly, if we had more years of data after 2001, we could have run separate regressions before and after China entered WTO, so that we could have found out the determinant variables of comparative advantage, as mentioned in result (c). Also, the regression results may be sensitive to the aggregation method. If the empirical study was done on provincial level or if the regions are defined differently, our conclusion may change.

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