Comparative advantages and complementarity of the Sino-US agricultural trade: An empirical analysis

Komparativní výhody a komplementarita obchodu mezi Čínou a Spojenými státy: Empirická analýza

Chuanmin SHUAI[1], Xi WANG[2]

[1]*School of Economics and Management, China University of Geosciences, Wuhan, China*
[2]*China Social Sciences Press, Beijing, China*

Abstract: By adopting the RCA, CMS, TCD, SI and TCI models, this paper has made an empirical analysis of the comparative advantages and complementarity of the agricultural trade between China and the United States in terms of sixteen major agricultural products since 1997. The results indicate that (1) the exporting agri-products of China and the United States reflect the characteristics of the resource endowment of each country; (2) China's agri-product competitiveness has decreased after its WTO accession, while the country's agri-export structure has been upgraded; (3) Sino-US agri-trade dependency continues to rise, and the U.S. relies more on China than China does on the U.S.; (4) China and the United Sates have good complementarity in the agricultural trade, which tends to strengthen after the China's accession to the WTO. Policy implications are proposed accordingly based on these findings.

Key words: agricultural trade, comparative advantages, complementarity, China, the United States

Abstrakt: Práce shrnuje výsledky empirické analýzy komparativních výhod a komplementarity agrárního obchodu mezi Čínou a USA, provedené s využitím modelů RCA, CMS, TCD, SI a TCI pro 16 hlavních zemědělských komodit od roku 1987. Výsledky analýzy ukazují, že (1) vývozní zemědělské komodity Číny a USA odrážejí specifika zdrojů obou zemí; (2) konkurenceschopnost čínských zemědělských komodit se snížila po vstupu Číny do WTO, zatímco její exportní struktura se zlepšila; (3) vzájemná závislost čínsko-amerického agrárního obchodu dále roste a USA jsou v tomto směru více závislé na Číně než naopak; (4) Čína a USA vykazují dobrou komplementaritu agrárního obchodu, což se ještě posiluje po vstupu Číny do WTO. Na základě uvedených zjištění byla navržena některá relevantní opatření hospodářské politiky.

Klíčová slova: agrární obchod, komparativní výhody, komplementarita, Čína, USA

China and the United Sates are both major agricultural producers and traders in the world, and they are important partners for agricultural trade to each other as well. China has become the fourth largest overseas market for American agricultural exports, while the U.S. are also an important country for exporting and importing China's agricultural products. According to the statistics from the China's General Administration of Customs, the total agri-trade value between these two countries has risen sharply from 3.219 billion US dollars in 1997 to 13.579 billion US dollars in 2007, increasing by 4.22 times with an annual increasing rate of 15.48%. However, the Sino-US agricultural trade has been considerably imbalanced. In 2007, for instance, the American agri-export value to China totaled $9.152 billion, while China's export value to the United States was only $4.427 billion (see Table 1 and Figure 1).

In recent years, with the rapid development of China's foreign trade and a closer trade relationship between China and the United States, frequent trade frictions have occurred, and the U.S. trade deficit with China and China's agri-trade deficit with the

Table 1. Development trend for the Sino-US agricultural trade (1997–2007) (millions of US Dollars)

Year	China's exports to the U.S.A.	US exports to China	Total value of Sino-US agri-trade	China's balance of trade	Total value up by %
1997	835.77	2 383.11	3 218.88	−1 547.34	
1998	885.30	1 826.86	2 712.16	−941.56	−15.74
1999	945.82	1 740.88	2 686.70	−79 5.06	−0.94
2000	1 184.62	2 591.01	3 775.63	−1 406.39	40.53
2001	1 261.20	2 791.99	4 053.19	−1 530.79	7.35
2002	1 681.59	2 720.44	4 402.03	−1 038.85	8.61
2003	2 084.64	5 012.70	7 097.34	−2 928.06	61.23
2004	2 396.06	7 689.00	10 085.06	−5 292.94	42.10
2005	2 959.52	6 722.64	9 682.16	−3 763.12	−4.00
2006	3 848.44	7 595.38	11 443.82	−3 746.94	18.19
2007	4 426.58	9 152.39	13 578.97	−4 725.81	18.66

Source: calculated by the author according to the statistics from the China General Administration of Customs (2009)

U.S. have continued to grow, which seriously hinders the trade balance and the overall economic and trade relations between the two countries. In the overall Sino-U.S. trade relationship, agricultural trade is one of the most sensitive and controversial issues, with both challenges and opportunities ahead. Therefore, under the new circumstances of the world financial crisis, the economic downturn and the potential rise of the trade protectionism, it is of great significance to analyze and estimate the comparative advantages and complementarity of the Sino-US agricultural trade, in an attempt to propose policy implications for the balanced growth of agri-trade and healthy development of the economic and trade relations between China and the United States, and for the facilitation of the recovery of the world economy.

LITERATURE REVIEW

The related research literature includes the following aspects: comparative advantages, competitiveness and complementarity of agricultural trade.

1. Agricultural comparative advantages and trade competitiveness

The proposition of comparative advantages was first proposed by David Ricardo in 1817. M.E. Porter et al put forward the theory of international competitiveness in 1990. The research on agricultural competitiveness includes the following literature: Wang Zhaoyang (2001), Shuai Chuanmin (2002), Jiang Manlin (2003), Lan Qinxin (2003), by applying the RCA, Xu Zhigang et al (2000) and Cheng Guoqiang et al (2001), by adopting the DRC methodology, conducted researches on the international competitiveness of China's different
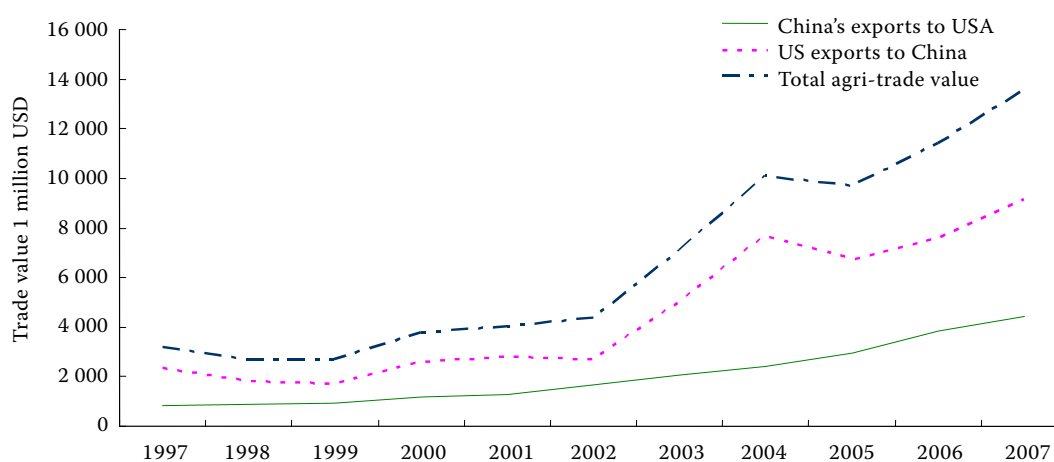

Figure 1. Overall trend of the Sino-US agricultural trade (1997–2007)

agri-products in different periods. Sun Xiaodan (2003), Sun Lin and Zhao Huie (2004) and Zhong Yu et al. (2005) analyzed the competitiveness of Chinese agri-products in the Japanese market, the ASEAN market and the factors influencing imports respectively. Huang Jikun and Ma Hengyun (2000), Xin Yi et al. (2002) and He Xiurong (2003) studied the production costs of major agricultural products, competitiveness of labor-intensive agri-products, and the related issues of agricultural trade in China.

Banerjee (2005) studied the international competitiveness of the sugar industry in Australia, Brazil and the EU, and Matthew Gorton et al. (2006) did it for the Hungarian agriculture with DRC methodology. The literature using the CMS approach includes the research on export competitiveness of East-Asian countries (ADB 2002), a comparison of price competitiveness of Turkish and South East Asian exports in the EU market (Kotan and Sayan 2001), the competitiveness of Canadian agri-food exports against competitors in Asia (Chen and Duan Yufeng 2000), and Belgium's export performance (Simonis 2000).

2. Sino-US Agricultural comparative advantages and trade competitiveness

Sun Xiaodan (2003) studied the competitors of China's agri-products in the U.S. market, showing that agri-products in North and South American countries have more similarities in the export structure to that of the U.S., and China faces challenges from these countries. Luan Jingdong and Li Jing (2006) analyzed the growth features and causes of the Sino-US agri-trade, pointing out that the vigorous market demands from both countries jointly pushed the agri-trade growth, and the main reason for China's rapid increase of importing the U.S. agri-products is the strong adaptability of America's export structure. Benson et al. (1999) stated that trade liberalization has provided additional market opportunities for some U.S. products, creating more trade surplus with more exports. China market has a great potential. Wailes et al. (1998) explained that constraints on the U.S.-China agricultural trade include tariffs, state trading, food security policies, and other non-tariff barriers.

Tuan et al. (2001) found that except for wheat production, China's grain, cotton, and oilseed production have become less trade competitive over the study period (1990–1998), whereas hogs, beef cattle, and broilers have been competitive in trade. Wu and Thomson (2003) studied China's major agricultural products since 1985 revealing that China's meat products had comparative advantages while grains had comparative disadvantages. Colin A. Carter and Scott (2002) pointed out that agricultural policy in China and trade barriers in other parts of the world have tilted China's agricul-

tural production away from its comparative advantage. American fresh fruits have strong competitiveness in China, and the U.S. share in the China's fresh fruit import market grew from less than 4% in 1992–1994 to nearly 10% in 1998-2000 (Wu Huang 2002). Although China has been exporting a large amount of fruits and vegetables, most of China's exports are processed fruits and vegetables that do not yet pose a serious challenge to the U.S. exports (Huang and Gale 2006). In 2007–2008, China imported a large quantity of soybean and cotton from the States (USDA, 2007). Schott (2006) concluded that compared with other developing countries, the cost advantage may be the key contributor to the China's export growth.

3. Sino-US trade complementarity

Zhan Boming (2004) made a descriptive analysis of the complementarity and competitiveness of the China – US trade. Zhou Haiyan (2006) argued that the main reason for the rapid growth of trade between China and the US and the quick rise of the American trade deficit with China lies in the fact that there is more complementarity than competitiveness in the Sino-US trade relations. Zhou Maorong and Du Li (2006) studied the complementarity of the two countries' merchandise trade, concluding that there exist close ties and sustainable complementarity. Yang Chunyan and Qi Jianhong (2006) analyzed the trade structures of both countries according to the HS classification, proposing that there is quite a potential for the Sino-US agricultural trade, and the two countries should readjust their policies on the basis of reciprocity and mutual benefit for further increasing their agricultural trade. Zhang Lixia and Meng Lingjie (2006) studied the Sino-US agri-trade complementarity according to the SITC classification. Zong Jianliang and Xiong Hao (2007) pointed out that the China-US trade complementarity is strong and becoming stronger. Under the WTO framework of free trade, there is a great potential for further complementarity. Hu Chaolin (2008) made an analysis of the Sino-US trade complementarity according to the SITC classifications, and stated that China and the United States have a strong complementarity of trade, and both countries should stabilize the existing trade policies.

Todate, however, no literature has been found targeting the comparative advantages and complementarity of the Sino-US agricultural trade in comparison of the pre- and post-periods of the China's accession to the WTO from the perspective of specific products.

METHODOLOGY AND DATA

The methodologies adopted in this paper include the Revealed Comparative Advantage Index (RCA), the

Constant Market Share (CMS), the Trade Combining Density Index (TCD), the Export Similarity Index (SI) and the Trade Complementarity Index (TCI). Through the estimation and measurement of the above indicators (1997–2007), this paper intends to find out the characteristics and changing trends of the comparative advantages and complementarity of the Sino-US agricultural trade since 1997 and the differences between the pre- and post-periods of the China's accession to the WTO. The definitions of these methodologies are described below.

Revealed Comparative Advantage Index (RCA)

The Revealed Comparative Advantage Index (RCA) was proposed by Balassa in 1965. It denotes the ratio between the export share of a specific commodity over the total export of commodities of a specific country, and that of a specific commodity over the total export of commodities of the world. If the ratio is > 1, it means that specific commodity of that country has revealed a comparative advantage, and vice versa. The model can be described as:

$$RCA = \frac{E_i / E_t}{W_i / W_t} \tag{1}$$

where RCA is the Revealed Comparative Advantage Index, E_i and E_t are the export value of a commodity of the country i and the total export value of country i respectively; whereas W_i and W_t are the export values of a commodity of the world and the world's total export value during the same period.

Constant Market Share (CMS)

In this paper, we adopted the CMS model revised by Jepma in 1986. The first decomposition of the trade growth is described as:

$$\Delta q = \sum_i \sum_j s_{ij}^0 \Delta Q_{ij} + \sum_i \sum_j Q_{ij}^0 \Delta s_{ij} + \sum \sum \Delta s_{ij} \Delta Q_{ij} \tag{2}$$

<div align="center">Structural   Competitive   Second-order
Effect   Effect   Effect</div>

Trade Combining Density Index (TCD)

The Trade Combining Density Index was first proposed by Brown in 1947, and perfected later by Kojima Kiyoshi and Yamazawa Ippei. The model can be illustrated as:

$$TCD_{ab} = (X_{ab}/X_a)/(M_b/M_w) \tag{4}$$

where TCD_{ab} indicates the trade combining density index between country a and country b, X is exports, M is imports, is the share of country a's exports to country b as against the total export values of country a, (M_b/M_w) is the share of country b's imports from country a as against the total import values that country b imports from the world. If $TCD_{ab} > 1$, it indicates a closer trade relationship between these two countries, and vice versa.

Export Similarity Index (SI)

The Export Similarity Index (SI), first put forward by Finger and Kreinin in 1979, is used to measure the degree of similarity of exports between two countries or regions in the third or world market. The model can be depicted as:

$$SI(ab,n) = \left[\sum \min \left(\frac{X_{an}^k}{X_{an}}, \frac{X_{bn}^k}{X_{bn}} \right) \right] \times 100 \tag{5}$$

where $SI(ab, n)$ is the similarity index of country a and country b's exports in market n or in the world market, X_{an}^k/X_{an} is the share of the commodity k of country a's export in market n as against the country a's total export value in market n, whereas X_{bn}^k/X_{bn} is the share of the commodity k of country b's export in market n as against the country b's total export value in market n. This index varies from 0 to 100. If the exports of both countries in the third country or in the world market (i.e. in market n) are entirely the same, this index is 100; if totally different, it is 0. When the index continues to rise during a specific period, it indicates that country a

Equation (2) can be further decomposed as:

$$\Delta q = s^0 \Delta Q \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_i s_i^0 \Delta Q_i \right) + \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_j s_j^0 \Delta Q_j \right) + \left[\left(\sum_i s_i^0 \Delta Q_i - s^0 \Delta Q \right) - \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_j s_j^0 \Delta Q_j \right) \right]$$

<div align="center">Growth Effect   Market Effect   Commodity Effect   Structural Interaction Effect</div>

$$+ \Delta s Q^0 + \left(\sum_i \sum_j \Delta s_{ij} Q_{ij}^0 - \Delta s Q^0 \right) + \left(Q^1/Q^0 - 1 \right) \sum_i \sum_j \Delta s_{ij} Q_{ij}^0 + \left[\sum_i \sum_j \Delta s_{ij} \Delta Q_{ij} - \left(Q^1/Q^0 - 1 \right) \sum_i \sum_j \Delta s_{ij} Q_{ij}^0 \right] \tag{3}$$

<div align="center">General   Specific Competitive   Pure Second-order   Dynamic Structural Residual Effect
Competitive   Effect   Effect
Effect</div>

and country *b* are getting more and more competitive to each other in the third market (i.e. in market n). When the index keeps going down, however, it shows that the trade of country *a* and country *b* are getting more and more specialized, i.e. more and more complementary.

Trade Complementarity Index (TCI)

The Trade Complementary Index (TCI) was first proposed by Kojima Kiyoshi and perfected by Peter Drysdale in 1967. The model can be described as:

$$C_{ij}^k = RCA_{xi}^k \times RCA_{mj}^k \qquad (6)$$

where C_{ij}^k is the complementarity index between country *i* and country *j* for commodity *k*, RCA_{xi}^k indicates the comparative advantage of country *i* in commodity *k* by way of exports, and RCA_{mj}^k is used to show the comparative disadvantage of country *j* in commodity *k* by way of imports, the equations of which are given below:

$$RCA_{xi}^k = \left(X_i^k / X_i\right)/\left(X_w^k / X_w\right) \qquad (7)$$

$$RCA_{mj}^k = \left(M_j^k / M_j\right)/\left(X_w^k / X_w\right) \qquad (8)$$

where X_i^k and X_w^k are the export value of commodity *k* of country *i* and the world's total respectively; X_i and X_w are the total export values of country *i* and the world; M_i^k is country *j*'s import value of commodity *k* and M_j is the total import value of country *j*. In fact, RCA_{xi}^k is the revealed comparative advantage index proposed by Balassa, and the greater the value, the more comparative advantage that country *i* has in the commodity *k*. Whereas, the greater the value of RCA_{mj}^k, the more commodity *k* that country *j* imports, hence, the more comparative disadvantage that country *j* has in the commodity *k*. When country *i* has a comparative advantage in commodity *k*, for which country *j* has a comparative disadvantage, it means that the two countries have trade complementarity in commodity *k*, the degree of which can be measured by their product C_{ij}^k. If $C_{ij}^k > 1$, it indicates that the two countries have trade complementarity in commodity *k*, and the greater the value, the higher the degrees of complementarity. If $C_{ij}^k < 1$, it means that the complementarity is low, and the smaller that value, the lower the degrees of complementarity.

Equation (6) is the model for the aspect of China exports, where *i* and *j* represent China and the United States respectively. When the agri-trade complementarity of the US export is measured, the model is written as:

$$RCA_{ji}^k = RCA_{xj}^k \times RCA_{mi}^k \qquad (9)$$

This paper has selected a sample of 16 major agricultural products of China and the United States, i.e., wheat, rice, maize, cotton, soybean, vegetables, fruits, sugar, tea, pork, beef, chicken, honey, silkworm cocoon and wool. All data have been derived from the official databases, i.e. the statistical databases of the U.N. Food and Agriculture Organization (FAO), the USDA FAS-Online and the China's General Administration of Customs. Agri-trade data for China exclude those of Hong Kong and Macau. Cross verification and modification of the data have been adopted for the same item from different sources, realizing the consistency and comparability of the dataset used in this research.

RESULTS AND ANALYSES

Comparative advantages of the Sino-US agricultural trade – the RCA approach

In this research, the RCA estimates of 16 major agricultural products of both China and the United States indicate that:

(1) China's labor-intensive agri-products still have high comparative advantages. Looking from the RCA values for 2006, China's labor intensive products still have comparative advantages, such as tea (RCA = 4.83), honey (4.30), vegetables (3.64), silkworm cocoons (3.01) and fruits (1.48); while land intensive products such as maize, soybean, cotton, meats and wool have no comparative advantages. From the perspective of the changing trends, the comparative advantages of vegetables, fruits and tea have been on the rise since 2001, with the RCA values increasing from 2.90, 1.04 and 4.05 in 2001 to 3.64, 1.48 and 4.83 in 2006 respectively. On the other hand, the comparative advantages of silkworm cocoons, honey, maize and rice have been on the decline, with the RCA values changing from 16.79, 7.16, 2.25 and 1.60 in 2001 to 3.01, 4.30, 1.00 and 1.25 in 2006 respectively (see Table 2 and Figure 2).

(2) Comparative advantages exist in America's land-intensive and capital intensive agricultural products. We can find from the RCA values for 2006 that the major US agricultural products that have strong comparative advantages are maize (RCA = 5.57), soybean (4.34), cotton (3.91), chicken (1.99), pork (1.89) and rice (1.23). Maize, rice, soybean and cotton are land intensive while chicken and pork are capital intensive products, which are produced by large scale modern broiler and swine farms. America's labor intensive products such as vegetables, fruits, tea, honey and sugar have no comparative advantages. From the point

Table 2. The RCA of China's major agri-products (1997–2006)

	1997	1998	1999	2000	2001	2002	**2003**	**2004**	**2005**	**2006**
Wheat	0.2114	0.1587	0.1018	0.0920	0.2091	0.2389	0.5655	0.3134	0.2007	0.3683
Rice	1.2149	3.5454	3.0321	2.7959	1.6016	1.8024	2.1571	0.9090	0.7475	1.2501
Maize	2.8766	2.1078	1.8228	3.7657	2.2499	3.6113	4.9328	0.9655	3.1210	1.0000
Cotton	0.0380	0.2673	1.6062	1.3958	0.4097	0.8401	0.4874	0.0732	0.0479	0.0823
Soybean	0.2198	0.2536	0.2858	0.2193	0.2369	0.2177	0.1737	0.3261	0.3425	0.2911
Vegetables	2.8372	2.7921	2.7602	2.7300	2.8963	2.8988	2.8473	3.3343	3.3638	3.6430
Fruits	0.8485	0.8594	0.9001	0.9151	1.0350	1.0258	1.1564	1.3819	1.3118	1.4821
Sugar	0.3882	0.3900	0.2939	0.3138	0.1847	0.2580	0.1022	0.0918	0.2547	0.1064
Tea	4.0272	4.1420	4.5165	3.9181	4.0527	3.7124	4.0703	4.8376	4.4523	4.8282
Pork	0.3062	0.3139	0.0764	0.0470	0.0429	0.1208	0.1240	0.0973	0.1052	0.0911
Beef	0.0167	0.0496	0.0068	0.0016	0.0003	0.0038	0.0002	0.0021	0.0005	0.0003
Mutton	0.0416	0.0724	0.0777	0.0844	0.0639	0.0969	0.2117	0.4111	0.4432	0.5217
Chicken	2.8221	2.5483	2.7226	2.6668	2.2966	1.6571	1.1256	0.5063	0.4967	0.4918
Honey	5.1112	6.8805	6.4882	6.2356	7.1630	3.5449	3.4608	3.7647	4.1510	4.2985
Silkworm	22.4658	14.4290	12.0316	13.7730	16.7869	9.2404	6.3163	10.9255	3.0275	3.0079
Wool	0.3892	0.3195	0.0461	0.0392	0.0319	0.0214	0.0258	0.0381	0.0255	0.0136

Source: calculated by the authors based on data from the FAO Statistical Database (2009)

of view of the RCA trends, the comparative advantages of the US cotton, maize and pork have been increasing since 1997, with the RCA values jumping from 2.14, 3.90 and 1.08 in 1997 to 3.91, 5.57 and 1.89 in 2006. The US soybean and wheat remain stable and slowly on the rise since 2001, with the RCA values slightly increasing from 3.84 and 1.57 in 2001 to 4.34 and 1.90 in 2006 respectively. American rice, however, had no comparative advantages before 2002 (RCA < 1) and has gained some comparative advantages since 2003 (RCA ranging from 1.22 to 1.35). Detailed RCA changing trends of US agricultural products are illustrated in Table 3 and Figure 3).

Competitiveness of China's agri-exports to the US – the CMS approach

In order to analyze the factors explaining the China's agri-export growth and to explore the changing trends of the China's agri-products exporting to the US in the pre- and post-periods of the China's accession to the WTO, we have made quantitative analyses of the above mentioned 16 major products by adopting the Constant Market Share (CMS) model through a comparison of different periods, in an attempt to identify the trends of competitiveness of China's agri-products in the American market.
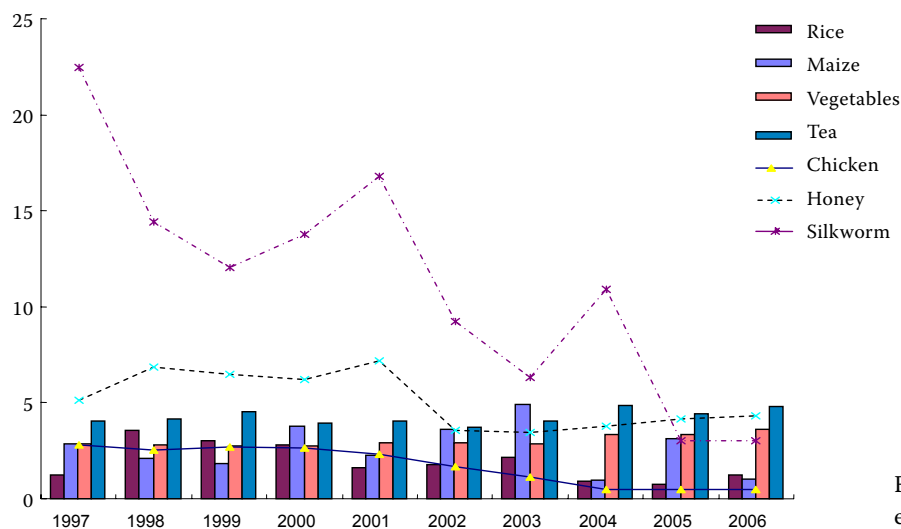

Figure 2. RCA Trends of China's eight agri-products (1997–2006)

Table 3. The RCA of the USA major agri-products (1997–2006)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wheat	1.5576	1.6927	1.8258	1.6102	1.5673	1.7564	1.8925	2.3220	2.2186	1.8981
Rice	0.8764	0.9661	0.9497	0.9362	0.7490	0.9275	1.2184	1.2385	1.3470	1.2326
Maize	3.9017	3.8652	4.6409	3.8830	3.9266	4.1304	3.7618	4.9559	4.5040	5.5663
Cotton	2.1367	2.3279	1.2778	2.0680	2.2633	2.5951	3.2202	3.6917	3.7817	3.9129
Soybean	4.8403	4.1250	4.7169	4.2070	3.8364	4.1561	4.2938	4.0827	4.0115	4.3403
Vegetables	0.7395	0.7797	0.7721	0.7826	0.7183	0.7385	0.6774	0.7254	0.7930	0.6769
Fruits	0.8875	0.8726	0.8893	0.9119	0.9209	0.9575	0.9285	1.0281	1.1170	1.0332
Sugar	0.0361	0.0336	0.0395	0.0328	0.0357	0.0414	0.0327	0.0570	0.0610	0.0782
Tea	0.0460	0.0372	0.0606	0.0618	0.0614	0.0734	0.0821	0.0864	0.0953	0.0698
Pork	1.0776	1.2873	1.2624	1.4679	1.3389	1.4323	1.3893	1.6105	1.9076	1.8948
Beef	0.4356	0.4379	0.6268	0.8867	1.0549	0.9744	1.0949	0.0578	0.1026	0.2088
Mutton	0.0222	0.0277	0.0254	0.0199	0.0240	0.0227	0.0219	0.0332	0.0582	0.0535
Chicken	2.0224	1.9310	1.7316	1.7836	1.7483	1.5879	1.5953	1.9587	2.0292	1.9896
Honey	0.1248	0.1562	0.1623	0.1350	0.1061	0.0783	0.0837	0.0867	0.1019	0.0998
Silkworm	0.1215	0.3081	0.6253	0.3912	0.1452	0.1826	0.3049	0.7075	0.5338	0.3225
Wool	0.0096	0.0096	0.0164	0.0174	0.0149	0.0188	0.0580	0.0700	0.0950	0.1156

Source: calculated by the authors based on data from the FAO Statistical Database (2009)

The whole period for this analysis covers from 1997 to 2006, breaking into two periods, i.e. 1997–2000, and 2001–2006 for the comparison purpose. The export structures of China's agri-products consist of data for the American market and the world market. China entered the WTO in 2001 and it was cutting its tariffs on agri-products ever since. By 2005, the China's average tariffs level was only 15%, and by 2006, China has ended the transition period of its WTO accession. Therefore, China's agri-exports are tested in such two time periods for the CMS model estimation, in order to find out the differences between the period before and that after the China's accession to

the WTO in the agri-export competitiveness in the US and the world over. The CMS model estimation results are given is Table 4.

From the CMS estimation result shown in Table 4, we can conclude the following:

(1) *China has exported more agricultural products after entering the WTO, but the competitiveness of China's agri-trade has reduced sharply.* The CMS results indicate that after the China's accession to the WTO, China's export value of the above-mentioned 16 major products increased considerably: during the period of 1997–2000, its exports went up by 764.437 million US dollars, with and annual increase
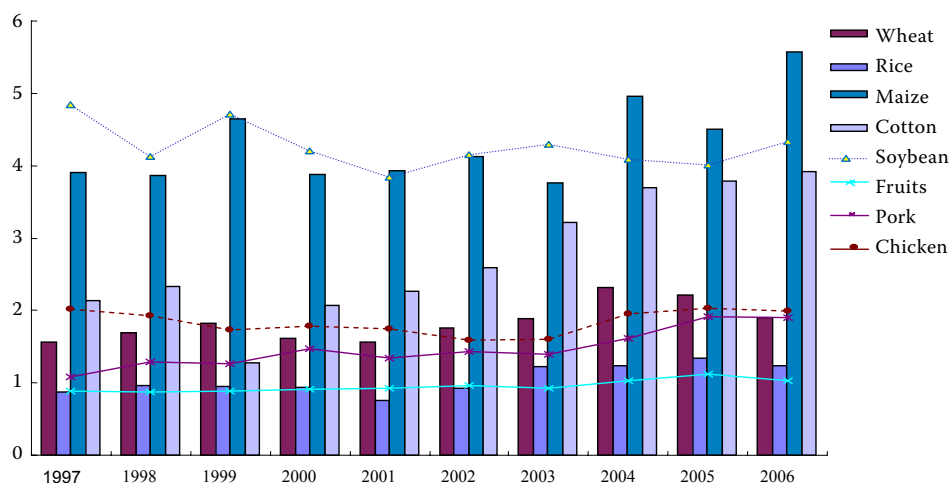

Figure 3. RCA Trends of the USA eight agri-products (1997–2006)

Table 4. CMS decomposition results of China's 16 major agri-products (1997–2006)

	1997–2000		2001–2006	
	value (1000 USD)	(%)	value (1000 USD)	(%)
Export growth	764 437.00	100.00	5 090 069.00	100.00
Total structure effects	−404 529.57	−52.92	4 077 924.98	80.12
growth effect	−735 384.38	−96.20	420 1941.18	82.55
market effect	−20 056.16	−2.62	−7 268.67	−0.14
commodity effect	36 5447.69	47.81	−155 412.02	−3.05
structural interaction effect	−14 536.72	−1.90	38 664.48	0.76
Total competitive effects	1 394 732.24	182.45	431 160.54	8.47
general competitive effect	1 711 175.49	223.85	533 447.74	10.48
specific competitive effect	−316 443.25	−41.40	−10 2287.20	−2.01
Total second-order effects	−225 765.67	−29.53	580 983.48	11.41
pure second-order effect	−172 268.94	−22.54	28 6671.11	5.63
dynamic structural residual	−53496.73	−7.00	294 312.37	5.78
Total	764 437.00	100.00	5 090 069.00	100.00

Source: CMS model estimation by the authors based on data from the FAO, the FAS-Online and the China's General Administration of Customs (2009)

by 4.28%, while in the period of 2001–2006, the export growth of these products reached 5090.069 million US dollars, with an annual increase by 16.11%, almost quadrupling that in the pre-WTO period. After analyzing the factors contributing to China's agri-export growth, however, we have found that during the pre-WTO period (1997–2000), among the total export growth, the share of competitive effects occupied 182.45% and that of the structural effects accounted for −52.92%; whereas in the post-WTO period (2001–2006), the share of competitive effects dropped to 8.47%, and that of the structural effects went up to 80.12%. This means that China's export growth of the above 16 major agri-products was the result of competitiveness in the pre-WTO period; and in the period after the China's WTO accession, 80.12% of China's agri-export growth was the result of the structural effects, of which the share of growth effect reached 82.55%. In other words, the main factor leading to the China's rapid export growth of the said products is the increase of import demands for these products by the US and the rest of the world market. After entering the WTO, the China's rapid export growth of these agri-products has concealed the real effect of decreasing competitiveness.

(2) *China has upgraded its agri-export structure after joining the WTO.* As per the definitions of the CMS model, the specific competitive effect refers to the part of the change in exports that can be attributed to changes in the China's export structure, given an unchanged pattern of the world export. The positive value indicates that the change of the China's export structure has a favorable impact on its export performance; the negative value indicates otherwise. From Table 4, we can see that the share of the specific competitive effect in the export growth increased from −41.40% in the pre-WTO period (1997–2000) to −2.01% in the post-WTO period (2001–2006). This indicates that the China's agri-export structure of the above products has been optimized and rationalized since entering the WTO and China has almost achieved the level of the world average (−2.01% is close to 0).

The CMS model also defines that the pure second-order effect refers to the change in exports due to the interaction of the changes in the China's export share with the changes in the level of the world export, given that the structure of the world demand is unchanged. The positive value shows that the changes of the China's export structure are adaptable to the changes in the level of the world export; the negative indicates otherwise. From Table 4, we understand that the pure second-order effect increased from −22.54% in the pre-WTO period to 5.63% in the post-WTO period. This change shows that the China's changes of the export structure of the said agri-products are getting more and more adaptable to the changes of the import structure for these products in the US and the world markets. All these indicate that China has upgraded its agri-export structure after its accession to the WTO.

Table 5. Trade Combining Density Index of the Sino-US agri-products (1997–2007)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
China exporting to the US	0.2321	0.2909	0.3286	0.3279	0.3323	0.4226	0.3694	0.3730	0.4580	0.5174	0.5369
US exporting to China	1.4897	1.2879	0.8673	1.6075	1.7418	1.6281	3.1084	3.0161	2.6236	2.7284	2.2785

Source: calculated by the authors based on data from China's General Administration of Customs and FAS-Online (2009)

The trade combining density index of the Sino-US agricultural trade

Based on the statistical data from the China's General Administration of Customs and the FAS-Online of the USDA, by adopting the TCD methodology, we analyzed and estimated the agricultural trade combining density index between China and the US for the past 11 years (1997–2007) from two different perspectives, the China's agri-exports to the US and the US agri-exports to China respectively. The sample data used here are the total agri-export values of each country in each year. The results are given in Table 5 and Figure 4.

The above results indicate that:

(1) *The Sino-US agri-trade combining density is on the rise.* The TCD of both countries from the perspective of China exporting to the US increased from 0.2321 in 1997 to 0.5369 in 2007; while the TCD from the perspective of the US exporting to China rose from 1.4897 to 2.2785 during the same period, indicating that the mutual dependency on agri-trade of both countries has been rising. The results also show that there is a tendency of rising more quickly after the China's accession to the WTO.

(2) *The degree of dependency of American agri-products on Chinese market is much higher than that of Chinese agri-products on the US market.* From Table 5, we understand that the US agri-TCD indexes with China are always > 1, and > 2 (> 3 in 2003 and 2004);

whereas the China's agri-TCD indexes with the US are always < 1.

This means that the American agri-exports are depending more and more on the Chinese market, while the China's agricultural products have a much lower, despite its slight increase, dependency on the US market.

The Export Similarity Index of the Sino-US agricultural products

Based on the FAO statistical data, by adopting the SI methodology, this paper has analyzed and estimated the Sino-US agri-product export similarity index in the world market in the period of 1997–2006, and the results are illustrated in Figure 5.

The results indicate that:

(1) *Agricultural products of China and the United States have good complementarity in the world market.* During the period from 1997 to 2006, the export similarity indexes of the China's and the United States agricultural products in the world market are low, ranging between 21 and 30. This means that the agri-exports of the two countries have a high level of specialization in the world market, hence, a good complementarity.

(2) *The agri-export structures of China and the United States have shifted after the China's accession to the WTO.* Prior to the China's accession to the WTO, the agri-exports of both countries were getting more and more competitive to each other in
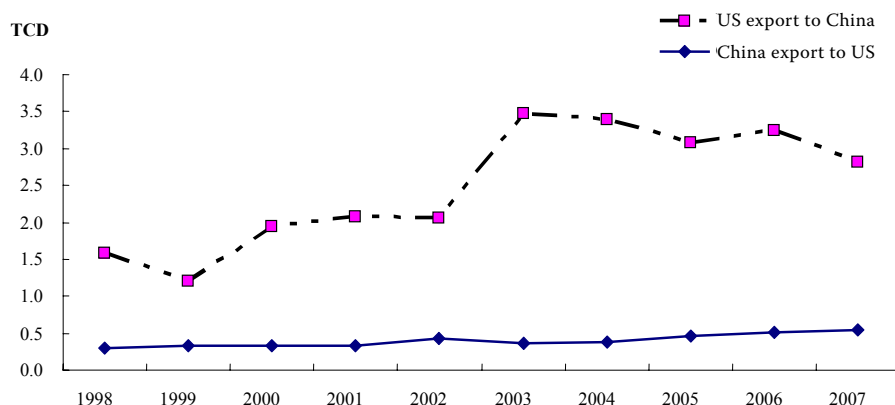

Figure 4. Sino-US Agri-Trade Combining Density Indexes (1997–2007)
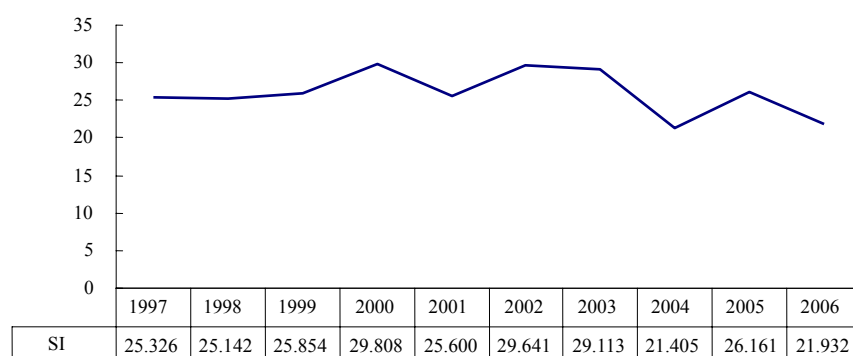
Export Similarity Index (SI)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
SI	25.326	25.142	25.854	29.808	25.600	29.641	29.113	21.405	26.161	21.932

the world market, and after China joined the WTO, their agri-exports to the world market are becoming more and more complementary in general. The results show that the Sino-US agri-export similarity index (SI) increased from 25.33 in 1997 to 29.81 in 2000, indicating that the agri-export structures in the world market of the two countries were changing towards being more and more similar, hence, getting more and more competitive to each other. Beginning from 2002, however, their SI has dropped from 29.64 in 2002 to 21.93 in 2006, with slight ups and downs but on the downward trend in general. This indicates that after the China's accession to the WTO, the agri-export structures of the two countries in the world market are becoming more and more

different, pointing to a general downward trend of competitiveness and upward trend of complementarity. This further implies that China and the United States have readjusted their agri-export structures and their division of the market share in the world market is on the right track towards maximizing each country's own resource endowments and comparative advantages.

The Sino-US agricultural Trade Complementarity Index

By adopting the TCI methodology, based on the FAO statistical data, we have analyzed and estimated

Table 6. The TCI of the Sino-US agri-trade (China exports to the World)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wheat	0.0485	0.0328	0.0202	0.0156	0.0421	0.0459	0.0679	0.0366	0.0266	0.0686
Rice	0.4104	0.7885	0.8053	0.8258	0.4191	0.4321	0.7196	0.2928	0.1829	0.4026
Maize	0.3570	0.4049	0.3513	0.6840	0.3409	0.4925	0.7374	0.1167	0.3737	0.1443
Cotton	0.0013	0.0094	0.4051	0.0721	0.0182	0.0393	0.0192	0.0024	0.0014	0.0017
Soybean	0.0198	0.0168	0.0117	0.0081	0.0072	0.0055	0.0056	0.0130	0.0147	0.0108
Vegetables	3.6414	3.8591	3.5355	3.6900	4.0040	3.8077	3.9602	4.7971	4.6263	4.8698
Fruits	1.2779	1.2325	1.3791	1.3779	1.5297	1.3642	1.6628	1.9894	1.7435	1.9544
Sugar	0.3723	0.2692	0.1816	0.1789	0.0904	0.1419	0.0588	0.0491	0.1617	0.0763
Tea	0.0174	0.0149	0.0181	0.0142	0.0153	0.0147	0.0157	0.0173	0.0155	0.0159
Pork	0.2608	0.2704	0.0650	0.0491	0.0442	0.1296	0.1349	0.0994	0.0990	0.0708
Beef	0.0113	0.0283	0.0041	0.0010	0.0003	0.0028	0.0000	0.0004	0.0001	0.0001
Mutton	0.0312	0.0706	0.0757	0.0867	0.0695	0.1079	0.2577	0.5300	0.5817	0.6308
Chicken	0.0336	0.0346	0.0450	0.0450	0.0609	0.0600	0.0409	0.0318	0.0263	0.0372
Honey	15.4332	12.8057	13.3570	12.5039	11.4624	8.2731	7.8300	6.6069	7.8343	9.7959
Silkworm	19.4971	14.8516	14.9267	13.6677	32.7741	23.4427	19.0150	49.5943	15.3227	13.9880
Wool	0.1982	0.1998	0.0160	0.0096	0.0060	0.0022	0.0032	0.0035	0.0020	0.0012

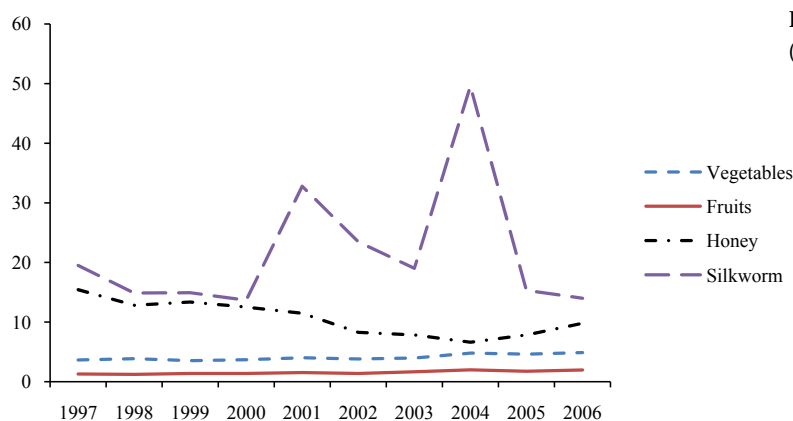Source: calculated by the authors based on data from the FAO database (2009)

Figure 6. The TCI of Sino-US Agri-Trade (China Exports to the World) (1997–2006)

the trade complementarity index of the two countries' 16 major agricultural products during the period of 1997–2006 from two aspects: China exports to the world market and the US exports to the world market respectively. The results are shown in Table 6 and 7, Figure 6 and 7.

From these results, we have found that:

(1) *The major agricultural products of China and the United States have strong trade complementarity.* From the point of view of the US exporting to the world, the following products have high complementarity indexes (TCI > 1): soybean, cotton, maize, chicken and wool, with their TCI indexes in 2006 being 41.70, 33.08, 6.15, 2.02 and 1.29 respectively. Observing from

the angle of China exporting to the world, silkworm cocoon, honey, vegetables and fruits have high complementarity indexes (TCI > 1), with their TCI in 2006 being 13.99, 9.80, 4.87 and 1.95 respectively.

(2) *The changing trends of the TCI indexes vary greatly.* During 1997–2006, the TCI of the following products were on the rise: soybean (from 20.43 in 1997 to 41.70 in 2006), cotton (from 3.19 in 1999 to 33.08 in 2006), vegetables (from 3.64 in 1997 to 4.87 in 2006), wool (from 0.05 in 1997 to 1.29 in 2006) and fruits (from 1.28 in 1997 to 1.95 in 2006); whereas the TCI of the following products were declining: honey (from 15.43 in 1997 to 9.80 in 2006), maize (from 9.08 in 1997 to 6.15 in 2006), chicken (from

Table 7. The TCI of the Sino-US agri-trade (US exports to the World)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wheat	1.2648	1.5480	1.0230	0.9708	0.8229	0.8782	0.7369	3.7588	2.2785	0.5550
Rice	0.4476	0.4024	0.3106	0.4429	0.2727	0.4210	0.5587	0.7974	0.6066	0.7539
Maize	9.0755	8.9025	9.5879	6.6699	7.5255	6.7930	5.1614	6.3650	5.6530	6.1515
Cotton	12.1674	8.1384	3.1912	3.7351	3.8048	5.9692	12.0956	21.8740	24.7686	33.0829
Soybean	20.4282	20.0085	28.5505	33.9111	31.5813	31.9836	37.5128	37.1702	42.1514	41.6957
Vegetables	0.1352	0.1763	0.1986	0.1904	0.2530	0.2351	0.1674	0.1914	0.2483	0.2357
Fruits	0.4272	0.4647	0.4933	0.4986	0.4850	0.5086	0.3981	0.3709	0.4338	0.3963
Sugar	0.0233	0.0182	0.0170	0.0195	0.0356	0.0348	0.0181	0.0358	0.0442	0.0587
Tea	0.0048	0.0046	0.0108	0.0099	0.0115	0.0139	0.0143	0.0126	0.0158	0.0134
Pork	0.0119	0.0718	0.0675	0.2484	0.0204	0.0243	0.0454	0.0500	0.0427	0.0000
Beef	0.0468	0.0461	0.0933	0.1111	0.2277	0.1465	0.1665	0.0048	0.0076	0.0049
Mutton	0.0119	0.0179	0.0193	0.0125	0.0171	0.0203	0.0144	0.0189	0.0363	0.0309
Chicken	1.0486	1.0449	3.4535	3.4507	2.4388	2.5056	1.9263	0.7850	1.5006	2.0216
Honey	0.0183	0.0233	0.0339	0.0236	0.0121	0.0083	0.0062	0.0060	0.0105	0.0077
Silkworm	0.6878	1.4434	3.0980	1.3624	1.8482	0.8206	0.7422	1.9366	1.4326	1.3067
Wool	0.0539	0.0832	0.1936	0.2195	0.1993	0.2430	0.5661	0.6948	1.1305	1.2893

Source: calculated by the authors based on data from the FAO database (2009)
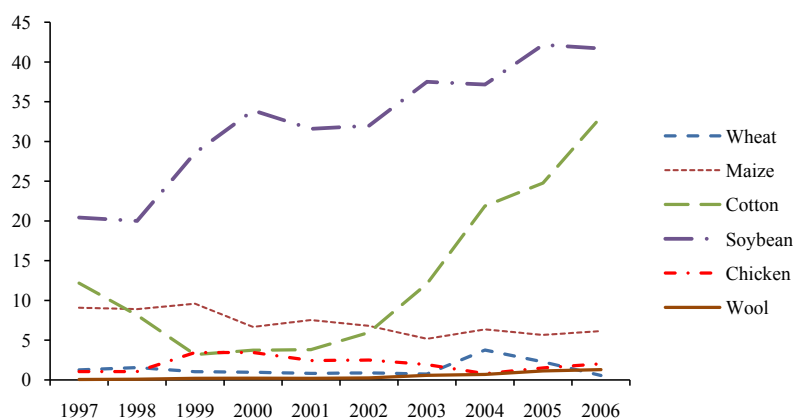
Figure 7. The TCI of Sino-US Agri-Trade (US Exports to the World) (1997–2006)

3.45 in 1999 to 2.02 in 2006) and silkworm cocoons (from 32.77 in 2001 to 13.99 in 2006).

(3) *The United States' land intensive and capital intensive agri-products have high complementarity with China, and China's labor intensive agri-products have high complementarity with the United States.* This explains in a different perspective that both countries have different fundamental characteristics of resource endowments and agricultural trade of each country has its own comparative advantages.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

Based on the above analyses, we can conclude the following:

(1) *China and the United States export different agricultural products, which reflect the characteristics of the comparative advantages and resource endowments of each country.* China's labor intensive products and America's land and capital intensive products still maintain strong comparative advantages. After China entered the WTO, China's fruits, vegetables, tea, honey and sugar have increased their exports to the United States; while the United States have exported more and more soybean, cotton, maize and wool to China. The products that China has strong comparative advantages are tea (RCA = 4.83), honey (4.30), vegetables (3.64), silkworm cocoons (3.01) and fruits (1.48); while those that the United States has strong comparative advantages are maize (5.57), soybean (4.34), cotton (3.91), chicken (1.99), pork (1.89) and rice (1.23).

(2) *The international competitiveness for the China's agri-products appears to be on a downward trend, while the China's agri-export structure has been upgraded since China entered the WTO.* The CMS model simulation results show that after the China's

accession to the WTO, the export growth of 16 major agri-products is mainly the result of the increase of the demands for these products from the U.S. and the world markets. The China's rapid growth of agri-exports has concealed the fact that the international competitiveness of China's agri-products is declining (the competitive effect dropped from 182.45% to 8.47% between the pre-WTO and post-WTO periods). The results also indicate, however, that the China's agri-export structure has been improved, changing towards the direction more adaptable to the changes of the demand structures of the U.S. and the world for these products.

(3) *The Sino-US agri-trade dependency is on the rise, and the degree of dependency of the American agri-products on the Chinese market is much higher than that of the China's agri-products on the U.S. market.* Observing from the TCD indexes, we understand that the TCD between China and the United States from the perspective of China exporting to the U.S. increased from 0.2321 in 1997 to 0.5369 in 2007; while the TCD from the perspective of the U.S. exporting to China rose from 1.4897 to 2.2785 during the same period, indicating that the mutual dependency on the agri-trade of both countries has been rising. The American TCD with China for its agri-trade is always greater than 1, and reached 2 or even 3 in some years, while the China's TCD with the U.S. is always below 1, showing that the U.S. relies more on the Chinese market than China does on the American market for their agri-exports.

(4) *China and the United States have good complementarity for their agricultural trade, which tends to consolidate after the China's accession to the WTO.* First, agricultural products of the two countries appear to be more complementary than competitive in the world market. During the period of 1997–2006, the export similarity indexes for the Sino-US agri-trade ranged between 21 and 30, indicating that there is a high level of specialization for the China's and US'

agricultural exports in the world market. Second, the agricultural export structures of the two countries have shifted from more competitive to more complementary after the China's accession to the WTO. The Sino-US agri-export SI indexes kept rising before 2000, and showed a downward trend in general since 2002, indicating that China and the United States have become more complementary than competitive for their agricultural exports since China entered the WTO, and their agri-export structures have been evolving towards the direction of maximizing the resource endowments and comparative advantages of each country for its agricultural exports.

Policy implications

The following policy implications are thereby proposed based on the above conclusions:

(1) *Both China and the United States should positively push the global free trade process to facilitate the economic recovery of all countries in the world including China and the United States.* The analyses indicate that under the WTO free trade framework, China has played a promoting role in agricultural exports for both China and the U.S. Therefore, under the current circumstances of the world financial crisis and the global economic downturn, China and the United States, both as big agri-product traders in the world, should strongly advocate trade liberalization and oppose trade protectionism, in an effort to reach the agreement of the Doha Round of the WTO free trade negotiations as soon as possible for the formation of a global free trade mechanism, for the benefit of all countries, especially for the developing countries, and the recovery of the world economy.

(2) *Both China and the United States should utilize each country's comparative advantages and further strengthen the agri-trade complementarity between them.* China and the United States should fully utilize the comparative advantages based on the resource endowments of each country, in an attempt to realize the win-win situation of complementary and the mutual benefit for the agricultural trade of both countries. More specifically, China should continue to produce and export labor intensive products such as fruits, vegetables, tea, honey, sugar and silkworms, and develop processing industries for these labor intensive products. The United States should further reinforce their dominant position for their land intensive and capital intensive products, in order to maintain their leading role worldwide in producing and exporting such agricultural products as soybean, cotton, maize, wool, chicken and pork etc. Only when they actively readjust their agricultural structures according to the

resource endowments of each country, will China and the United States be able to realize a higher level of agri-trade complementarity and a win-win situation for further development.

(3) *China should adopt positive measures to further increase the international competitiveness of its agricultural products.* Despite the fact that China's agri-exports have grown faster than ever after its WTO accession, the international competitiveness of the China's exporting agricultural products is on a downward trend. Therefore, China should continue to expand its agri-exports on the one hand, and take positive measures to enhance the international competitiveness of its agri-exports on the other. These measures include: continuing to strengthen the support for agriculture, encouraging agri-exports by adopting export facilitating policies, strengthening agri-product quality supervision from the field to the table, fostering brands for export products, and advocating intensive agri-business on a moderate scale to achieve the economy of scale in agricultural production, processing and trade.

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Contact address:

Chuanmin SHUAI, School of Economics and Management, China University of Geosciences (Wuhan), 388 Lumo Road, Hongshan, Wuhan 430074, China; e-mail: shuaicharm@gmail.com