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Abstract

Using Chinese agricultural and resources data and an adaptation of the Heckscher-Ohlin-Vanek (HOV) international trade model, this paper projects what Chinese trade, production, and consumption patterns would be if China allowed the laws of comparative advantage to direct production and trade decisions. This work is motivated by the fact that current production and consumption patterns in China are likely very different from those that would exist under complete liberalization. Any econometric-based model must use current production patterns as a base against which policy changes can be evaluated; however, the greater role of market forces following trade liberalization may render the conclusions of the econometric model invalid.

Key words: Agricultural trade, Chinese agriculture, comparative advantage, Heckscher-Ohlin-Vanek model.

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Introduction

The gradual liberalization of sectors of the Chinese economy, and the associated growth in the income of Chinese consumers in recent years, has created interest in how China will influence world agricultural markets should it decide to liberalize its food sector. The existing work on this topic is based on partial equilibrium econometric analyses, or on general equilibrium computable analyses. (Rosengrant et al.; Huang et al.; USDA/ERS 1994; the Overseas Economic Cooperation Funds of Japan (OECF); Mitchell and Ingco; Johnson 1994, 1995; Crook; Alexandratos; Wang; Anderson). This work is useful for analyzing policy changes such as the likely impact of Chinese accession to the World Trade Organization (WTO) and, in short, for medium term forecasting. However, both methods implicitly assume that current production patterns are optimal. For example in either approach an increase in the farm price of a commodity will *ceteris paribus* lead to an increase in output of that commodity. These methods may not predict well if the crop is grown to meet a production target, or if the farmer is coerced into an acreage allocation that is sub-optimal. A similar problem emerges if local officials dictate consumption patterns, or if trade restrictions ensure zero consumption of some products. The existing research is also dependent on the quality of the data on production and consumption patterns. Yet recent work has shown that Chinese meat consumption data may be exaggerated by an amount that is greater than the combined output of the United States and the European Union (EU) (Fuller et al.).

The purpose of this research is to get a sense of the degree to which current consumption, production, and trade patterns in Chinese agriculture deviate from optimal levels. We arrive at our estimate of the optimal levels by means of the Chinese resource base and an application of the laws of comparative advantage as described in the Heckscher-Ohlin-Vanek (HOV) equations. The methodology we use is based heavily on Leamer (1980, 1984), and Bowen, Leamer, and Sveikauskas. However, we make two important changes to the basic HOV model. First we invert the HOV to understand forces driving *future* trade patterns rather than use actual trade data to test the HOV model. Second, we make some additional assumptions to allow us to focus on disaggregated agricultural products as was done in Hayes et al.

The results we present are not forecasts; nor, given the particularly restrictive assumptions we use, are the quantity changes likely. What the results do show are the type of products China will emphasize should it liberalize. Our results also give a sense of the enormous trade impact such a move would have, and how sensitive these trade patterns will be to changes in capital availability. And, they support the observation that Chinese agriculture is land scarce and labor intensive.

Methodology

One of the oldest propositions of standard trade theory is that when a country moves from autarky to a trading regime it will export goods in which it has a lower relative marginal cost of production prior to trade. In other words, a country tends to export goods in which it has a comparative cost advantage in production and import goods in which it has a comparative disadvantage. A country's comparative advantage may arise from differences across countries in consumer preferences, technology, and factor abundance. As Dixit and Norman point out, differences in consumer preferences are most relevant when analyzing trade in markets exhibiting imperfect competition and having differentiated products. Differences in production technology are the heart of the Ricardian trade model, the model first used to illustrate the theory of comparative advantage; however, analysis of the relationship between factor abundance and comparative advantage has proven most insightful in understanding trade patterns. In particular, the factor-abundance hypothesis states that a country will tend to export goods that use intensively the productive factors that are abundant in that country relative to its trading partners. This paper employs the factor-abundance hypothesis and several of the propositions that are associated with the HOV trade model to analyze China's comparative advantage in agricultural trade.

The general HOV model assumes that all commodities can be separated into one of two categories, goods (**Q**) and productive factors (**V**). We assume that all goods are traded and that all factors are non-tradable. The production technology describes the feasible set of output and factor combinations (**Q**,**V**). We assume that all countries have costless access to the same production technology and that this technology exhibits constant returns to scale and diminishing marginal products. Both factor and final good markets are assumed clear competitively, implying full employment of productive factors. Given a set of prices for traded goods (**P**) a country determines its optimal production vector by maximizing total revenue (**P•Q**) over the set of feasible factor and output combinations. The revenue maximization problem is dual to the minimization of unit costs, given input prices (**W**), resulting in a matrix of optimal unit input requirements (**A**). If **Q** and **V** are both non-negative, n-dimensional vectors, and if the columns of **A** span the n-dimensional space over which technology is defined, **A** can be inverted, and the revenue maximizing equilibrium output can be described as in Equation (1).

$$\mathbf{T} = \mathbf{T}^{-1}\mathbf{V} \tag{1}$$

Consumer preferences in all countries are assumed to be identical. Moreover, consumers choose a bundle of goods (**C**) that maximizes their utility defined by a homothetic utility function. Initially we assume that the total value of consumption is equal to the country's value of production, constraining the trade balance to equal zero. Later, we relax this assumption. In a free-trade equilibrium, all consumers face the same vector of output prices, so identical homothetic preferences imply each country consumes goods in the same proportion. If we assume further that the factor endowments for each country are sufficiently similar to equalize factor prices across countries,[1] a country's consumption vector can be expressed in terms of its share of global consumption (*s*) and the global endowment of productive factors ($\mathbf{V}^{w}$) as in Equation (2).

$$\mathbf{T} = s\mathbf{T}^{w} = s\mathbf{T}^{-1}\mathbf{V}^{w} \tag{2}$$

Net trade for each country (**T**) is defined as the difference between production and consumption. We can obtain an expression for trade in terms of factor endowments in Equation (3) by combining Equations (1) and (2).

$$\mathbf{T} = \mathbf{T} - \mathbf{T} = \mathbf{T}^{-1}\left(\mathbf{V} - s\mathbf{V}^{w}\right) \tag{3}$$

Given an efficient technological specification embodied in the unit input requirement matrix, we can use Equation (3) to find the trade vector for China that is consistent with its factor endowments and, hence, its comparative advantage.

There are several difficulties associated with utilizing this approach to project Chinese agricultural trade patterns. First, the model is formulated in a general equilibrium context, encompassing all goods and productive factors in the Chinese and global economies. A tremendous amount of data is required to construct the **Q** and **V** vectors for China and the world. Second, invertibility of the input requirement matrix requires an equal number of goods and productive factors. Consequently, a direct application of Equation (3) would limit the analysis of the agricultural sector to a very small set of broad aggregates, decreasing the level of detail in the results. Third, a suitable technology must be defined that is consistent with the assumption of an efficient resource allocation through a competitive market system. Although the Chinese economy has become increasingly market orientated over the last two decades, socialist planning objectives continue to influence current Chinese production levels, particularly in the agricultural sector.

We adopt a number of additional assumptions to overcome the difficulties described above. First, we limit the scope of the analysis to agricultural commodities by assuming that the vector of outputs contains only agricultural goods. Likewise, we restrict the endowment of factors to those factors used in agricultural production. Essentially, we assume the agricultural sector is isolated from the rest of the Chinese economy.[2] Second, we limit the data requirements further by using Equation (3) to solve for the global endowment of productive factors in terms of the endowment and trade vector for a particular country, namely the United States. This gives us $\mathbf{V}^{g} = {}^{1}\!/\!_{g^{US}}\left(\mathbf{V}^{US} - \mathbf{AT}\right)$. Substituting the result back into the expression for the Chinese trade vector yields Equation (4), which defines Chinese agricultural trade as a function of differences between U.S. and Chinese factor endowments and income.

$$\mathbf{T}^{gg} = \mathbf{A}^{-1}\left(\mathbf{A}^{gg} - g\mathbf{A}^{US}\right) - g\mathbf{T}^{US}, \text{ where } g = g^{gg}\!/\!_{g^{US}}. \tag{4}$$

This derivation assumes that after liberalization the United States and China have identical technologies because they face the same factor prices and output prices. Thus, it is sufficient to gather data on Chinese and U.S. production, net trade, prices of agricultural products, and the use of primary inputs in the agricultural sector. Finally, we assume that the technology currently used by U.S. agricultural producers is representative of efficient input requirements generated in a competitive market economy.

Data, Commodity Aggregations, and Input Requirements

U.S. Factor Endowments and Agricultural Product Supply and Demand

Productive factors in agriculture were aggregated into nine broad categories: subtropical land, temperate continental land, semi-arid land, pasture, labor, capital, fertilizer, pesticides, and fuel. While this list of inputs is not complete it does include the most important productive factors of land, labor, and capital. Moreover, land, which is particularly important to agricultural production, is differentiated by climate to identify comparative advantage in crop production associated with relative endowments of particular land types. Labor was not differentiated into skilled and unskilled labor because compatible data for these variables was not available for both the United States and China.

Major World Crop Areas and Climatic Profiles (USDA 1994) was used to identify the land type that is predominant in each state of the United States. Though several states fall in more than one climatic region, each state was placed in the climatic category that encompassed more than half of its land area. The U.S. endowment of subtropical, temperate continental, and semi-arid land was calculated by summing the 1995 cropland area harvested for each state within the climatic categories. Table 1 shows the breakdown of states and harvested area. The U.S. endowment of pasture land is the sum of grassland and nonforest pasture across all states. U.S. crop and pasture area was obtained from *Agricultural Statistics (AS) 1997* (USDA/NASS).

U.S. agricultural labor and capital were also obtained from *AS.* The agricultural labor endowment is the total number of hired and unpaid labor involved in agriculture in 1995, and agricultural capital is the value of farm machinery and vehicles. U.S. use of fertilizer in 1995 was obtained from *Agricultural Resources and Environmental Indicators* (USDA/NRED). The U.S. Department of Agriculture reports pesticide use by crop in annual agricultural chemical usage summaries, and these data were used to compute U.S. aggregate pesticide use.[3] Finally, U.S. agricultural fuel consumption was computed from the total value of fuel and oil used in agriculture reported in *AS.* The value was converted into gallons using the annual average price of diesel fuel. Fuel use was converted into metric tons at a rate of 3.093 kg/gal (0.8171 g/ml), which is the weight per volume conversion of diesel fuel at 25 degrees Celsius.

Agricultural products were aggregated into nine commodity groups: rice, wheat, other grains (coarse grains and tubers), oilseeds, cotton, cash crops (tobacco and sugar), fruits and vegetables, swine and poultry (including eggs), and other livestock (beef, milk and milk equivalent of dairy products,[4] mutton, and wool). U.S. production figures for 1995 were obtained from *Agricultural Statistics 1997* and converted into metric units. U.S. consumption was calculated as domestic disappearance by subtracting net exports from total production. U.S. trade statistics were obtained from the U.S. Department of Agriculture's *1999 Production, Supply, and Distribution (PS&D)* data set and *Foreign Agricultural Trade of the United States* (1996).

All factors and outputs, except capital, are expressed in quantity terms; however, it is useful for cross-commodity and trade comparisons to measure inputs and outputs in value terms. U.S. agricultural statistics report output levels in both quantity and value terms, so unit values were easily calculated. Likewise, fertilizer, pesticides, and fuel use are also reported in value and volume terms. The value of agricultural labor was calculated as the sum of net farm income and payments for hired labor. Computing the value of agricultural land was more complicated. U.S. Department of Agriculture estimates of state-level cash rents for non-irrigated crop and pastureland[5] were deflated by the commodity production price index and averaged over the 1990–1994 period. The average real rental rate was re-inflated to the 1995 price level. This average nominal rental rate was multiplied by the cropland and pastureland area in each state and summed to form the climatic group land value. The total value for each land type was divided by area to arrive at the unit value for each land type.

Table 1. U.S. land endowment by climate and state in 1000 hectares

State	Area Harvested	State	Area Harvested
Subtropical (Land I)		**Temperate Continental (Land II)**	
Alabama	870.9		
Arkansas	3062.0	Connecticut	57.5
California	3244.5	Delaware	187.8
Florida	991.9	Illinois	9313.0
Georgia	1585.6	Indiana	4749.2
Hawaii	55.0	Iowa	9475.6
Louisiana	1666.6	Kansas	10203.7
Mississippi	1940.1	Kentucky	2014.2
North Carolina	1746.3	Maine	165.9
Oklahoma	4045.4	Maryland	599.0
South Carolina	770.1	Massachusetts	69.2
Tennessee	1672.6	Michigan	2860.4
Texas	8731.0	Minnesota	7880.3
Total	**30382.0**	Missouri	5070.5
		Nebraska	7862.5
Semi-Arid (Land III)		New Hampshire	44.1
Alaska	11.3	New Jersey	196.3
Arizona	388.9	New York	1366.7
Colorado	3378.4	North Dakota	9892.5
Idaho	1942.2	Ohio	4064.4
Montana	5641.9	Pennsylvania	1620.4
Nevada	193.4	Rhode Island	7.7
New Mexico	527.3	South Dakota	6255.9
Oregon	1505.5	Vermont	165.1
Utah	486.4	Virginia	1036.8
Washington	2630.6	West Virginia	260.6
Wyoming	802.9	Wisconsin	3297.5
Total	**17508.9**	**Total**	**88716.7**

Chinese Factor Endowments and Agricultural Product Supply and Demand

China's agricultural land endowment was broken into the four land types according to climatic conditions in each province. Sown area data at the provincial level were obtained from the *China Statistical Yearbook (CSY)* (China State Statistical Bureau 1998). Area from provinces within each climatic group were added together to obtain China's total endowment of each land type. Sown area was used rather than arable land to avoid problems associated with the multi-cropping practices in China. Table 2 displays the breakdown of Chinese agricultural land by climatic group and province. China's endowment of pastureland is the total useable grassland reported in the *CSY*.

China's agricultural labor endowment is the 1995 agricultural labor force reported in the *CSY.* China's agricultural capital endowment was estimated from the value of agricultural machinery and vehicles owned by rural households. Household-level data reported in the *CSY* was multiplied by the number of rural households to obtain the national total value of machinery owned by households. The value of machinery owned by state farms is not reported, but the number of machines and vehicles is available. Using this data, the shares of all farm machinery and vehicles owned by state farms and households were computed. The value of machinery and vehicles owned by households was divided by the share of machinery owned by rural households to obtain an estimate of the total value of China's stock of farm machinery and vehicles in 1995. Fertilizer use and agricultural petroleum consumption reported in the *CSY* were used as China's endowments of fertilizer and fuel. Pesticide use was obtained from the *Rural Statistical Yearbook of China (RSYC)* (China State Statistical Bureau 1996).

China's agricultural production for 1995 was obtained from the *CSY* and *RSYC.* Outputs were aggregated into the nine commodity groups described above. China's net exports for all commodities except wool, fruits and vegetables, and tobacco were taken from the *PS&D* data set. Trade in other commodities was found in the *CSY.* Chinese consumption of agricultural commodities in the base year was computed by subtracting net exports from total production. Given our assumption that the law of one price and the factor price equalization theorem hold in our analysis, Chinese outputs and inputs, except capital, are valued at the U.S. unit values described above. Table 3 displays the 1995 factor endowments, production, and trade vectors and unit values for the United States and China.

Table 2. Chinese land endowment by climate and province in 1000 hectares

Province	Sown Area	Province	Sown Area
Subtropical (Land I)		**Temperate Continental (Land II)**	
Anhui	8354.2	Beijing	553.2
Fujian	2835.1	Hebei	8720.1
Guangdong	5304.3	Heilongjiang	8647.4
Guangxi	5745.7	Henan	12136.8
Guizhou	4203.1	Jilin	4059.8
Hainan	870	Liaoning	3623.7
Hubei	7413.7	Shaanxi	4496.9
Hunan	7840.4	Shandong	10837.3
Jiangsu	7909	Tianjin	572.7
Jiangxi	5950.6	**Total**	**53647.9**
Shanghai	542.1		
Sichuan	12838.8	**Semi-Arid (Land III)**	
Yunnan	4958.9	Gansu	3773.3
Zhejiang	3923	Nei Monggol	5079.4
Total	**78688.9**	Ningxia	956
		Qinghai	568.8
		Shanxi	**3895.6**
		Xinjiang	3050.2
		Xizang	219.3
		Total	**17542.6**

Table 3. Base year factor endowments, production, trade, and unit values

	Million Units	United States	China	Unit Value in U.S. Dollars
Factors				
Land I	Hectares	30.38	78.69	130.99
Land II	Hectares	88.72	53.65	156.12
Land III	Hectares	17.51	17.54	93.81
Land IV	Hectares	239.26	313.33	26.53
Labor	Workers	2.84	323.35	18022.82
Capital	U.S. Dollars	86900.00	34852.81	
Fertilizer	Metric Tons	45.99	35.94	218.16
Pesticides	Metric Tons	0.28	1.09	27099.86
Fuel	Metric Tons	22.81	12.03	249.29
Production				
Rice	Metric Tons	7.89	185.23	201.26
Wheat	Metric Tons	59.40	102.21	164.76
Other Grains	Metric Tons	230.14	161.31	130.56
Oilseeds	Metric Tons	69.03	40.38	256.96
Cotton	Metric Tons	3.90	4.77	1687.03
Cash Crops	Metric Tons	7.77	8.61	551.45
Fruits & Vegetables	Metric Tons	42.64	303.04	392.52
Swine & Poultry	Metric Tons	34.41	62.60	823.25
Other Livestock	Metric Tons	90.28	12.21	503.38
Net Exports				
Rice	Metric Tons	0.49	-0.6	
Wheat	Metric Tons	5.26	-12.0	
Other Grains	Metric Tons	7.85	2.8	
Oilseeds	Metric Tons	7.60	-11.91	
Cotton	Metric Tons	2.67	-0.72	
Cash Crops	Metric Tons	0.67	0.47	
Fruits & Vegetables	Metric Tons	-0.08	1.98	
Swine & Poultry	Metric Tons	1.46	0.11	
Other Livestock	Metric Tons	1.89	-0.35	

Input Requirements

The input requirement matrix ($\mathbf{A}^{-1}$) embodies the cost minimizing mix of inputs per unit of output for a given set of output and factor prices. We assume that agricultural input and output markets in the United States more closely resemble the undistorted, competitive markets that underlie the theoretical model than Chinese markets. Moreover, our assumptions regarding factor price equalization, technology transfer, and output prices enable us to use the U.S. input requirement matrix as the common technology for U.S. and Chinese agricultural output.

The input requirement matrix was primarily constructed from U.S. output and area data and cost of production estimates published by the U.S. Department of Agriculture.[6] Land input requirements for crops were computed by multiplying the inverse of the average yield in each climatic region by that region's share of total crop production. Pastureland is only used in production of "other livestock," so the unit input requirement was computed as total pasture divided by total output. Other input requirements were derived from each input's share of total cost multiplied by ratio of the output and input prices. Since several of the outputs in the analysis are aggregates of a number of commodities, the aggregate input cost share was computed from the weighted average of input cost shares of the individual commodities. Each commodities' share of total aggregate production was used to weight the input cost shares in computing the aggregate input cost share. Feed demands were computed using feed consumption data and per unit feed requirements reported in *AS.* Table 4 shows the input requirement matrix used to derive the results discussed below.

Analysis and Results

We assess China's comparative advantage in the agricultural sector by computing its production, consumption, and trade vectors given the price and technology assumptions of the model. Production levels are determined as the revenue maximizing output subject to feasibility constraints. This linear optimization problem is programmed in Microsoft Excel. Chinese consumption is computed using the assumption of identical and homothetic preferences. Chinese consumers purchase a proportion of the U.S. consumption vector that is determined by the relative incomes of consumers in the two countries.

Our measure of income is gross agricultural revenue per person involved in the farm sector. Implicit in the selection of this measure of income is the assumption that as the technology embodied in the input requirement matrix is adopted, some of the Chinese agricultural labor force in the base period is able to migrate into other sectors of the economy. When they leave the

Table 4. Input requirement matrix

	Rice	Wheat	Other Crops	Oilseeds	Cotton	Cash Crops	Fruits & Veg.	Pork & Poultry	Other Livestk.
Land I	0.153	0.071	0.011	0.069	1.568	0.101	0.084	0.005	0.002
Land II	0.006	0.245	0.127	0.352	0.054	0.049	0.013	0.016	0.002
Land III	0.000	0.097	0.003	0.000	0.049	0.007	0.018	0.001	0.002
Land IV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.650
Labor	0.001	0.001	0.003	0.002	0.021	0.009	0.013	0.010	0.008
Capital	41.115	47.530	62.969	61.894	416.092	87.430	62.609	320.498	198.582
Fertilizer	0.080	0.093	0.100	0.052	0.691	0.241	0.095	0.000	0.000
Pesticides	0.001	0.000	0.000	0.001	0.006	0.001	0.001	0.000	0.000
Fuel	0.044	0.020	0.017	0.021	0.310	0.128	0.027	0.127	0.036
Wheat	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.006
Other Crops	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.704	0.131
Oilseeds	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.780	0.038

agricultural sector, these workers obtain at least as great a return for their labor as those who remain in the agricultural sector. This movement of labor is not entirely consistent with our treatment of the agricultural sector as a complete economy; however, it does provide a crude approximation for the fact that as China's economy becomes increasingly market orientated, global output and China's share of that output will increase. Finally, net trade is calculated as the difference between production and consumption.

In Scenario 1, we maximize agricultural revenue using the data in Table 3 and Table 4. The results of Scenario 1 are displayed in Table 5. Note that the capital endowment is fully employed, while land and labor are less than 50 percent employed. The scarcity of agricultural capital in China relative to other productive factors is also reflected in the value of output per dollar of capital input. In the United States, this ratio is 1.52; however, the results from Scenario 1 indicate that capital is more than three times more productive than in the United States. We view these results as being unrealistic because we do not expect a land scarce country to let productive land sit idle. What appears to be happening is that capital is so scarce and labor so plentiful that it is optimal to use all of the available capital to grow fruit and vegetables. The lack of capital results in land being idled because any alternative use would require some capital and this capital is most productively used in fruit and vegetables. This result is clearly driven by the assumption that Chinese agriculture is independent of the rest of the Chinese economy and that it is limited to the

Table 5. Scenario 1: Chinese production, consumption, trade, and factor use

Outputs	Production	Consumption	Net Exports
		Million Metric Tons	
Rice	0.0	23.0	-23.0
Wheat	0.0	90.3	-90.3
Other Grains	0.0	161.1	-161.1
Oilseeds	0.0	5.9	-5.9
Cotton	0.0	9.8	-9.8
Cash Crops	0.0	27.7	-27.7
Fruits & Vegetables	377.2	181.0	196.2
Swine & Poultry	0.0	137.8	-137.8
Other Livestock	55.9	365.6	-309.7

Factors	Endowment	Use	Ratio
Land I	78.7	31.9	0.40
Land II	53.6	4.9	0.09
Land III	17.5	6.9	0.39
Land IV	313.3	148.1	0.47
Labor	323.3	5.1	0.02
Capital	34852.8	34852.5	1.00
Fertilizer	35.9	35.9	1.00
Pesticides	1.1	0.4	0.37
Fuel	12.0	12.0	1.00
China/U.S. Income Ratio	0.92		
Revenue/Capital Ratio	5.01		
Trade Balance	-266.2 Billion U.S. Dollars		

resources employed in the sector in the base period. A far more realistic assumption is that capital and other variable resources would flow into Chinese agriculture so long as they had a return that was greater than that available elsewhere.

Scenario 2 relaxes the capital, fertilizer, and fuel constraints so that the productivity of capital is slightly more than two times the level in the United States (3.42 versus 1.52). This implies that capital is scarce in China, with an interest rate that is 2.25 times that in the United States. The results for Scenario 2 are shown in Table 6. As capital becomes relatively more abundant, livestock production increases. Almost all of the land is used, and labor use expands from 5.1 million to 13.5 million. China becomes a major exporter of cash crops and fruits and vegetables and imports all other agricultural commodities including swine and poultry.

In Scenario 3, we relax the capital constraint even further so that Chinese interest rates are 50 percent greater than in the United States (2.3 versus 1.52). We also relax the fertilizer constraint and allow fuel use to rise to eight times existing levels.[7] As capital becomes increasingly abundant, pork and poultry production increase, and China becomes a major net exporter of nonruminant livestock products. This result indicates that Chinese net trade in pork and poultry is

Table 6. Scenario 2: Chinese production, consumption, trade, and factor use

Outputs	Production	Consumption	Net Exports
		Million Metric Tons	
Rice	0.0	24.2	-24.2
Wheat	0.0	112.2	-112.2
Other Grains	285.7	541.7	-256.0
Oilseeds	0.0	113.6	-113.6
Cotton	0.0	10.3	-10.3
Cash Crops	107.4	29.1	78.2
Fruits & Vegetables	757.9	190.4	567.5
Swine & Poultry	134.8	145.0	-10.2
Other Livestock	118.2	384.5	-266.3

Factors	Endowment	Use	Ratio
Land I	78.7	78.7	1.00
Land II	53.6	53.6	1.00
Land III	17.5	15.5	0.88
Land IV	313.3	313.3	1.00
Labor	323.3	13.5	0.04
Capital	141498.5	141498.5	1.00
Fertilizer	126.7	126.7	1.00
Pesticides	1.1	1.0	0.90
Fuel	60.0	60.0	1.00
China/U.S. Income Ratio	0.97		
Revenue/Capital Ratio	3.42		
Trade Balance	20.1 Billion U.S. Dollars		

Table 7. Scenario 3: Chinese production, consumption, trade, and factor use

Outputs	Production	Consumption	Net Exports
		Million Metric Tons	
Rice	0.0	22.7	-22.7
Wheat	0.0	146.3	-146.3
Other Grains	243.9	1392.5	-1148.6
Oilseeds	0.0	361.7	-361.7
Cotton	0.0	9.7	-9.7
Cash Crops	115.7	27.4	88.3
Fruits & Vegetables	732.8	179.0	553.8
Swine & Poultry	453.0	136.3	316.7
Other Livestock	118.2	361.5	-243.2

Factors	Endowment	Use	Ratio
Land I	78.7	78.7	1.00
Land II	53.6	53.6	1.00
Land III	17.5	15.2	0.87
Land IV	313.3	313.3	1.00
Labor	323.3	16.4	0.05
Capital	240000.0	240000.0	1.00
Fertilizer	126.7	122.1	0.96
Pesticides	1.1	0.9	0.87
Fuel	100.0	100.0	1.00
China/U.S. Income Ratio	0.91		
Revenue/Capital Ratio	2.30		
Trade Balance	116.4 Billion U.S. Dollars		

dependent on the relative cost of capital. If capital is very scarce, then China optimally imports meat. However, if capital is slightly less scarce, feed grains are imported to supply the export orientated pork and poultry industries.

Given the heroic assumptions required to produce these results, one must be somewhat skeptical about the magnitude of the numbers, particularly those related to trade. However, certain features do stand out. The capital requirements in Scenario 3 are almost seven times existing levels, while the labor requirements are one twentieth. These results indicate that liberalization of Chinese agricultural markets would release enormous quantities of labor *even if* China specialized in labor intensive products. It also suggests that an enormous inflow of capital will be required to modernize Chinese agriculture. It is also interesting to see that China continues to produce some feed grains in Scenario 3 because both Japan and South Korea eliminated feed grain production after liberalization.

Conclusions

Ongoing changes in the Chinese economy suggest that China may eventually liberalize agricultural markets. One way to better understand what this liberalization might mean is to ask what Chinese agriculture would look like today if it had evolved under free trade and full technological mobility.

In this paper, we have used U.S input/output coefficients to find the revenue maximizing output and trade mix for China using the existing Chinese resource endowment. We discovered that the Chinese agriculture we see today is dramatically different from that which would have evolved had it been open to trade and factor mobility. In particular, capital use is many times lower than it would otherwise be, and labor use is many times greater. If we allow capital to flow into agriculture so that all productive land can be used, then China uses its abundant labor supply to grow cash crops, fruits and vegetables, and pork and poultry for export. It imports enormous quantities of land-intensive crops such as wheat, feed grains, and rice. The results we present are based on a highly restrictive model and are not meant to be used as forecasts; moreover, we do not believe that the magnitudes of some of the results are realistic. However, the analysis does suggest that Chinese agriculture is so far from an optimal input/output mix under a market economy that any alternative model that assumes the existing patterns are rational in a liberalized economy will produce results that are seriously flawed.

Endnotes

1. Dixit and Norman contains an excellent discussion of the conditions for factor-price equalization. In general, a technology may result in factor-price equalization if each country's vector of factor endowments lies in the n-dimensional space defined by the input requirements consistent with the globally integrated equilibrium.

2. Later we drop this restriction and allow capital, fuel, and fertilizer to flow in and labor to flow out of agriculture.

3. Data for 1995 pesticide use on vegetable crops was not found, so 1996 use levels were used.

4. Conversion rates for butter, cheese, nonfat dry milk powder, and whole milk powder to milk equivalent are 22.32, 10.53, 11.42, and 7.4, respectively.

5. Cash rents for irrigated cropland was used for California, Arizona, New Mexico, and Nevada.

6. Field crop and livestock cost of production estimates were obtained from the Economic Research Service's *Costs and Returns Reading Room.* Fruit and vegetable cost of production estimates were based on the 1987 census of U.S. agriculture and made available in *U.S. Fruit, Nut, and Berry Production* and *U.S. Vegetable and Melon Production.*

7. If we relax the fuel constraint even further the production of fruits and vegetables drops to zero as cash crop production increases. This result is driven by the high fuel content of cash crops because tobacco, which is the dominant U.S. cash crop, is fuel intensive.

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