July 1994

North Central Regional Research Publication No. 179

Transportation Research Needs and Issues for Chinese Agriculture

中国农业

THE OHIO STATE UNIVERSITY

OARDC

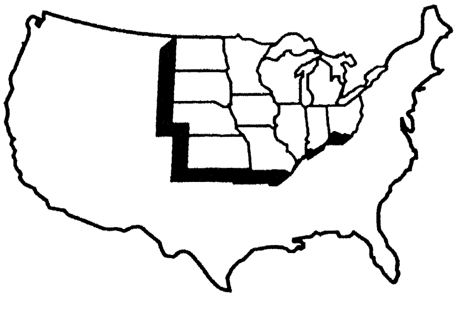
Ohio Agricultural Research and Development Center

OARDC Special Circular 144

Transportation Research Needs and Issues for Chinese Agriculture

Proceedings of a Special Session on
Transportation at a Conference
"On Prospects for Chinese Agricultural
Development in the 1990s"
August 20-25, 1992
Beijing, China

Edited by Donald W. Larson



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This bulletin (North Central Region Research Publication 179) is published by the Ohio Agricultural Research and Development Center. Requests for copies may be sent to SCT, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691-4096.

Contents

Preface

This volume is the result of a conference "On Prospects for Chinese Agricultural Development in the 1990s" sponsored by the Agricultural Economics Association of China, the Rural Economics Society of China, and the American Agricultural Economics Association (AAEA). The conference was held in Beijing, China from August 20-25, 1992. In cooperation with Chinese scholars, the members of NC-137 (Impacts of Transportation Changes on Agricultural Marketing and Local Communities) organized a special session on transportation at the China meeting. Most of the papers presented at the special session on transportation address concepts and issues of common interest to Chinese and American scholars conducting research on transportation problems. In many cases the papers may also be published by the authors at a later date in a journal or other publication outlet. Please contact the authors if you are interested in a copy of the current paper or in the forthcoming publications.

I wish to thank my fellow members of the review committee, Paul L. Farris, T.Q. Hutchinson, and Roland R. Robinson. All manuscripts were edited for consistency after reviewer comments were incorporated by the authors. I also wish to thank Susie Sheller for preparation of the papers for this edited volume and Janice DiCarolis for completing the art work for the papers. I also appreciate the assistance of David Scardena, Editor and Publications Coordinator; Sandra Born, Graphic Designer; and John Victor, Senior Graphic Designer from the Section of Communications and Technology, OSU Extension for production of this manuscript.

I thank Wen S. Chern (The Ohio State University), Liu Zhicheng (Chinese Academy of Agricultural Sciences) and Hsi-Huang Chen (National Taiwan University), members of the conference steering committee, and members of the program committee and local arrangement committee for their valuable contributions to the China conference "On Prospects for Chinese Agricultural Development in the 1990s." The conference was financially sponsored by the Ford Foundation, the Farm Foundation, the Economic Research Service of the U.S.D.A., Winrock International, and the Chung-Cheng Foundation for Agricultural Science, Technology, and Social Welfare.

The views presented in this book represent those of the authors and editor and should not be attributed to any of the institutions that support this effort. The usual disclaimers apply.

Donald W. Larson

Interprovincial Circulation of Grain and Wholesale Markets in China

Wu Shuo[1]

Introduction

The agricultural economy in China has greatly developed in the 1980s. Grain production (rice, maize, wheat and soybeans) increased by 39.2 percent and increased from 350 million tons to 400 million tons in a few years. Grain production is now approaching 450 million tons (Table 1). During this decade, grain yields increased 43.8 percent while the areas planted dropped by 3.2 percent. This yield growth demonstrates that the increase of grain production was due mainly to the rise of agricultural productivity, especially the application and extension of science and technology in agriculture. The natural conditions also played a role in the production increases.

Compared with 1982, when grain production jumped to 350 million tons, the yield of grain in 1990 increased by 25.9 percent, while the area planted for the two years was almost the same (the difference was only 50,000 mu; 15 mu equal 1 hectare). The increase of grain production (by 25.9 percent) was totally the result of yield increases (Table 1). If compared with 1984, when grain production was over 400 million tons, grain yields in 1990 increased by 0.9 percent and the area planted increased by 0.5 percent, or a 8.73 million mu increase. Therefore, nearly all the 0.9 percent increase of total production resulted from the increase of yield. Nevertheless, it should be noted that the decrease of grain production in 1985 and 1988 was due to the decrease of grain area planted to some extent. Since the multiple crop index increased in 1989, the total planted areas of the same year recovered to the 1980's level and increased further to 2.2 billion mu in 1990. This level was similar to that of 1979 and 3.3 percent more than in 1985, when the level of planted area was the lowest in the last ten years (that is, increased by 71.4 million mu). The areas planted to grain in 1990 recovered to the 1982's level and increased 4.2 percent from the lowest level of 1985, or a 69.31 million mu increase. About 97.6 percent of the increase of multiple crop index and the recovery of total planted areas were due to the recovery of planted areas of grain (Table 1).

The total supply of domestic grain increased by 128.3 percent, or 78.662 million tons from 1980 to 1990 (Table 2). The commodity ratio of grain reached to 35.7 percent of all production, 13 percentage points more than in 1980. Over 68.5 percent of the total production increment was marketable grain. The Chinese grain production is transforming gradually into commodity production. The fact that about 70 percent of the increased grain production in the 1980s was commodity grain also indicates that the food problem in rural China has already been resolved. Most increased grain production was sold on markets.

In 1991, several regions of China were hit by serious natural calamities, nevertheless, total grain production reached 435.2 million tons, that is 11 million tons less than 1990, or a 2.5 percent decrease. If grain production of the 1990s continues the fine trend of the 1980s, total production of grain would

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exceed 500 million tons. If the increase were half that of the 1980s, i.e. about 19.6 percent, then the grain production in 2000 would reach to 533.7 million tons. If the commodity grain accounted for 70-100 percent of the total production increase, the commodity ratio would reach 41.3-46.2 percent, or 5.6-10.5 percentage points higher than in 1990.

Decreasing Government Market Shares

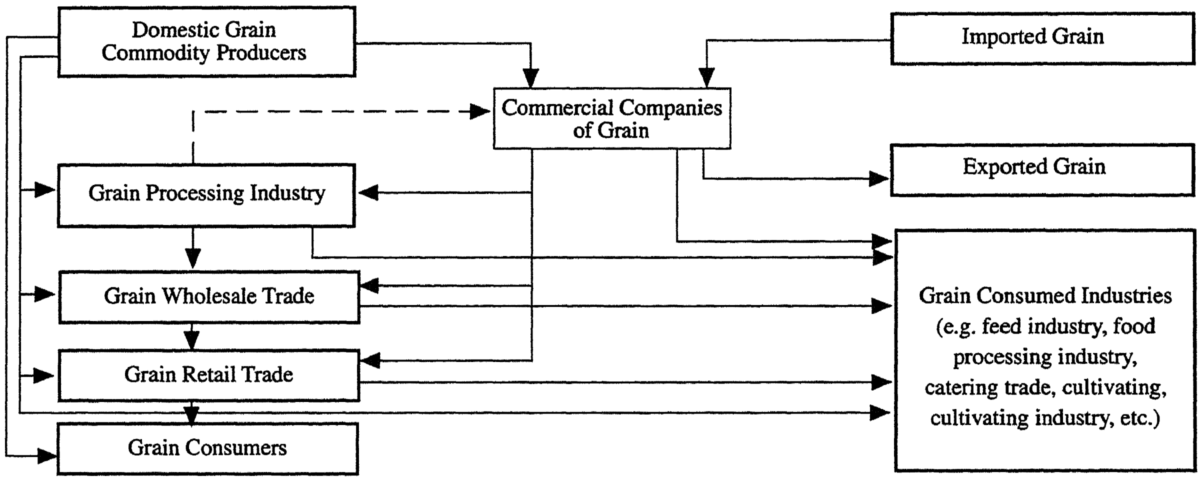
In the 1980s, Chinese peasants provided about 1.018 billion tons of commodity grain for the markets, or over 0.1 billion tons per year. Some 60 percent was sold to the state grain organizations according to instruction purchasing plans. Only 40 percent was freely sold to the state grain companies which buy or sell grain according to negotiated price, the supply and marketing co-operatives, other state commercial companies, private commercial companies and peddlers. Some peasants also sold grain directly to consumers in rural fairs or urban farm products trade markets. The shares of various kinds of marketing were changing in the 1980s. The general trend was that the share of government instruction procurement decreased while that of free will increased. The ratio of the former to the later varied roughly from eighty to twenty in the early 1980s and declined to forty to sixty in the late 1980s. In 1990, grain procured by the state accounted for only 36 percent of the commodity grain provided by the peasants while free marketing by peasants accounted for 64 percent. Since the market prices dropped in 1983 and 1984, it became worthwhile for peasants to sell grain to the state at a higher price paid for the grain that exceeded the procurement quotes. Therefore, the shares of state procurement in 1983 and 1984 were exceptionally high at 89 percent and 87 percent respectively.

Before 1983, the state grain organizations were the sole operators in Chinese grain transactions. After that, commercial enterprises and peddlers of various ownerships were permitted in grain marketing. In 1986, state commerce accounted for about 85 percent of grain circulation, whereas co-operative commerce and private commerce accounted for about 6 and 9 percent respectively (in some areas, private commerce could reach to about 20 percent). There are millions of commercial enterprises and merchants who are engaged in grain circulation scattered in rural and urban areas of China. There are more than 80 thousand procurement offices and retail grain shops owned by the state grain enterprises, more than 600 thousand supply and marketing co-operatives, and there are about 4 million staff who work in each of them. About 100 million agricultural productive enterprises and peasants have grain to sell. More than 400 million urban residents, grain processing enterprises and industries, and tens of millions of rural households who are deficit of grain are integrated into an organic whole through grain circulation. What a magnificent picture of grain commodity circulation it is!

Grain Marketing Channels

China is a large country with a quite imbalanced development of its agricultural commercial economy (Figure 1). Nearly all kinds of channels in grain marketing that represent various historical stages of development exist (Figure 2). The Chinese commodity grain is mainly procured and imported or exported by the state grain commercial organizations. The state sells grain by wholesale or retail to various consumers, including grain industries and individuals. This channel accounts for about 85 percent of sales. Even though, processing industry, food industry, feed industry, catering trade, cultivating industry, wholesale trade and retail trade (including the state grain shops and private peddlers) also buy grain directly from

Figure 1. Provinces of China



Notes: Grain commercial companies are primarily the state grain companies which buy or sell grain according to negotiated price and export and import corporations

Figure 2. Grain Marketing Channels, China

producers of grain commodity respectively. This channel accounts for about 9 percent. In addition, some grain commodity producers also sell their products directly to consumers, more than 5 percent of use. Among them, indirect marketing is dominant while direct marketing accounts for only a small proportion.

Grain Surplus and Deficit Areas

China is vast in territory and its agricultural commodity economy develops very imbalanced. Grain is a commodity produced regionally and seasonally whereas consumption is national and regular. Moreover, as grain production is affected substantially by natural conditions, the harvest is usually unstable. There is a gap in space as well as in time between grain production and consumption. The functions of transportation and storage can solve the above problem.

Basing upon historical, economic and natural differences, thirty Chinese provinces, autonomous regions (AR), and municipalities directly under the Central Government (MDUCG) are divided into grain-surplus regions and grain-deficit regions. In view of the general balance of production and demand, the six provinces of Sichuan, Hunan, Hubei, Anhui, Jiangxi and Jiangsu in the middle and lower reaches of the Yangtze River, Heilongjiang and Jilin in the Northeast China and Xinjiang in the Northwest China, as well as Henan and Shandong in the middle and lower reaches of the Yellow River are grain-surplus provinces and ARs (Figure 1). Nine coastal provinces, MDUCGs and ARs of Liaoning, Beijing, Tianjin, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan, along with Inner Mongolia, Gansu, Yunnan, and Guizhou are the main grain-deficit regions. Shanxi, Hebei, Ningxia, Qinghai and Tibet are somewhat deficit areas of grain. In terms of the balance of production and demand of a given type of grain, nearly all provinces and ARs are surplus in some while deficit in others. Rice produced in the middle and lower reaches of the Yangtze River is transported and marketed to Southern and Northern China. Soybean and maize produced in the Northeast China are transported and marketed southward through Shanhaiguan or by seaway. Wheat and maize produced in North China are transported also to the Yangtze valley and regions to its south. Grains with limited production are transported and marketed to everywhere in China. Among counties and cities within a province, or an AR, or even a MDUCG, the phenomenon of grain surplus or deficit also exists. Consequently, the Chinese grain commodity circulation is quite large in volume. According to an approximate calculation, the average volume of circulation per year in the 1980s was about 200 million tons. The year 1984 and the last five years were all above 200 million tons.

In commodity grain circulation, about 90-95 percent were transported and marketed within a province, interprovincial circulation accounted for only 5-10 percent. That is, interprovincial grain circulation averaged about 10-20 million tons per year, and it was somewhat less in bad years and more in good years. The remaining 180-190 million tons were marketed within a province (direct export is included in it). Grain is transported by nearly all the means of transportation from shoulder poles and carts to trains, ships, and trucks. For instance, in 1988, the volume of commodity grain transportation totaled to 215.4 millon tons. Among them, 28.76 million tons were transported by railways, 97.67 million tons by trucks, 16.58 million tons by ships, and 1.27 million tons by joint land and water transportation. The above totaled to 144.28 million tons, or 70 percent of the whole. That is to say, about 30 percent of commodity grain were transported by backward means.

Before 1978, when grain markets were reopened and the method of Buying and Selling Grain According to Negotiated Price (BSGANP) was introduced, almost the whole interprovincial commodity grain circulation was based upon the planned allocation. The BSGANP was usually through the wholesale trade and not the planned allocation. By the late 1980s, less grain was circulated interprovincially by the planned allocation. The wholesale trade of BSGANP replaced it gradually. Because the purchasing of grain according to contract order dropped from 79 million tons in 1985 to 50 million tons in 1987, less grain could be allocated out of most grain-surplus provinces and ARs after offsetting the planned purchase against marketing. With the decrease in purchases based on contract order and the increase of the production of commodity grain, the quantity of BSGANP increased substantially. As mentioned before, it accounted for 64 percent of the whole supply of domestic commodity grain in 1990. Most of the interprovincial commodity grain circulation was the grain sold with a negotiated price. This is a kind of market regulation under the guidance of plans and not a planned regulation. The planned allocation was replaced by the wholesale trade.

Problems of Planned Grain Allocations

In the early 1950s commodity grain was allocated according to plans based on administrative divisions. Many grain depots and distribution stations delivered and received grain scattered in vast areas. The transportation routes were crisscrossed and irrational so that the same grain was transported to and from on the same route simultaneously or circulated on different routes and grain was loaded and unloaded repeatedly were frequent occurrences in grain transportation. Given this situation, grain organizations took various measures to change the confusion of transportation by railways. Firstly, they altered the original method of allocating grain based on the administrative divisions, and began to organize grain circulation according to economic regions. Also, they created an effective method of "working on the chart." The Institute of Mathematics of the Chinese Academy of Sciences highly appraised it: The advanced method of working on the chart applied in grain transportation is simple in method, easy to be managed, swift in calculation and quite important in practice. This method permits the transportation routes to be the most rational ones, or satisfy the requirement that the ton kilometer is the least. Nevertheless, if it had to be done through the known mathematical method of cost minimization used by foreign countries, tens of thousands of unknown numbers and linear equations would have to be listed. Only through complicated calculation could the least cost, rational transportation program be worked out. Even for a person specialized in mathematics to do this would need lots of time.

Professor Hua Luo-geng was convinced that the method of "working on the chart" was applying the principle of operations research. Thereafter the Ministry of Food divided the whole country into several production-marketing regions according to grain types based on the balance of production and marketing, and worked out rational transportation routes with a regional balance between production and marketing for eleven grain types. In 1956, the above transportation system was approved by the State Council and was put into effect. This planned allocation system worked for more than 30 years. It satisfied various grain requirements for all the provinces, ARs and MDUCGs under the situation that domestic grain was insufficient or even deficient sometimes. Since the system was based upon a planned unified domestic market, it completed its historical mission and was abandoned gradually with the disintegration of the planned unified domestic market of grain.

Changes in the Planned Allocation Model

The interprovincial circulation BSGANP is carried out through the wholesale trade. A traditional method of negotiation secretly by one-to-one between buyers and sellers is adopted in the wholesale trade. Trade is free and is not bounded by the law and the control of authorities. Therefore, markets and price could be bargained at any location. Nevertheless, few people knew the wholesale prices actually traded except a few persons. Consequently, a really perfect market mechanism to regulate production as well as supply and demand of grain did not develop. Since the market price of grain is usually fluctuating and there is no mechanism to shift or to undertake price risks, in case of price variation, both buyers and sellers would use improper measures to shift price risks. When price rises the sellers often breach contracts, and vice versa. In general, the ratio of completed contracts is rather low and grain circulation is often an anarchy. This is not only a problem of no commercial morality or no commercial reputation, but also a problem that economic interests are unequal between buyers and sellers and no one undertakes the price risks. Additionally, the BSGANP companies belong to local governments on different levels and so are subject to the administrative departments. The excessive administrative interference resulted in the two wars of grain in 1986 and 1988, and seriously hindered the interprovincial grain circulation and aggravated the disorderliness. Therefore, "hard to sell" and "hard to buy" emerged alternately in grain circulation.

In light of the situation, the planned unified domestic market was disintegrating gradually. The rational transportation system with regional balance between production and marketing would step down from the economic stage. Whereas the wholesale trade through secret negotiation by one-to-one method often led to a disorderliness in grain circulation and made the market out-of-control, a new circulation system based on the grain markets regulated by the state to standardized the transactions between various grain commercial enterprises was established.

Development of a Wholesale Cash Grain Market

In 1988, the Chinese government put forward a guiding principle of establishing a wholesale market step by step and putting the market regulation into effect methodically. At the same time, the government committed research institutions to make a study of the wholesale market and the futures market of grain. In October, 1989 a report on "establishing the first Organized, Restrictive and Standardized Wholesale Market (ORSWM) of grain in China" was subjected to the State Council for approval after repeated demonstration by all respects and a joint-signing of nine departments. In May, 1990 the State Council formally approved the "Report on Establishing Wholesale Market of Grain in Zhengzhou as an Experiment." On October 12, 1990 the Chinese Zhengzhou Grain Wholesale Market (CZGWM) which was jointly run by the Ministry of Commerce (MOC) and the government of Henan province to regulate the interprovincial grain circulation formally opened for business.

Why should a standardized wholesale market of grain be established? As discussed above, "there is neither ORSWM, nor planned guidance, nor macro-regulation in the BSGANP, consequently the grain markets are often in disorderliness. The phenomena of hoarding and speculation, blocking and monopolization, driving up prices and buying for reselling are very serious. To eliminate the disorderliness, the grain should be marketed at a negotiated price into a standardized wholesale market, reorganize transactions and set up a market discipline so as to realize the objective of "control without rigidity, flexibility without disorderliness." The standardized wholesale market of grain could become a practical form combining the planned mechanism with the market one. Certainly, it is an experiment in reform of the grain circulation system.

What does a ORSWM mean? An organized market means that the wholesale market is run by the government and it is to provide a market service but not to earn a profit. A restrictive market means that all enterprises or persons who want to trade on the wholesale market should apply to the authority according to relevant provisions and obtain the relevant approval. A standardized market means a wholesale market based on the law of value and general commercial principles. This kind of wholesale market is neither the existing one run by some commercial enterprise which plays the roles of administrative organs as well as business enterprises, nor the one that producers, operators and consumers can use randomly, nor one on which transactions are completed according to principles subjected to market runners.

Such a wholesale market should be the key link in the grain market system of China. Grain market system includes the rural fairs, the urban farm products trade markets, the spot wholesale markets, and the futures markets. The spot wholesale market is the most important one among them. A set of reasonable wholesale prices could result from an open competition on the market. The producer price and the consumer price would be linked to the wholesale price. So long as the government regulates the wholesale markets and the wholesale prices, the whole grain markets and prices would be regulated to a great extent. It is also advantageous for dredging the circulation channels and coordinating supply and demand as well as stabilizing the prices.

To get the CZGWM developed better, the Chinese State Council made eight policies (see Documents issued by the State Council, No. 46, 1990): (1) The management organ of CZGWM is an unprofitable and serving institution; (2) The ceiling price and the floor price of wheat traded on the CZGWM are set by the MOC and the State Price Bureau based on the supply and demand of wheat and the country's relevant policies. The price of a special transaction is determined by the open market competition; (3) The market management organ will issue transportation certifications to the wheat traded and concluded on the CZGWM. Transportation departments should give support to it. Local governments on every levels should not enforce a blockade to the grain with a transportation certification when it passes through their boundaries; (4) All grain enterprises engaged in wholesale trade on the CZGWM are prohibited to do wholesale trade outside of it; (5) The forward contracts based on the spot wholesale trade are permitted to transfer within the CZGWM according to the market regulations, but it should be distinguished strictly from the spot transactions; (6) The MOC should give guidance through quota to the provinces, ARs and MDUCGs; (7) All grain enterprises engaged in wholesale trade on the CZGWM must get the permissions of grain administrative departments above the level of a county. Moreover, they should be granted by and registered in the industrial and commercial administrative organs and get approvals of the MOC; (8) It is necessary to set up a regulation grain (wheat) which is controlled by the central government with a volume of 250-500 thousand tons. In case that the wholesale price of grain on the CZGWM is above the ceiling price or below the floor price set by the state, the grain trade company committed by the MOC should buy or sell grain on the CZGWM so as to stabilize the market price. Meanwhile, the necessary storage and transportation installations should be established and expanded respectively. We can see from here the special contents of combining plan mechanism with the market one. The plan factors primarily mean those of the purchase allocations for all provinces, ARs and MDUCGs set by the MOC, the guiding price of wheat set by both the MOC and the State Price Bureau to be the ceiling and floor limits of the concluded prices, the regulation of the MOC through buying and selling grain by the Chinese grain trade company, and the administration of the MOC, i.e. giving credentials and approvals for wholesale enterprises, big production units and consumption units of grain which apply to enter the CZGWM, and etc. The market factors primarily mean that the transference of ownerships of the commodity grain on the CZGWM is by free exchange and that the wholesale price results from open competition under the guidance of the government. In this way, the wheat marketed at negotiated price is under the administrative management and the macro-regulation of the government, and that the market mechanism be developed and a new market system be established.

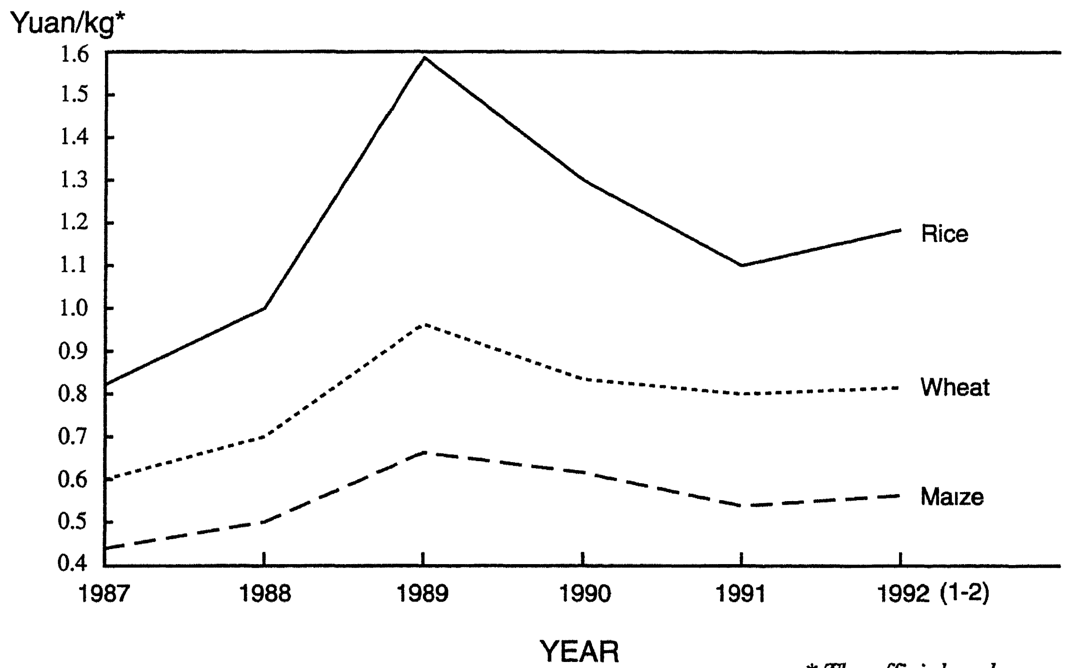
Conditions for a Grain Futures Markets

In addition, the CZGWM adopts some provisions of futures market to control and to share the risks. For example, both buyers and sellers should pay a basic deposit according to a given percentage of the volume of a business to the market management organs after striking a bargain and to pay an additional deposit at necessary times; the market may set a fluctuation limit for price and a purchase volume; the government may buy or sell grain in case the market prices surpass the ceiling or floor limit of the guiding prices to restrict the price within a given limit. So, if price is within the limit, the price risk is undertaken by both buyers and sellers, or, it should be undertaken by the government; the contracts are permitted to transfer within the market; a membership system is introduced, and so on. It illustrates that most of the trade on the CZGWM are spot wholesale trade. The forward contracts are encouraged to sign on this basis in order to lead to a futures exchange gradually.

The CZGWM has already operated for nearly two years. During this time it has demonstrated its advantages and realized the expected objectives. (1) The CZGWM began to become a particular form combining the plan mechanism with the market one; (2) A regular order of circulation has been set up. More than one third of the contracts signed on the CZGWM are forward contracts. The ratio of working contracts is more than 90 percent, and the commercial reputation has been recovered. The debt chain has not occurred so far. An actual guiding price—Zhengzhou price has appeared. The unhealthy tendency in the commerce was swept away by open, competitive marketing, supervision and consultation. The government supervision to the business is realized; (3) A new system of price management has begun. That is, the market price results from open competition. The direct pricing by the government is replaced by the indirect regulation of a market price by buying and selling grain; (4) The price risks could be controlled to a certain extent; (5) Market price information begins to play a role in guiding the production and operation of enterprises; (6) The government has a foundation for macro-regulation. Clearly, the establishment of an ORSWM opened a new way for the reform of grain circulation system.

In the late 1980s and the early 1990s, a popular interest in the wholesale market emerged in China. Wholesale markets of grain on three levels have gradually evolved. The first level is the wholesale market local autonomous areas. The basic method of transaction is a kind of secret negotiation to strike a bargain after seeing goods exchange for money at the spot. The second level is a more advanced wholesale market of grain run by the governments of provinces or municipals. The trading method is mainly one of striking bargains after seeing samples and transacting under the supervision of the market management organs, or registering after negotiation. The third level is primarily the central standardized wholesale market, or the CZGWM. All three wholesale markets of grain are doing interprovincial trades of grain.

Nevertheless, the spot wholesale market does not totally eliminate the problem of transferring price risk. The grain price in China fluctuates by a rather large range. During the period from January, 1988 to June, 1991, the grain market price increased by a big range in July and August, 1988, that of rice, maize and wheat reached the peak in June, August, and November, 1989 respectively, or increased by 79.4 percent, 67 percent and 61.7 percent from January, 1988 respectively. After that, the market weakened and the prices dropped a lot. Compared with the peak price in 1989, the prices of rice in June 1991 dropped by 30 percent, maize by 23 percent, and wheat by 22 percent, about the same level in September, 1988 (Figure 3) Since the price risks from the price fluctuation have no transfer mechanism, the above phenomenon of a low ratio of completed contracts still exists.



** The official exchange rate was Yuan 5.30 per U.S. $1 and the parallel rate was about Yuan 7 per U.S. $1.*

Figure 3. Wholesale Grain Prices in China

The options for the management of price risks depend upon the public policy towards price and market. If the government adopts a policy of price support and makes the support price higher than the market price, the price risks would be assumed by the government. The futures market for transferring the price risks has no function in this case. If the government adopted a policy of regulation of price and limits price risks within a certain range, the price risks outside the range would be assumed by the government, and the price risks would be controlled and regulated to some extent. Under such a situation, both buyers and sellers could bear the burden of price risks. The futures market would not be used to transfer price risks. If the range between ceiling price and floor price set by the government was large, the price risks would be large, then the futures markets would be used to transfer price risks at last. If the government adopted a policy of free prices but no support price or regulation price, the futures market would be needed to transfer price risks. Given the existing Chinese situation, it is impossible to adopt a policy of price support for its limited financial capacity. Therefore, it is important to create conditions, including market conditions, to set up a futures market for grain.

A futures market in China should conform with the general principles used in futures markets in the developed countries, while considering the Chinese actual situation so as to set up a futures market with a Chinese feature. That is, on the one hand, it should not copy the foreign models mechanically, while it should persist in standardization and so that a veritable futures market is developed.

Since it is difficult to provide the basic conditions especially the market conditions needed for establishing the grain futures market in a short time in China, a policy of preparing actively and putting into practice carefully the establishment of futures market should be adopted. By preparing actively, we mean that: (1) to make preparations in the public opinions and the theories, i.e. to introduce the knowledge of futures market to sectors concerned to popularize and increase the market consciousness. for instance, write articles explaining the markets in simple terms, to set up research groups, to open seminars, to run training classes, and etc.; (2) to improve the existing standardized wholesale markets so as to demonstrate that the establishment of wholesale markets on various levels deepens the reforms and is the key link to perfecting the commodity economy; (3) to select some standardized wholesale markets with better conditions to develop transactions of forward contracts and to experiment on standardized contracts in order to introduce the factors of futures transactions gradually into the market. In case the contracts were standardized, along with the buying and selling prices, it would step into the threshold of futures markets; (4) to oppose monopoly, local blockage, and unstandardized transactions of enterprises through regulations so as to constitute an integrated domestic commodity market and financial market; (5) to reform the financial system and transportation system in order to perfect the commodity circulation, transportation and financing; (6) to separate some investors and risk capitals specialized in risk businesses from domestic public and private commercial financial and insurance enterprises, and to encourage risk investors from Hong Kong, Macao and Taiwan to the Mainland to make risk investment. The State should assure the risk investment through legislation and make the investment standardized. Alternatively, it is possible to find some kind of price risk insurance companies similar to the foreign financial engineering companies to undertake price risks. The net deficit or net surplus of the price risk insurance companies could belong under the public finance; (7) to cultivate a group of managerial personnel and transaction personnel for the futures markets; (8) to select a correct place to set up the futures market. As to putting into practice carefully, we mean that the standards should not be lowered and the futures market should not be put into practice hastily without proper conditions. It is both requirement and an outcome of the development of commodity economy to set up a futures market with Chinese features. At present, the most important thing is to decide the public policies for price and market, and begin to create conditions to carry it out step by step in a planned way.

Conclusions

This paper describes the development of Chinese grain economy in the 1980s and forecasts its tendency in the 1990s. The grain production increases achieved in the 1980s originated mainly from increases in yields with little change in area planted. Also, the paper analyzes the general situation of grain circulation between provinces, describes the government planned allocation of grain, identifies the main problems of transportation and grain marketing, and discusses the prospect for development of wholesale grain markets and the conditions necessary to establish a futures market.

Table 1: Grain Production, Area Planted and Yields in China, 1980-1990

Year	Grain Production (million tons)	Production Change (%)	Grain Area Planted (million mu)	Grain Yield (kg/mu)
1980	320.56	100.0	1758.51	182.3
1981	325.02	101.4	1724.37	188.5
1982	354.50	109.1	1701.94	208.3
1983	387.28	109.2	1710.71	226.4
1984	407.31	105.2	1693.26	240.6
1985	379.11	93.1	1632.68	232.2
1986	391.51	103.3	1663.99	235.1
1987	402.98	102.3	1669.02	241.5
1988	394.08	97.8	1651.84	238.6
1989	407.55	103.4	1683.07	242.2
1990	446.24	109.5	1701.99	262.2

Table 2: Total Domestic Supply of Commodity Grain in China, 1980-1990[a]

Year[b]	Total supply domestic commodity grain (million tons)	Commodity ratio (%)	Year[b]	Total supply of domestic commodity grain (million tons)	Commodity ratio (%)
1980	61.29	22.8	1986	115.16	33.8
1981	68.46	24.2	1987	120.92	34.4
1982	78.06	25.9	1988	119.95	34.9
1983	102.49	30.9	1989	121.38	34.4
1984	117.25	34.8	1990	139.95	35.7
1985	107.61	30.5			

[a]Commodity grain means cleaned rice equivalent which equals to 70 percent of paddy; unprocessed grain includes paddy.

[b]Calendar year.

Inter-State/Province Grain Transportation in the U.S. and China

Tenpao Lee, Robert J. Hauser, Stanley R. Thompson, and Barbara J. Hrutka[1]

Introduction

The role of grain transportation can be described by either economic theory or by empirical observations. Theoretically, transportation demand for grain is a derived demand, depending on the grain prices at different locations. If the difference in prices between two locations is higher than the transportation cost, then there will be an incentive for trade and hence a demand for transportation and a corresponding infrastructure. However, grain production, utilization, and prices are influenced by the existing transportation infrastructure. Consequently, the demand for transportation and the infrastructure available to meet this demand are not independent, but involve a complex inter-relationship.

Likewise, transportation and economic development can be viewed as having catalytic effects upon each other. The existence of a good transportation system may cause further economic development and the development of an economy may stimulate the construction of better transportation systems. As a result, a well developed economy usually has a well developed transportation system. Production efficiency and the appropriate level of geographical concentration in production are contingent upon the "correct" transportation system.

In the next section we will briefly describe the evolution of the grain transportation system in the U.S., and its implication for the development of infrastructure in other countries. U.S. grain use and transport patterns are then described in general terms, followed by a comparative illustration between the U.S. and China of geographical concentration. Some concluding remarks are then offered.

The U.S. Infrastructure

Much of today's U.S. grain-transportation infrastructure exists because of government policies aimed at stimulating agricultural economic development. The railroad industry is an excellent example. During the latter half of the 1800s, east-west trunk (main) lines were developed in large part to provide freight and passenger service to rural areas. "Branch lines" were then extended from the main lines into small communities. The expansion of main and branch lines was so extensive and rapid that by the late 1800s most people in the rural Midwest lived within five miles of a rail line (Baumel and Rudel).

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While some of the financing for this railroad expansion was from private industry (mostly in the form of stocks and bonds sold to farmers), a major portion was in the form of government (public) assistance. Tax exemptions, provision of lumber and stone, and other types of public subsidies were common. Public assistance included the right-of-way area plus large sections around the right of way. A total of 130 million acres (Locklin) was donated by the federal government to railroads, representing an area equal to the combined states of Illinois, Indiana, Ohio, and Missouri.

The resulting railroad infrastructure provided considerable in-bound and out-bound service to rural communities, stimulating economic growth. However, it also proved to be excessive. Railroad miles have declined from 254,251 miles in 1916 to 162,470 miles in 1990 (Fruin and Baumel).

Rural road construction followed the same historical pattern as railroads. In the late 1800s and early 1900s, an extensive rural road system was developed in many parts of the country. Much of this system was based on one mile square grids, resulting in quick travel times for farmers using horse and wagons. Recent studies, however, have indicated that much of this system is not economically justified, given current farming technology and road demands. Nonetheless, it has been politically difficult to reduce the number of rural roads.

In addition to land transportation, the U.S. grain industry relies heavily on inland waterways (rivers). This system has also received considerable public support. Since 1930, the federal government has financed the construction of several locks and dams, dredging (deepening) projects, new canals, and other expensive development and maintenance projects which enable efficient barge transportation of grain, coal, fertilizer and other agricultural products and inputs. Most of the barge shipments are on the Mississippi, Illinois, Ohio, and Columbia Rivers, although other rivers have received considerable public support and, in retrospect, government investment during the 1930s and 1940s into some of the river systems was probably not warranted given the economic changes which occurred after the investment.

The U.S. interstate (federal) and state highway system is also extensive throughout rural America, providing vital links between the farm and the final consumer. Consequently, the total transportation system in the U.S.— including rural roads, highways, water, and rail— represents the largest transportation infrastructure investment in the world. It is obvious that the U.S. has placed high priority on developing a good transportation infrastructure, and much of this effort has resulted from explicit and implicit policies aimed at stimulating and enhancing the grain production and marketing industries. It could be argued that public investment in the infrastructure was, in retrospect, excessive in many cases. However, decisions were made in response to political forces of the time and to current and projected economic and technological factors. As technology and other factors changed over time, there was (and still is) pressure to reduce the infrastructure. In some cases (example, railroads), scale adjustment in the form of reduced railroad mileage occurred. In others (example, rural roads and waterways) appropriate scale adjustments have been difficult.

Perhaps the most important factor in determining the degree of adjustment response is whether the adjustment decisions are dominated by private industry or by government. At one extreme, railroad companies have abandoned rail lines because of economic pressure to do so. At the other extreme, any reduction in rural road miles has been slow and politically difficult. The case of inland waterways falls between these two extremes. Traditionally, the costs of developing and maintaining the waterway system have been publicly financed. However, a user-fee policy was implemented in 1982 which placed some of the cost burden on private industry. One half of all inland waterway construction costs must now be financed by commercial users through user fees. This partial privatization will undoubtedly force scale adjustment decisions to be based more on short-run economic factors.

We believe that public financial support (and sometimes regulation) of the transportation system is needed and warranted to help a private economy of agriculture grow and specialize. However, the U.S. experience may reveal an important lesson for countries which are developing their agricultural transportation infrastructure. Public support of transportation is often a long-term investment. The appropriateness of the investment depends on future economic and technological changes, and these changes may indicate that the investment policy should be adjusted. It is important, therefore, that decisions about location, type, and future adjustments should rely heavily on economic signals. Consideration of how these signals will be measured is of utmost importance when developing plans and policies.

U.S. Grain Patterns

Figure 1 indicates the levels of grain production and population by state for the U.S. The midwestern part of the U.S. is where most of the grain is produced, while the population tends to be concentrated along the coast lines.

We will briefly review the major uses and transportation needs associated with corn, wheat, and soybeans. The use of corn in the U.S. can be classified into four general categories: (1) processing, (2) livestock feeding, (3) exports, and (4) storage. Corn processing involves the use of corn for products such as starch, meal, cereal, sweeteners, and ethanol (fuel alcohol). Most of the processing occurs within the production areas although some processing plants (especially for cereal and meal) are located near population centers. Consequently, most corn which is used for processing is transported relatively short distances by truck or by small rail shipments to the processing plants. The processed product is then usually shipped to other plants for use as an input into a consumer product. Most of the livestock production occurs in three general areas of the country — midwest, southeast, and southwest. Hog production is concentrated in the corn production region (Midwest). Poultry (chicken and

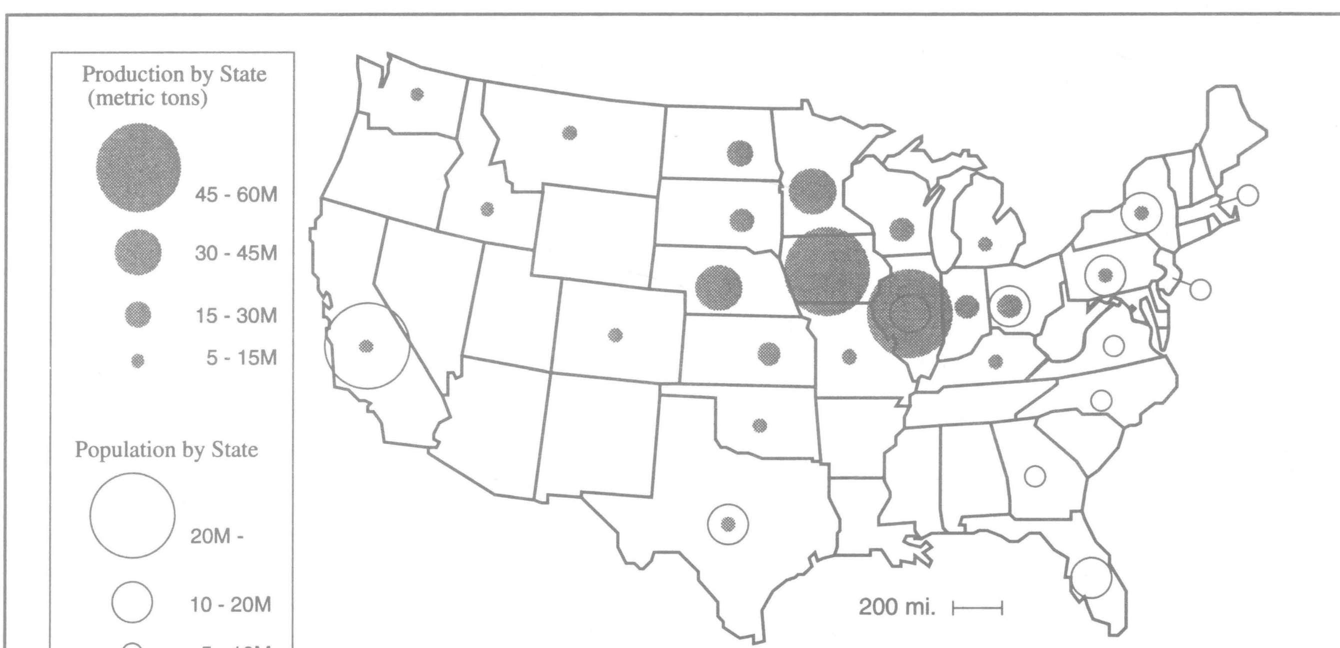

Figure 1. U.S. Population and Grain Production

turkey) production is mostly in the Southeast, requiring corn shipments by rail from eastern parts of the Midwest. The location of cattle feeding is relatively dispersed, but has become more concentrated in the Southwest during the past 30 years, requiring more corn transportation from the Midwest. The corn export industry relies heavily on barge shipments which originate on the Mississippi, Illinois, and Ohio Rivers and are destined to the Gulf of Mexico, and on railroad shipments of 75 to 100 cars per shipment from the Midwest to the Gulf. Before 1980, rail shipments of corn (and soybeans) to the East Coast were common, but these shipments have decreased considerably during the past decade. On the other hand, there are now periods during which corn shipments via rail from the west-central Midwest to the Pacific Northwest coast are quite large.

Soybeans are either processed into meal and oil, exported as raw soybeans, or stored. Virtually all of the processing occurs within the production region. The meal is then either transported to livestock feeding regions or exported. The oil is used as an input into a wide variety of consumer products. About 50% of the soybeans are exported in raw form. Virtually all of these exports are transported to the Gulf of Mexico by barge or rail.

The major wheat producing states are Kansas, North and South Dakota, Montana and Washington. Wheat is processed (milled into flour) in both production and consumption regions, although most of the milling is near production. The two primary export outlets are the Gulf of Mexico and the Pacific Northwest, served mostly by rail.

P.R.C. Development

We indicated earlier that transportation needs in agriculture are inextricably linked to development. This linkage manifests itself through the effect of per capita income changes on food consumption. As the quantity and quality of food consumed evolves, the derived demand for transportation services shifts.

Consider the relationship between development and food needs. A generalized consumption-income relationship has been derived by Rask (1991) and is shown in Figure 2. This relationship was estimated using annual data for 75 countries during 1961-85. FAO country-level consumption data were used to derive a measure of per capita food consumption in cereal equivalent units. Cereal equivalent conversion factors were used to reflect the quantity of grain necessary to produce a unit of meat or other consumption products. Per capita consumption was used to reflect the diet changes which are independent of

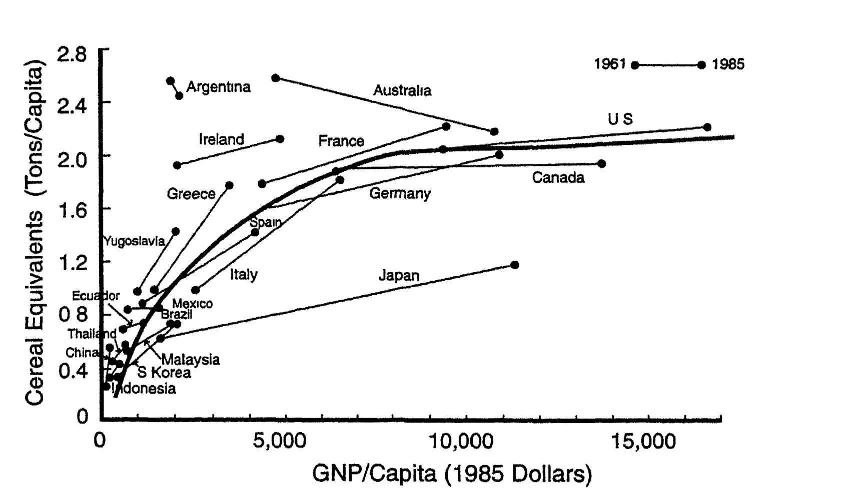

Figure 2. Food Consumption and Income 1961-1985

population. Gross National Product (GNP) was used as an income proxy (World Bank), and was also placed on a per capita basis and converted to U.S. dollars.

The generalized consumption-income relationship shows that, at low income levels (under $1000 per capita), annual consumption is usually between 0.3 and 0.5 metric tons, rising to 1.6 metric tons at $6000 and 2.0 at $10,000. As countries move along this curve, three stages of development are identified (Rask). First, (Stage I), at low levels of income (development) countries are essentially self sufficient in food, and production levels determine consumption. Second, (Stage II), as per capita income grows there is an increased demand for higher quality of food. In this second stage of development, food production response generally lags consumption demand, creating periods of excess demand. Third, (Stage III), for high income countries, food production response has adjusted sufficiently to close the production-consumption gap and quite often production technology continues to generate surpluses except in those countries where arable land constraints exist.

In 1985, annual food consumption in China was 0.53 metric tons and the average annual per capita income was $310 ($U.S.). Income/capita is currently estimated at $410 and growing at 5.7%/year. Thus, China could be characterized in the latter stages of Stage I development and positioning itself to enter Stage II.

What are the implications for the Chinese transportation system as it moves from Stage I into Stage II development? Recent changes in China have spurred significant income increases (e.g., the movement toward a more market oriented agriculture sector). As income grows, rapid consumption gains in high-valued livestock products occur as meat consumption tends to substitute for grains. Fruit and vegetable consumption grows to a much lessor extent in Stages I and II. As more livestock is produced, either feed grains need to be transported to the livestock producing centers (if not near the population centers) or livestock products need to be transported to the consuming population centers. In countries which are short on arable land, forage areas cannot sustain the required growth in livestock population. China has 0.08 hectares per capita (down from 0.14 in 1965) while the U.S. has 0.75 hectares per capita.

Whether feed grains need to be moved to the livestock producing centers and/or livestock products moved to the population centers, substantial increases in the quantity and type of transportation services and facilities will be required. If processed livestock products are moved, refrigerated facilities will be needed. Improved interior handling as well as transportation and storage facilities will become necessary. In addition, as development continues and domestically produced feed grain shortages occur, increased pressures will be placed on port terminals and handling facilities for grain imports. To facilitate development, general improvements in the entire transportation infrastructure will be essential. If commensurate transportation system development does not occur, the transportation system will serve as a binding constraint to development.

Under free-market conditions, resources tend to shift to areas and activities in a manner which creates the greatest benefit to society as a whole. Economic development and grain production/ utilization becomes geographically concentrated according to comparative-advantage factors. As comparative-advantage effects are realized, both the quantity and quality of food consumption increases as development occurs. Another common result of the development is that fewer people participate in farm production activities and a greater number of people migrate to urban areas. As development continues there will usually be less congruence between grain production and population centers.

A simple Lorenz curve (Figure 3) is used to illustrate the inequality between producing and consuming areas in the U.S. and China. The Lorenz curve is traditionally used to describe the inequality of income distribution by comparing the percentage of population to the percentage of national income. However, in this illustration, the percentage of grain production is substituted for national income. When the geographical disparity between grain production and consumption (population) increases, the Lorenz curve will move away from the 45 degree diagonal line. As the development process continues, one would expect a greater curvature in the Lorenz curve, *ceteris paribus*. However, basic differences in grain production conditions and location within each country will affect the shape of the curves.

In the U.S. there is substantial separation of grain production and population (see Figure 1). It is important to note that very little of the U.S. grain is used

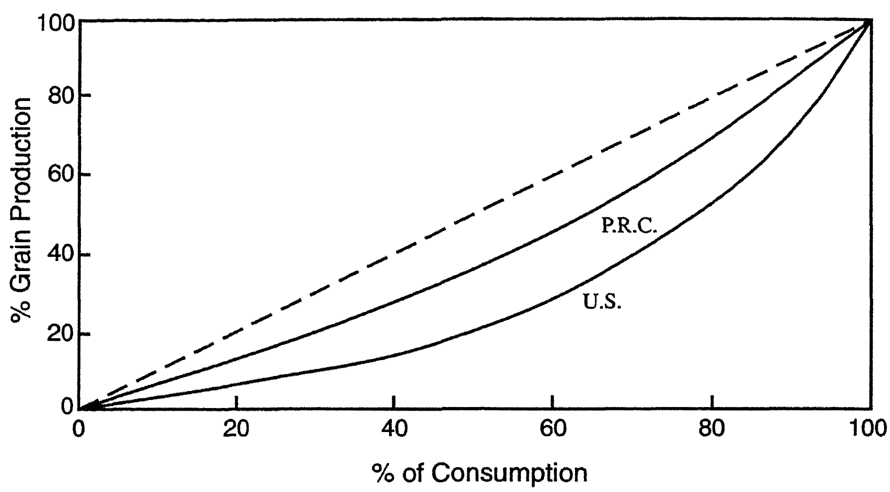

Figure 3. Lorenz Curve Illustration - Percent Consumption vs. Percent Grain Production, U.S. and P.R.C.

by the consumer in raw form. Instead, derived products such as meat, starch, oil, sweeteners, bread and many others represent the human consumption and use of grains and oilseeds. The geographical difference between where the grain is produced and where people reside (population) is thus a good indicator of transportation needs associated with domestically-consumed grain *if* the intermediate use (example, corn processing or livestock feeding) does not cause a large circuity between production and final consumption. For example, a transportation need results from the production of wheat in Kansas and the consumption of bread in New York. Regardless of whether the flour is processed in Kansas or in New York, the same transport infrastructure is needed. However, if the flour were milled in Florida but still consumed in New York, then a different need is implied. A large share of the grain products require a relatively direct route between the production region and the consumer because the intermediate processing occurs near production and/or consumption. A notable exception, however, may involve livestock feeding. The poultry industry is concentrated in the Southeast, and many cattle are fed in the Southwest. Both of these regions require in-bound shipments of corn and soybean meal from the central part of the U.S. and then outbound shipments of livestock and livestock products to population centers. Consequently, the geographical difference between grain production and population in this case underestimates the transportation need.

Another important caveat to the Lorenz-curve comparison of population and production is that the export infrastructure is not reflected. About 1/3 of the raw grain and grain products in the U.S. is exported, and a very large share of these exports depends on the rail and waterway infrastructure connecting the central part of the country to southern and northwestern ports.

The general shape of the Lorenz curves are based on 1988 data for the PRC and 1990 data for the U.S. PRC data were obtained from the *China Agriculture and Trade Report, 1991* and the U.S. data were obtained from *Crop Production, 1990 Summary*, USDA and the U.S. Bureau of the Census. Unlike the U.S., a large population resides in the rural areas in the PRC. As a result, production and consumption regions tend to be more highly correlated in the PRC. In the U.S., population is concentrated on both the east and west coasts while grain production is centered in the Midwest. In the PRC, however, population centers and farmland tend to coincide (see Figure 4). As increased pressures on farm land continue, due to urbanization growth and diet changes, China will likely experience a greater substitution of perishable products for grain around the urban areas. And to the extent that arable land constraints influence grain production, grain imports can be expected to develop.

In closing, we wish to highlight and summarize some of the important points and implications of our discussion:

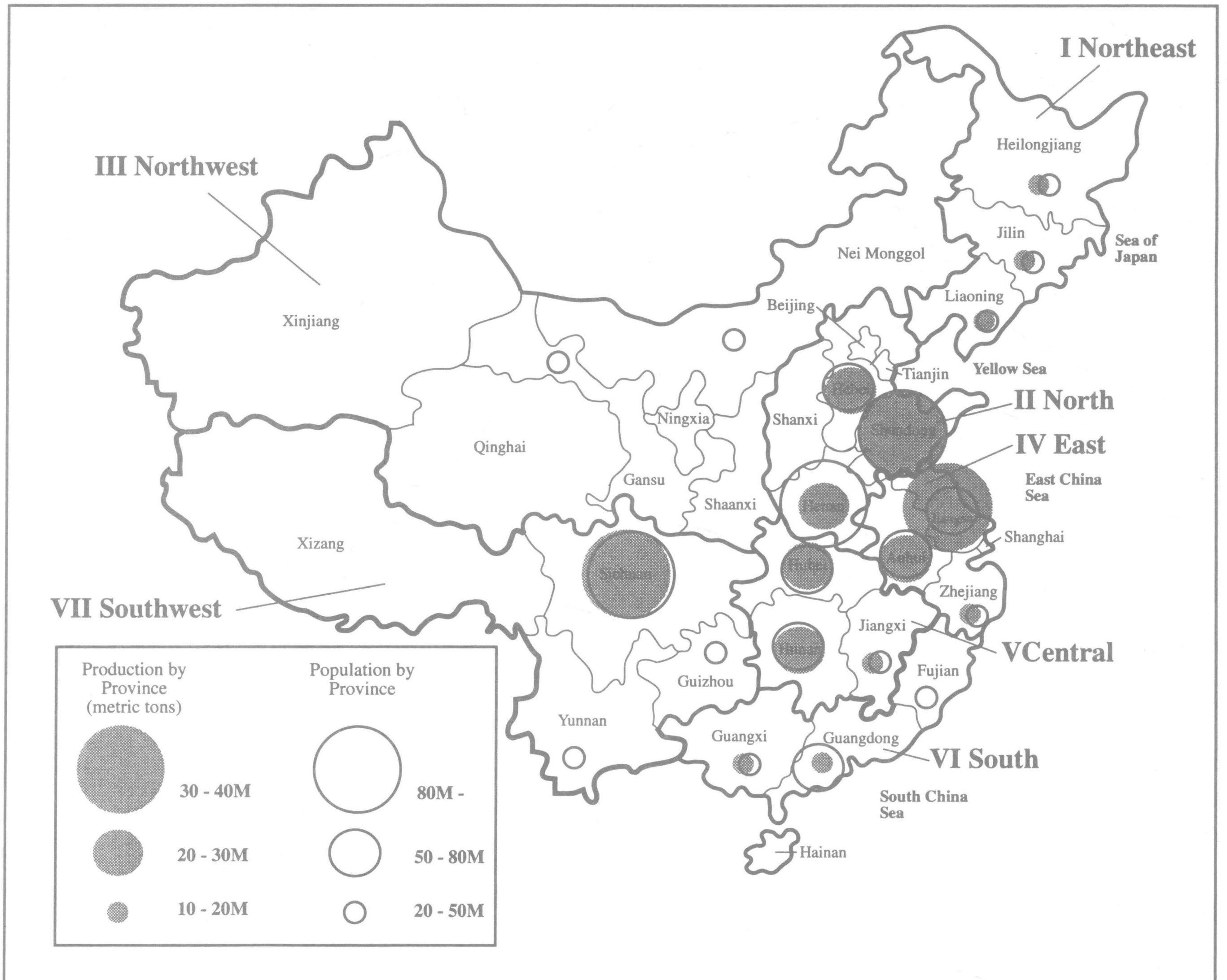

Figure 4. PRC Population and Grain Production

Concluding Remarks

1. Grain production, utilization, and prices are important factors determining the demand for grain transportation and infrastructure. However, the existing infrastructure has a large effect on where and how grain is produced/utilized and on the grain price differences between locations.

2. Government support for the infrastructure should be large because it will stimulate economic development and allow comparative-advantage effects to be realized. However, government investment decisions should be made carefully and based in large part on predicted comparative-advantage factors.

3. The comparative-advantage analysis should focus on all types of grain use (e.g., cereals and livestock feeding) as well as on production. China is entering "Stage II" of economic development, implying that it should place particular emphasis on where the livestock industry will evolve.

4. As development occurs, it is important that further investments *or* disinvestments respond to economic signals. The U.S. experience has demonstrated that it is often difficult to correct overinvestment decisions.

5. All transportation planning hinges on the degree to which China maintains a self-sufficiency policy at the local level. Continuance of such a policy will inhibit comparative-advantage effects and the resulting economic-development benefits. The transportation needs under such a policy would likely be considerably different than under a more market-oriented policy. The definition and forecast of self-sufficiency aspects must be done simultaneously with any transportation plan.

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Methodology and Data Systems for Study of Transportation

Won W. Koo and Jerry Fruin[1]

Introduction

The world economy tends to be increasingly specialized based on the principle of comparative advantage in producing agricultural and nonagricultural products. This is especially true for agricultural commodities, which require certain weather and soil conditions for production. The regional specialization has stimulated interregional trade. Consequently, an efficient transportation system plays an important role in shipping grains from producing regions to consuming regions. Producers' prosperity in agriculture is highly dependent upon a transportation system that delivers agricultural products as economically as possible. Consumers also rely on the transportation system to provide them with low cost and adequate supplies of food. The ability of a country's agriculture to compete in foreign markets for agricultural products is also highly dependent upon the country's agricultural productivity and the domestic and international transportation system. Thus, farmers, domestic consumers, and foreign buyers all can benefit from an efficient transportation system.

Interregional and international trade volume has increased dramatically over the last several decades because of regional specialization of agricultural production, steady world population growth, and increased demand for food in developing countries. A regional specialization in agricultural production can create regional disequilibrium; a region may produce larger quantities of few commodities than what the region needs and, on the other hand, may not produce enough other commodities to meet the region's consumption needs. A transportation system can connect all regions and create equilibrium conditions in the regions by shipping agricultural commodities from surplus regions to deficit regions. In addition, a transportation system can connect all countries, which are specialized in producing agricultural commodities on the basis of the principle of comparative advantage. Thus, an efficient transportation system is necessary for production specialization, which increases productivity and social welfare.

The objective of this study is to examine the basic modelling techniques applied to transportation systems for agricultural products to analyze how a transportation system can improve the efficiency of agricultural production through production specialization in the Chinese agricultural sector.

Evaluating transportation efficiency for grain shipments has generated volumes of studies on various aspects of it. Literature on the subjects covers such issues as optimal subterminal location (Ladd and Lifferth 1975; Hilger, McCarl, and Uhrig 1977; Baumel et al. 1975; Baumel et al. 1977; Koo and Cox 1977), interregional commodity flows (Fedeler, Heady, and Koo 1975; Koo and Thompson 1982; Koo and Cramer 1980; Binkley and Shahman 1980; Leath and Blakely 1971), and the potential impacts of changes in ocean freight rates and trade restrictions on agricultural trade (Koo 1984; Barnett et al. 1982; Koo and Uhm 1986).

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Interdependency Between Transportation System and Production Specialization

Chinese agriculture is characterized as small, substance, and labor intensive. About 80 percent of its more than 1.1 billion inhabitants live in rural areas, and 73.9 percent of the total labor force works in agriculture. The per capita income of the rural population ($165) is less than half that of the urban population ($340). Chinese policy makers know that their goal of quadrupling the national output by the year 2000 cannot be achieved unless the country's more than 800 million rural people become substantially more productive and prosperous. According to a World Bank report, Chinese agriculture will remain one of the largest and most important sectors of China's economy for the next two or three decades. In the year 2000, food expenditures will account for 50 percent of the household budget and more than 50 percent of the total labor force will work in agriculture. This implies that the Chinese agricultural sector will be of great importance to the Chinese economy.

The Chinese government has used a self-sufficiency policy of agricultural production at the local level because the country does not have an adequate transportation system to ship agricultural commodities from producing regions to consuming regions under production specialization. The policy caused inefficiency in agricultural production in China and recently was relaxed in an attempt to increase agricultural productivity. Agricultural production in China, however, is still largely regionalized and inefficient. The Chinese agricultural sector may be able to increase its productivity through increased production specialization and trade activities among regions and with other countries. However, a reliable transportation system must be established for regional specialization of agricultural production to be effective.

Review of the Theory of an Intermodal Transportation System

Modes of transportation used for grain shipments are rail, truck, and water modes. Based on the cost structure of these modes of transportation, the least cost mode of transportation can be expressed as a function of distances traveled.

In Figure 1, hypothetical short-run average cost curves are constructed for rail, truck, and water modes according to distance between origin i and destination j. The hypothetical average total cost curve of trucking, depicted

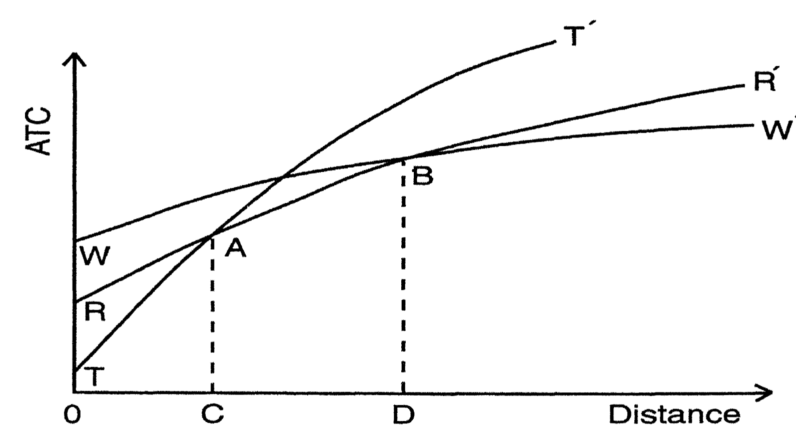

Figure 1. Hypothetical Average Total Cost Curves for Rail (RR', Truck (TT'), and Water (WW', Modes of Transportation for a Given Origin/Destination

as TT′, shows that trucks have a comparative advantage for short hauls because they have relatively insignificant fixed and terminal cost components compared to other modes of transportation. Similarly, with respect to the cost structure of the water mode, the average total cost curve can be shown as WW′ in Figure 1 since the water mode is generally recognized as the cheapest mode of transportation for bulk commodities over long distances. The cost structure for railways stands between truck and water modes as shown in Figure 1. The shape of these curves also reflects the concept of "rate taper," that is those rates increase at decreasing rates as distance increases due to economies of long-haul. The cost curves, however, can be changed depending upon other factors including volume, frequency of services, nature of terrain (uphill and downhill or degree of curvature), and commodity characteristics. In other words, the intercept of the curves and their shape depend upon the cost factors stated above and these factors contribute to variations in freight rates, given the distance from one origin/destination pair to another. If the freight rate is solely determined by the cost of providing services, the transportation market will be divided among modes according to the hauling distance. The trucking industry will have a natural advantage in the OC market, railways in the CD market, and water in distances greater than OD. In an open economy intermodal competition exists among modes of transportation to maintain and/or to expand their market share. Intramodal competition also exists in the regions served by several operators of the same mode (e.g., two railways). If rates are not regulated, railways can penetrate the markets for other modes of transportation. Railways by nature have an incentive to compete with other modes of transportation by engaging in discriminatory pricing policies to penetrate markets where other modes have a comparative advantage. Where intra- or intermodal competition exists, railways may lower rates below their average costs while charging higher rates elsewhere.

Transportation Models in an Open Economy

Two different types of models have been developed to solve the agricultural transportation problems: (1) stochastic behavior models and (2) deterministic optimization models. The stochastic behavioral model is used to examine and to understand pricing behavior of transportation modes, such as rail, truck, and water, and competition among these transportation modes. On the other hand, the deterministic optimization model is used to improve the efficiency of the grain distribution system. This paper is mainly focused on alternative optimization models, which can be used to optimize the Chinese agricultural transportation system.

The deterministic optimization models applied to transportation research are generally categorized into intraregional and interregional models. The intraregional model is designed to evaluate efficiency of physical distribution of agricultural products in a region, while the interregional model evaluates optimal flows of agricultural commodities from assembly warehouse to final destinations. This model is also capable of evaluating carrier capacity, handling and storage capacity, distribution, pricing, and competition among modes of transportation at national and international levels. This study will focus on interregional models mainly because interregional trade activities are directly related to production specialization.

Interregional studies are classified in terms of modelling into quadratic programming, linear programming, and network flow models. While the objective function and constraints are not necessarily linear in a quadratic programming model, linear programming and network flow models are based on an assumption that the objective function and constraints are linear. These interregional models are used to optimize freight flows, infrastructure, and modal choice, subject to the spatial equilibrium conditions. The model contains domestic and international trade activities which either can be exports of agricultural commodities to other countries or imports of agricultural commodities from other countries.

The spatial equilibrium of a single commodity with transportation costs is illustrated in Figure 2. The quantity of the commodity traded (OQ_t) is equal to the quantity exported (ef) and the quantity imported (gh) at the equilibrium price (OP_e). Inclusion of transportation costs, represented by a vertical distance ab, changes the spatial equilibrium conditions; it increases the price in the consuming region from OP_e to OP_m and decreases the price in the producing region from OP_e to OP_x. Changes in the equilibrium prices of a commodity in consuming and producing regions can be expressed as a function of transportation costs as follows (Kreinin 1979):

$$P_nP_m = \frac{e_X}{|e_m| + e_x} ab \quad (1)$$

$$P_eP_X = \frac{|e_m|}{|e_M| + e_x} ab \quad (2)$$

where e_x is the price elasticity of excess supply and e_m is the price elasticity of excess demand of the commodity. When several consuming and producing regions are included in trading more than one commodity, the effects of transportation costs on the spatial equilibrium condition cannot be obtained from Equations 1 and 2. The reason for this is that the equilibrium price in a consuming region is influenced by transportation costs from all producing regions to the consuming region. Similarly, the equilibrium price in a producing region is influenced by transportation costs to all consuming regions from the producing region.

To develop a spatial equilibrium model for the Chinese agricultural sector, China should be divided into several producing and consuming regions. Major ports also should be identified to connect domestic Chinese agriculture to the rest of the world.

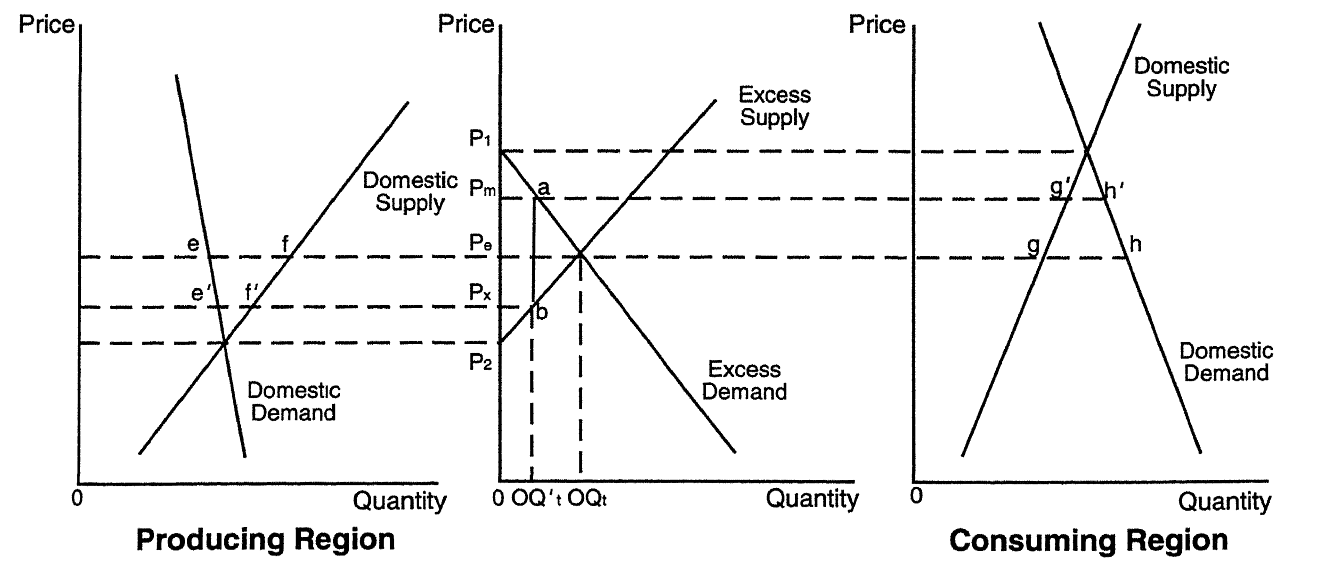

Figure 2. Two Regions Trade Model Under the Existence of Transportation Cost

A quadratic programming model has been used to optimize large-scale spatial equilibrium problems. Assuming linear supply and demand functions, the spatial equilibrium model was formulated in a quadratic programming algorithm by Takayama and Judge (1964). A similar model could be used for the Chinese agricultural sector. Under an assumption that China adopts an open economy to optimize its agricultural production and distribution system, the model should recognize both import and export activities. The objective function used in the model could be to maximize the net social pay-off function defined by Samuelson (1952). The objective function is calculated by integrating excess demand ($ED_n = a_{0n} - a_{1n} P_n$) for the nth importing country, excess supply ($ES_m = a_{om} - a_{1m}P_m$) for the m[th] exporting country, domestic demand ($D_j = b_{oj} - b_{ij}P_j$) for the j[th] consuming region, and domestic supply functions ($S_i = ß_{0i} + ß_{1i}P_i$) for the i[th] producing region with respect to prices as follows:

$$W = \sum_n \int ED_n dP_n + \sum_m \int ES_m dP_m + \sum_j \int D_j dP_j + \sum_i \int S_i dP_i - \sum_i \sum_j t_{ij} X_{ij} - \sum_i \sum_p t_{ip} X_{ip}$$
$$- \sum_p \sum_n t_{pn} X_{pn} - \sum_m \sum_p t_{mp} X_{mp} - \sum_p \sum_j T_{pj} X_{pj} \qquad (3)$$

where

P_n	=	price in importing country n,
P_i	=	price in producing region i,
X_{ij}	=	quantity of commodity shipped from the ith producing region to the jth consuming region
X_{ip}	=	quantity of commodity shipped from producing region i to port p
X_{pn}	=	quantity of commodity shipped from port p to importing country n
X_{pj}	=	quantity of commodity shipped from port p to consuming region j
X_{mp}	=	quantity of commodity shipped from exporting country m to port p
$t_{ij}, t_{ip}, t_{pn}, t_{pj}$	=	the corresponding transportation costs per unit of commodity

This objective function is quadratic in terms of the domestic and foreign prices. The first two summation terms in Equation 3 represent foreign exporters' and importers' welfare gains. The third and forth summation terms represent consumers' and producers' welfare gains in China. The next three summation terms represent transportation costs in exporting agricultural commodities; transportation costs in the ith producing regions to the jth consuming region (X_{ij}), those from the ith producing regions to port P, and those from port P to importing country m. The last two summations represent transportation costs in importing agricultural commodities; transportation costs from foreign exporting country m to port P in China, and those from port P to domestic consuming region j.

To accomplish a spatial equilibrium condition among these regions, the objective function is maximized subject to the following constraints:

$$\beta_{0i} + \beta_{1i}P_i = \sum_j X_{ij} + \sum_p X_{ip} \qquad (4)$$

$$b_{0j} - b_{1j}P_j = \sum_i X_{ij} + \sum_p X_{pj} \qquad (5)$$

$$\alpha_{0n} - \alpha_{1n}P_n = \sum_p X_{pn} \qquad (6)$$

$$a_{0m} + a_{1m}P_m = \sum_p X_{mp} \tag{7}$$

$$P_n - P_i \geq t_{ip} + t_{pn} \tag{8}$$

$$P_j - P_m \geq t_{mp} + t_{pj} \tag{9}$$

$$\sum_i X_{ip} = \sum_n X_{pn} \tag{10}$$

$$\sum_m X_{mp} = \sum_j X_{pj} \tag{11}$$

where Equations 4, 5, 6, and 7 satisfy the spatial equilibrium condition shown in Figure 2. The total domestic supply ($\sum_j X_{ij} + \sum_p X_{ip}$) and domestic demand ($\sum_i X_{ij} + \sum_p X_{pj}$) must satisfy domestic supply and demand schedules, respectively. Similarly, the total imports in country n ($\sum_p X_{pn}$) and the total exports in country m ($\sum_p X_{mp}$) must satisfy their import demand and export supply schedules, respectively. Equations 8 and 9 indicate that price differences between two regions must be greater than the corresponding transportation costs. Equations 10 and 11 represent export and import activities through ports, respectively. These constraints do not allow storage of agricultural commodities at ports.

Koo (1984) and Koo and Uhm (1986) developed a quadratic programming model similar to one developed by Takayama and Judge (1964). The objective function of the model was to maximize the net social pay-off function associated with producers in exporting countries and consumers in foreign importing countries. Domestic transportation activities were used to connect producing regions to domestic consuming regions and export ports and ocean transportation activities were used to connect export ports to foreign importing regions. This study did not allow carry-over stocks at each port. A different type of quadratic programming algorithm was also developed for large-scale spatial equilibrium problems (Plessner and Heady 1965; Meister, Chen, and Heady 1978). Because these models treated production activities as variable, only regional demand functions were specified rather than specifying demand and supply functions. The purpose of these models was to optimize grain livestock production activities in the United States.

Unlike quadratic programming models, linear programming models assume that the objective function and constraints are linear. This indicates that in the context of spatial equilibrium, quantities of a commodity demanded in consuming regions and importing countries and those supplied in producing regions and exporting countries are fixed rather than price dependent.

The objective function of this linear programming model is to minimize transportation costs in shipping agricultural commodities from producing regions to domestic consuming regions and foreign importing countries and those from exporting countries to domestic consuming regions as follows:

$$Z = \sum_i \sum_j t_{ij} X_{ij} + \sum_i \sum_p t_{ip} X_{ip} + \sum_p \sum_n t_{pn} X_{pn} + \sum_m \sum_p t_{mp} X_{mp} + \sum_p \sum_j t_{pj} X_{pj} \quad (12)$$

This objective function is optimized subject to the following constraints:

$$\sum_j X_{ij} + \sum_p X_{ip} \leq S_i \quad (13)$$

$$\sum_p X_{mp} \leq ES_m \quad (14)$$

$$\sum_i X_{ij} + \sum_p X_{pj} \geq D_j \quad (15)$$

$$\sum_p X_{pn} \geq ED_n \quad (16)$$

$$\sum_i X_{ip} = \sum_n X_{pn} \quad (17)$$

$$\sum_n X_{mp} + \sum_j X_{pj} \quad (18)$$

Where

S_i = quantity of commodity supplied in the ith producing region
ES_m = quantity of commodity exported in the mth exporting country
D_j = quantity of commodity demanded in the jth consuming region
ED_n = quantity of commodity imported in the nth importing country
Other variables have been defined previously.

Equations 13 and 14 represent supply constraints in domestic producing regions and exporting countries, indicating that the total quantity shipped out in a region (country) should be less than or equal to the total quantity available in the region (country). Equations 15 and 16 represent demand constraints in domestic consuming regions and importing country, indicating that the total quantity of commodity received in a region (importing country) must be larger than or equal to the quantity needed in the region (importing country). Equations 17 and 18 represent export and import activities through ports.

The model simply determines flows of commodities from supply regions to consuming regions on the basis of an objective function that minimizes the total transportation costs. Since the model has demand and supply constraints in each consuming and producing region, respectively, and has export supply and import demand constraints in each exporting and importing country, respectively, it satisfies the spatial equilibrium condition in the study area.

The model is simple to use and very efficient in terms of computer operation. Theoretically, the model does not have any limitation in size and complexity. Consequently, it has an advantage in formulating a large-scale model with great detail. The limitation of the model in solving spatial equilibrium problems is the assumption of fixed demand and supply. The model cannot recognize the price response of supply and demand in each region. Hence, the solution obtained from the model cannot be viewed as a global optimal solution, but as a conditional optimal solution under predetermined demand and supply conditions. Another advantage of this linear programming model over a quadratic programming model in applying the Chinese agricultural sector is that the linear programming model does not need to estimate price dependent demand and supply equations with time series data. It is difficult to estimate these equations mainly because of unavailability of the data.

More recently, a network flow algorithm was developed by Ali et al. (1984) to solve the linear programming transportation model. Unlike previously developed network models, the network flow algorithm developed by Ali et al. recognizes more than one commodity and is two to three times faster than the general linear programming simplex algorithm. The network flow algorithm was applied to the U.S. grain transportation system by Barnett et al. (1982) to evaluate U.S. port capacity in exporting grains. The model treated quantities of grain handled at each U.S. port as endogenous variables. Port capacity was evaluated on the basis of shadow prices estimated from the model. Multiproduct network flow models may be superior to simple linear programming models in terms of computational efficiency. However, the multiproduct network model can only optimize the flow of commodities from producing regions to consuming regions. A model including production and transportation activities to optimize production location of commodities and their flows cannot be efficiently accomplished by using the multiproduct network flow algorithm.

Transportation Models with Production Activities

The transportation models are not capable of optimizing agricultural production on the basis of the principle of comparative advantage. To optimize the Chinese agricultural production and the transportation system needed under the production specialization, production activities should be added to the transportation models. The production activities for agricultural commodities should be constrained by resource endowments, such as arable land in each region.

When the production activities are included in the linear transportation model, the objective function is to minimize production and marketing costs as follows:

$$Z = \sum_{i} PC_i A_i + \sum_{i}\sum_{j} t_{ij} X_{ij} + \sum_{i}\sum_{p} t_{ip} X_{ip} \quad (19)$$
$$+ \sum_{p}\sum_{n} t_{pn} X_{pn} + \sum_{m}\sum_{p} t_{mp} X_{mp} + \sum_{p}\sum_{j} t_{pj} X_{pj}$$

where pc_i is production costs of a crop in producing region i, and A_i is total arable land in producing region i. The other variables have been defined.

The objective function is optimized subject to the following constraints:

$$A_i \leq L_i \quad (20)$$

$$\sum_j X_{ij} + \sum_p X_{ip} \leq A_i Y_i \quad (21)$$

$$\sum_p X_{mp} \leq ES_m \quad (22)$$

$$\sum_i X_{ij} + \sum_p X_{pj} \geq D_j \quad (23)$$

$$\sum_p X_{pn} \geq ED_n \quad (24)$$

$$\sum_i X_{ip} = \sum_n X_{pn} \quad (25)$$

$$\sum_n X_{mp} = \sum_p X_{pj} \quad (26)$$

where L_i is total arable land in producing region i, Y_i is yield of a crop in producing region i, and the other variables are previously defined. Equation 20 represents the land constraint in producing region i, indicating that the total arable land in a region should be larger than the land used for agricultural production. Equation 21 represents the supply constraint in producing region i. In this equation the total supply is equal to $A_i.Y_i$. Other equations have been explained previously.

The production activities can be included to the quadratic programming model in the same way as that included in the linear programming model. In this case the objective function is to maximize social welfare in exporting and importing countries minus production and transportation costs as follows:

$$W = \sum_i \int S_i dP_i + \sum_m \int ES_m dP_m + \sum \int D_j dP_j + \sum_n \int ED_n dP_n - \sum_i \sum_j t_{ij} X_{ij} - \sum_i \sum_p t_{ip} X_{ip} - \sum_p \sum_n t_{pn} X_{pn} + \sum_m \sum_p t_{mp} X_{mp} \sum_p \sum_j t_{pj} X_{pj} \quad (27)$$

This objective function is optimized subject to a set of linear constraints, which consists of Equations 4 through 11 and Equations 20 and 21.

Since the Chinese agricultural sector needs to optimize agricultural production based on the principle of comparative advantage and agricultural distribution system, the models with production activities will be more appropriate than the transportation models.

The Data System

To develop the data system needed for interregional modeling, China should be divided into a number of producing regions and a number of domestic consuming regions. Producing regions should be delineated on the basis of soil, climate, and other crop production factors. Consideration should also be given to establishing the regions along historical statistical or political lines to reduce data collection and reconciliation problems. An example for the U.S. would be to build producing regions that consist of several of the U.S. Department of Agriculture crop reporting districts.

Domestic consuming regions should be delineated based on population density, livestock producing areas, and food processing centers.

Exporting and/or importing ports should be defined. Depending on model complexity, it may be desirable (or necessary) to divide the rest of the world up into importing and exporting regions by commodity type based on historical data.

Transportation activities for shipping agricultural commodities from producing regions to domestic consuming regions consist of domestic and ocean transportation activities. The domestic transportation system includes the highway, railroad and waterway transportation systems between producing and consuming regions. Ocean transportation includes transportation from exporting countries to importing countries.

To operationalize the transportation activities for optimization modeling a link-node transportation network must be defined. At least one node is needed for each of the producing and consuming regions, for each port, and for each of the rest of world exporting and importing regions. Nodes for producing and consuming regions generally should be regional production or population centroids although transportation centers may be appropriate.

The nodes (centroids of producing and consuming regions, ports, etc.) must then be linked by the transportation activities that will allow goods to be shipped among nodes. Data requirements for the transportation activity or link include the cost to move goods over the link, the capacity of the link, and link's other characteristics such as seasonal limitation for waterway movements.

Multiple links may exist between regions if the nodes are served by both highway and rail (or water) or if there are multiple routes (2 or more highways or railroads between nodes). Link capacity may be limited by the capacity of the way, other required traffic movements, or equipment limitations. To ease data handling and collection, all nodes do not have to have links connecting them if traffic between the two nodes is unlikely for commercial purposes or impossible because of transportation limitations.

The optimization models which are applicable to the Chinese agricultural sector require production activities for each crop to be considered in a producing region. Data required for the production activities include production costs for individual crops in producing regions, yields of individual crops in producing regions, and the total arable land in producing regions. Additional data needed are labor, fertilizer, machinery time, and other scarce resources required to produce a unit of each crop. This type of data is typically obtained from "crop budgets" or farm management records in the United States. Multiple production activities for a crop may be necessary if more than one production method is to be considered, i.e., high or low fertilizer levels. Data on the quantity available of scarce resources such as land, labor, and fertilizer in each producing region are required as constraints for the model.

Optimization models also require data on the consumption of each commodity in each consuming region. This may be obtained from historical consumption data or may be computed based on population and dietary requirements. Data is needed for the historical use or planned requirements of food processing plants and/or animal feeding operations so these requirements can be included in the model.

In addition, the model needs exports of individual crops in exporting countries and imports of individual crops in importing countries. For the quadratic programming model, several years of export and import data are needed to estimate export supply equations in each exporting country and import demand equations in each importing country.

Concluding Remarks

Many different mathematical models could be developed to optimize the Chinese agricultural sector. Choice of model depends upon the production and transportation issues to be analyzed and the objectives of the study. Developing better models could be accomplished with innovations in computer technology, programming algorithms, and data availability on agricultural transportation.

One alternative in modelling the Chinese agricultural sector is to combine production and transportation activities. Interregional transportation models have been used to optimize grain transportation activities without considering agricultural production activities. Optimizing the Chinese transportation system may not provide a global optimal solution for the Chinese agricultural system mainly because production specialization is interrelated to transportation activities. The transportation model with production activities will optimize agricultural production based on the principle of comparative advantage and the marketing system in shipping agricultural commodities from producing regions to final destinations.

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An Application of a Spatial Equilibrium Model to Analyze the Impact on China's Trade of a Policy Change

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Introduction

China's natural resource endowment varies significantly from one area to another over the 9.6 million square kilometers of its land areas. Very different growing conditions across its 97 million hectares of farmland have created a diverse agricultural production pattern. Maintaining grain self-sufficiency is a necessity at the household, and provincial levels because of limited transportation and marketing facilities and fragmented land use patterns. In general, people consume locally produced goods and the regional consumption pattern is more diverse than the regional production pattern. Because of the diversity in China's agriculture, the impact of changes in policy on its economy and international agricultural markets can be more accurately predicted from a regionalized model rather than from an aggregate national model.

The impact on international agricultural markets of a change in China's agricultural sector depends on how policy, technology, and other factors affect its regional production, distribution, and consumption. We developed a multi-crop spatial price equilibrium (SPE) model allowing interactions among commodities and across regions to capture the diversity in China's production and consumption patterns. In this regionalized multi-crop model, the solution algorithm will find a market equilibrium condition subject to each region's resource and market constraints.

Despite a series of agricultural reforms which have been adopted in China since 1979, the desire to maintain maximum food self-sufficiency is still an important goal for China's government. We use this model to analyze the impact on China's budget expenditures, interregional trade and international trade if China were to maintain self-sufficiency of wheat, the most important agricultural import. We also formulated an alternative scenario to analyze the impact of free trade on China's consumption costs, interregional and international agricultural trade.

Model Description and Characteristics

The mathematical framework for the multi-crop SPE model developed in this paper follows the development of Takayama and Judge (1971) who specified appropriate algorithms to find the optimum solution. The model assumes the existence of known linear supply and demand functions for each region and are specified as:

$PD_{ik} = a_{ik} + \Sigma_m b_{imk} QD_{ik}$ ..... demand function
$PS_{ik} = d_{ik} + \Sigma_m e_{imk} QS_{ik}$ ..... supply function

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where

i = 1...15 regions

k = 1...7 major field crops

a_{ik} = the intercept of the demand response function for crop k in region i.

b_{imk} = the slope of the demand response function of PD_{ik} to QD_{ik} of the m[th] commodity in region i where, if m=k, then $b_{imk} < 0$, else b_{imk} is unrestricted in sign.

d_{ik} = intercept of the supply response function for crop k region i.

e_{imk} = the slope of the supply response function of PS_{ik} to QS_{ik} of the m[th] commodity in region i where, if m=k, then $e_{imk} > 0$, else e_{imk} is unrestricted in sign.

QD_{ik} = quantity demanded at different price levels for crop k in region i.

QS_{ik} = quantity supplied at different price levels for crop k in region i.

PD_{ik} = prices at different output levels for crop k in region i.

PS_{ik} = supply prices at different output levels for crop k in region i.

The quasi-welfare objective function, W, can be specified as:

$$W \equiv \int^{q} PD'_{ik}\, d\eta_i - e^{q}\, PS'_{ik}\, d\xi_{ik} \qquad (1)$$

$$\equiv \int^{q} (PD_{1i}\, d\eta^1_i + \cdots + PD_{im}\, d\eta^m_i + \cdots + PD_{ik}\, d\eta^k_i)$$

$$- \int^{q} (PS_{1i}\, d\xi^1_i + \cdots + PS_{im}\, d\eta^m_i + \cdots + PS_{ik}\, d\eta^k_i \qquad (2)$$

The multi-crop SPE model presented in this paper contains region specific and crop specific demand and supply functions. The matrix consisting of own and cross-price coefficients of demand and supply functions is not symmetric and therefore, violates integrability conditions[2]. Consequently the objective function formulated as equation (1) becomes unsolvable. According to Takayama and Judge, the objective function can be reformulated as the quadratic net revenue function in order to find the equilibrium condition:

$$R = \Sigma_k \Sigma_i (PD_{ik}\, QD_{ik} - PS_{ik}\, QS_{ik}) - \Sigma_k \Sigma_i T^k_{ij} M^k_{ij} \text{ .... } (1)'$$

Subject to

$PD_{ik} = a_{ik} + \Sigma_m b_{imk} QD_{ik}$ ..... demand function

$PS_{ik} = d_{ik} + \Sigma_m e_{imk} QS_{ik}$ ..... supply function

$QD_{ik} \geq QS_{ik} + M^k_{ij}$ .... product balance

[2] *To be able to integrate this quasi-welfare function, the following properties must hold:*
$\partial^2 W_i / \partial QD_{im}\, \partial QD_{ik} = \partial PD_{ik} / \partial QD_{im} = \partial PD_{im} / \partial QD_{ik} = \partial^2 W_i / \partial QD_{ik}\, \partial QD_{im}$
$\partial^2 W_i / \partial QS_{im}\, \partial QS_{ik} = \partial PS_{ik} / \partial QS_{im} = \partial PS_{im} / \partial QS_{ik} = \partial^2 W_i / \partial QS_{ik}\, \partial QS_{im}$
The economic interpretation of these integrability conditions means that the magnitudes of substitution and/or complementary of any pair (m and k) of commodities must be equal in the corresponding pair (k and m) of demand and supply functions (Takayama and Judge, 1971, p. 116).

$PD_{ik} - PS_{ik} \leq T^k_{ij}$ .... market equilibrium all variables are positive

T^k_{ij} = transfer costs for moving commodity k from region i to j.

M^k_{ij} = amount of crop k transferred between regions i and j.

Takayama and Judge (1971) proved that this type of programming formulation, if solvable, would yield a solution that satisfies the competitive equilibrium condition. The equilibrium prices and quantities for individual commodities in a specific region are then used to calculate the value of net social benefits (NSB).

This linearly constrained quadratic program can be solved using the reduced-gradient algorithm (Wolfe, 1962) in conjunction with a quasi-Newton algorithm (Davidson, 1959) to find the solution to meet the market equilibrium condition. GAMS (Brooks, et al.) software is used to solve the linearly constrained quadratic program for the model. An extensive review of available SPE studies (Koo and Uhm, Boyd and Krutilla, Koo et al., Chien and Epperson, Anania and McCalla, Cramer et.al. and others) indicates that those SPE models are either single commodity multi-region models or multi-commodities and multi-region models for which all regions are forced to have identical demand and supply functions (e.g. assuming no cross-price effects). The multi-crop SPE used in this study differs from other SPE studies in that it encompasses seven commodities with multiple cross price effects in the supply and demand functions. SPE model developed under this study contains region specific and crop specific supply and demand response functions.

Data

A multi-crop SPE model requires 4 data sets: 1) own and cross-price elasticities of supply and demand; 2) provincial crop prices; 3) quantity produced and consumed in the base year; and 4) the transfer costs between possible pairs of 15 regions[3]. Crops included in the model are: rice, wheat, corn, soybeans, cotton, peanuts, and rapeseed.

Demand and Supply Parameters

The coefficients of the demand and supply curves are derived using the elasticities in the SWOPSIM (Static World Policy Simulation Model, Roningen et al.,). The slope coefficients (b_{imk} and e_{imk}) are calculated by multiplying the elasticities (as shown in Table 1) by the ratio of quantity to price (or cross-price). Provincial prices are shown in Table 2. The slope coefficients are then substituted into the corresponding demand and supply functions to calculate the intercept parameters. These calculations are shown below.

$$b_{imk} = \eta^D_{mk} \left(QD^0_{ik} / P^0_{ik} \right)$$
$$a_{ik} = QD^0_{ik} \left(1 - \Sigma_m \eta^D_{mk}\right)$$
$$e_{imk} = \eta^S_{mk} \left(QS^0_{ik} / P^0_{ik} \right)$$
$$a_{ik} = QS^0_{ik} \left(1 - \Sigma_m \eta^S_{mk}\right)$$

where

[3] *In the model, China is divided into 14 regions plus a trade region. Several small provinces are aggregated into fewer large regions. Fifteen regions are: 1. Heilongjiang, 2. Lijil (includes Liaoning and Jilin), 3. Shandong, 4. Hebeti (includes Hebei, Beijing, Tianjin), 5. Henan, 6. Shashaa (includes Shanxi and Shaanxi), 7. Gannei (includes Gansu, Nei Monggol, Ningxia, Xingjiang and Qinghai), 8. Zheianh (Zhejiang and Anhui), 9. Jianshan (Jiangsu and Shanghai), 10. Hubei, 11. Hujiang (Hunan and Jiangxi), 12. Ggnanfu (Guangdong, Guangxi and Fujian), 13. Sichuan, 14. Guizyunn (includes Guixhou, Yunnan, and Xizang), and 15. Port as a composite region to represent trade with outside world. Quantity demanded in the Port region is an export and quantity supplied from the Port region is an import to China.*

η^D_{mk} = own price (m = k) or cross-price elasticity of demand for the k^{th} commodity.

QD^0_{ik}= quantity of the k^{th} commodity consumed in the i^{th} region in 1988.

P^0_{ik} = price of the k^{th} commodity in i^{th} region in 1988.

η^S_{mk} = own price (m = k) or cross-price elasticity of supply for the k^{th} commodity.

QS^0_{ik}= quantity of the k^{th} commodity supplied in the i^{th} region in 1988.

Regional Production and Consumption of Modelled Commodities

Quantity supplied for each individual crop in the base year (1988) is assumed to equal to that year's production. Provincial crop production is available from *China's Agricultural Yearbook*, 1989 issue. There are no published provincial consumption data by individual crops. Authors developed procedures to estimate provincial consumption by crop as shown in Tables 3 and 4.

Transportation Cost Matrix

A major population center with a train station serves as a reference point for each region (Table 5). A computerized digitizer was used to get actual distances by tracing rail lines between reference points as shown by a World Bank map of China's railways. These distances (in kilometers) were multiplied by a tapered scale of rates in yuan per ton-kilometer to derive transportation costs for all possible pairs of trade flows among 15 regions.

Scenarios

The base model is constructed based on the assumption that due to capacity and other policy constraints, the transportation costs which are calculated as rail rates times distance are not true constraints upon commodity transfers. Instead, to reflect the existing policy measures in dictating the distribution of China's major agricultural commodities, the transfer costs for crop k between two regions (i and j) are derived as follows:

$$T^k_{ij} = \begin{cases} PD^0_{ik} - PS^0_{jk} & \text{If } PD^0_{ik} > PS^0_{jk} \\ 0.001 & \text{If } PD^0_{ik} = PS^0_{jk} \\ C_{ij} & \text{otherwise} \end{cases}$$

where C_{ij} is the actual rail rate between regions i and j.

In addition to the base run, two more scenarios - maintaining self-sufficiency and limited free trade, are formulated to analyze the impact of China's alternative policies on its domestic and international agricultural markets.

Base Model Validation

The projected magnitudes for all the decision variables of prices, quantity supplied and quantity demanded deviated less than 15 percent from the 1988 levels. Since there are no data available on 1988 interregional trade flows, the validation was not done on this variable. The projected prices, quantity supplied, and quantity demanded for corn, rice, soybeans, and cotton deviated less than 5 percent from their 1988 actual levels. For rapeseed and peanuts, the deviations for these variables are less than 10 percent. Wheat prices and imports have deviations ranging from 11 to 14 percent. The infrastructure capacity is a real constraint in interregional trade. This might explain the poor model results for projected wheat imports which were 11 percent lower than 1988 actual wheat imports in the base run.

Self-sufficiency

Since the 1979 rural economic reforms, the government of China (GOC) has adopted many reform measures to increase incentives in agricultural production. The adoption of the household production responsibility system allows farmers to sell their surpluses after meeting quota procurements. Even though grain procurement prices have increased substantially over the last 10 years, the returns on grain crops still lag behind cash crops such as vegetables and tobacco. With the increase in freedom, farmers shifted production into cash crops and livestock products. On the other hand, urban subsidies for staples remained intact. As a result, grain production fell short of targeted production and wheat imports continued to increase since 1985 when the GOC implemented a two-tier pricing system[4]. In 1989, the GOC decided to make grain production, especially wheat, a top priority again. We formulate a scenario in which China is to achieve self-sufficiency of grains and oilseeds. Among seven crops, wheat is the only commodity that China has to import. Maintaining grain and vegetable oil self-sufficiency would mean that wheat imports (accounted for about 15 percent of China's wheat consumption in 1988) are reduced to zero. The self-sufficiency run also assumes that there are no changes in regional demand for these 7 crops.

Free Trade

In this scenario the transfer costs are the current rail rates for domestic regions. This scenario assumes that the current Chinese investment strategy will increase rail capacity so that it no longer constrains crop shipments. In general, the rail rates are much lower than the ones used in the base model.

Results

This paper focuses on the overall effects on trade. In the base run, many pairs of the transfer costs are derived from the price differentials. The interregional trade flows estimated from the base run can be interpreted as free trade under the existing price structure. China's procurement and distribution policies have created a price structure that does not reflect the relative scarcity of resource endowments in different regions. Regional price differentials are much smaller than their differentials in the costs of production. The small price differentials between surplus and deficit regions induced very little additional production from surplus regions. Consequently, the optimum trade flow patterns create a very low level of interregional flow. The consumption patterns are just as diverse as production patterns.

In the base run, interregional trade accounts for about 8 percent of domestic consumption of these 7 major agricultural commodities (Table 6). Food grains of wheat and rice have the lowest proportion of their consumption come from

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[4] *On the procurement, the GOC negotiated a contract with peasants prior to planting. The state could procure beyond the contracted amount only at "negotiated" prices. The GOC distributes most agricultural commodities to urban residents and specialized households at fixed low prices. Under the new system, the GOC negotiates the quantity from the peasants and distributes them to the industrial users at "negotiated" prices that the GOC has to pay.*

interregional trade, with 2 and 6 percent respectively. About 98 percent of wheat produced in China is used within the region in which it is produced. Domestic wheat production only supports 86 percent of domestic consumption. Under this scenario, China relies on imports to support about 14 percent of wheat consumption. Cotton is the most traded commodity in China, with interregional trade accounting for about 31 percent of domestic use. Most state-owned textile factories are located in a few large cities such as Guangzhou and Shanghai, contributing to a much higher level of cotton interregional trade.

International trade (imports plus exports) of these 7 crops accounts for about 7 percent of the domestic consumption in the model. The amount of wheat imported is about to equal to the total exports from corn, rice, soybeans, cotton, and peanuts. Using world prices, China enjoyed a surplus balance of payments valued at 3.4 billion yuan[5] from these 7 crops. China's consumers spend about 173.2 billion yuan (12.4 percent of GNP) on these 7 crops. About 35 percent (Table 7) of these expenditures are on rice and 31 percent on wheat.

The impacts on regional quantity supplied and demanded are estimated to be small except for wheat under the self-sufficiency scenario. The decision not to import any wheat into China would cause regional wheat prices to increase by 65 to 80 percent. A price increase of this magnitude would cause domestic wheat production to increase by about 9 percent and consumption to decrease by about 6 percent. The impact on other crops is small. Two reasons contribute to the very small impact on quantity supplied of other crops. First, the cross price effects (reflected in very small elasticities) built in the model are very small. Second, the land constraints are not directly built in the model and only implied in the upward sloping regional supply functions. The authors believe the elasticities in SWOPSIM study are too low and indicate that the estimates are based on data from the period when price was merely an administrative measure for procurement and distribution policies and could not serve as an allocation mechanism. The cross price relations would become much stronger if China were to continue economic reforms. Further study is needed to collect relevant data to improve the estimates of price response coefficients. Land constraints would also improve the study. However, they are probably not as critical as more responsive cross relations which will imply much strong resource constraints built in the supply functions.

Impact on interregional trade

The impact on interregional trade of alternative scenarios is much stronger than the impact on production or consumption. Maintaining wheat self-sufficiency, although it would increase interregional trade, would also cause a higher level of regional self-sufficiency. The ratio of a region's own production to its own consumption would increase from 86 percent to 88 percent. However, interregional trade flows would also increase, with wheat increasing by about 4 times (Table 6) from the base to offset the decrease in reliance on international markets. With very small cross-price coefficients, the impact on the interregional trade for other crops would be small.

If China were to improve transportation capacity and allow free trade, the ratio of in-region use of these 7 crops would decrease by about 3 percent while the interregional trade would increase by about 12 percent. The increase is the most apparent for wheat. This indicates that the GOC has interfered with wheat production and consumption through pricing measures creating very small price variations between deficit and surplus regions. Under the free trade scenario,

[5] *In 1988, the foreign exchange rate is one US$ equals to 2.76 yuan. Since then, the yuan has been depreciated many times. In January 1992 the rate is about 1 US$ to 5.4 yuan. The port price is used as the proxy for the world prices in calculating net foreign exchange earnings for the model.*

China's in-region wheat use would decline from 84 percent in the base run to 72 percent. Interregional wheat trade would increase by 7 fold. Corn would increase by about 31 percent, peanuts by 5, rice and rapeseed by 2.

Impact on trade

If China were to maintain wheat self-sufficiency, wheat imports would decrease by about 13.7 million metric tons. China's wheat accounted for about 20 percent of global wheat trade. Assuming a price elasticity of .4 in the world wheat market, a decrease of 20 percent in quantity demanded for wheat in the world would depress world wheat price by about 50 percent. The decrease in wheat imports is projected to have only very small impact on the exports of other crops.

The free trade scenario would have quite a significant impact on China's trade. Wheat imports would increase by about 5 percent to 14.7 mmt. Exports of all other crops would increase with peanuts by 19 percent, followed by soybeans 8, rice 4, corn 3 and cotton 2 percent.

Impact on prices, costs and exchange earnings

To reduce wheat imports to zero would cause wheat price to increase by an average of 62 percent (Table 6). Corn and rice would increase by about 14 and 12 percent respectively while the impact on prices of other crops is very small. Wheat consumers would benefit the most from free trade with prices decreasing by 6 percent. Domestic soybean and peanut prices would increase by about 4 percent each. The price impact on other crops is fairly small.

If China were to maintain self-sufficiency, the total exchange earnings from these 7 crops would increase by about 188 percent (or about 6 billion yuan). However, to save this 6 billion yuan from wheat imports, China's consumers have to pay dearly. The costs to consumers would increase by 22 percent or 30 billion yuan. Under the free trade scenario, the exchange earning would increase by about 7 percent (about 200 million yuan) while costs to consumers would increase by about 1 percent (about 2.3 billion yuan). The real gain for the GOC is the saving on subsidies. In 1988, the GOC spent about 30 billion to make up the difference between procurement and urban coupon prices which created a price structure showing very little price variations across regions. Under the free trade scenario, the overall effect on prices is very small. If annual subsidies of 30 billion yuan were used in the improvement of transportation facilities, the increase in interregional trade flow would probably create a price structure similar to the base run. The infrastructure investment would have a much more significant impact on China's economic development.

Conclusions

This paper adopts a multi-crop SPE which differs from most other SPEs in that it is multi-region with multi-crop cross elasticities built into the model. Results from this model indicate that maintaining self-sufficiency and expanding transportation capacity would increase interregional trade by 23 and 57 percent respectively. The impact on international trade is also quite significant, with a decline of 52 percent under a self-sufficiency scenario and an increase of 5 percent for the transportation scenario.

Chinese consumers would have to pay much higher prices to increase domestic wheat production. The increase in costs to consumers is far higher than the savings from exchange earnings by about 2 billion yuan. The real savings for China under the free trade scenario are the savings on the GOC's subsidy expenditures to reduce price differentials between producers and consumers.

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Table 1. Price elasticities of supply and demand

	corn	wheat	rice	soybeans	rapeseed	cotton	peanuts
				Supply			
corn	.18	-.03	-.01				
wheat	-.03	.15	-.02		-.010		-.02
rice	-.01	-.02	.15				
soybeans				.10	-.02		-.02
rapeseed		-.01		-.02	.10		-.01
cotton						.10	
peanuts	-.02		-.02	-.01		.10	
				Demand			
corn	-.13	.02					
wheat	.02	-.10	.02				
rice		.02	-.12				
soybeans				-.24			
rapeseed					-.44		
cotton						-.10	
peanuts							-.44

Table 2. Provincial price major 7 crops in China, 1988

	Corn	Soybeans	Rice	Wheat	Cotton	Peanuts	Rapeseed
Heilongjiang	318.2	741.6	503.4	485.2	4154.4	1158.6	1053.8
Lijil	308.8	791.4	496.4	600.2	4154.4	1158.6	1053.8
Shandong	337.6	830.0	496.4	440.8	3851.6	1089.8	1053.8
Hebeti	349.6	830.0	700.0	514.6	3915.4	1198.6	1053.8
Henan	384.0	828.6	496.4	482.0	4026.6	1089.8	1053.8
Shashaa	384.0	538.2	277.4	363.6	3956.2	971.8	832.2
Gannei	368.2	819.8	504.0	489.4	3956.2	971.8	828.4
Zheianh	328.8	813.2	392.8	454.8	3837.6	1234.0	940.4
Jianshan	334.8	800.0	419.8	448.2	4154.4	1234.0	1053.8
Hubei	288.6	830.0	350.2	434.0	3657.2	960.0	978.0
Hujiang	472.8	830.0	348.8	448.2	3698.6	1600.4	1006.0
Ggnanfu	317.6	830.0	391.2	424.0	4154.4	1234.3	1053.8
Sichuan	403.0	800.2	348.0	397.2	4154.4	1234.0	956.8
Guizyunn	457.0	830.0	388.2	423.4	4154.4	NA	806.4
Port	461.6	1201.5	598.2	591.6	4837.3	2174.5	936.6
Total	351.2	864.0	437.4	447.2	3767.6	1192.0	NA

Table 3. Regional production, consumption for grain crops in China, 1988 (1,000 thousand tons).

	Corn		Soybeans		Rice		Wheat	
	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
Heilongjiang	6838	5438	3844	2438	2435	2141	2504	2575
Lijil	19120	14292	1477	839	5726	5809	134	158
Shandong	11494	8090	909	510	484	508	14401	17677
Hebeti	9019	10040	557	505	1338	1339	9305	11000
Henan	6002	5292	699	491	1622	1879	15210	20611
Shashaa	5565	7086	584	593	943	1036	6403	8106
Gannei	6439	7308	619	636	988	817	9747	11383
Zheianh	1153	942	827	574	24659	23595	6940	7732
Jianshan	2483	2627	637	545	18321	13494	9226	7918
Hubei	920	1758	245	373	15761	11908	4081	3605
Hujiang	194	597	352	1646	38501	33510	367	373
Ggnanfu	803	2524	325	836	31359	33304	334	386
Sichuan	5825	4649	318	202	20434	21934	5720	7180
Guizyunn	4121	5518	204	224	7646	11766	1358	2349
Port	3810		1178		717			
Total	79976	76166	11597	10418	163764	163047	85730	101060

Table 4. Regional production and consumption for oilseed crops in China, 1988

	Cotton		Peanuts		Rapeseed	
Region	Production	Consumption	Production	Consumption	Production	Consumption
Heilongjiang	0	79.3	1	0.1	38	6.9
Lijil	6	245.9	140.6	108.1	0.0	0.0
Shandong	1137	424.7	1947	1027.4	18	8.4
Hebeti	589.7	695.0	500.8	548.4	24.1	17.6
Henan	637	257.4	764	473.9	86	46.9
Shashaa	142.1	240.4	145.9	130.1	100.1	82.6
Gannei	283.2	94.7	1.1	0.9	332.3	354.3
Zheianh	250.0	336.9	301.5	240.8	916.1	739.5
Jianshan	575.5	873.3	353.6	359.5	813.6	787.2
Hubei	362	336.4	125	179.2	426	535.9
Hujiang	76.4	186.2	227.9	391.9	622.9	945.4
Ggnanfu	0.2	198.4	819.4	1601.1	21.9	35.7
Sichuan	88	141.9	267	251.9	1184	982.4
Guizyunn	1.5	57.7	58.6	80.2	461.7	501.6
Port	0.0		0.0			
Total	4148.7	3911.0	5653.6	5393.6	5044.3	5044.3

Table 5. Regions and reference points

Region	Reference point	Population	Sown Area: 7 crops
Heilongjiang	Harbin	34015	6129
Lijil	Shenyang	61829	5331
Shangdong	Jinan	80092	9165
Hebeti	Beijing	76392	7027
Gannei	Baotou	65111	6800
Henan	Zhengzhou	82798	9247
Shashaa	Xi'an	58714	5252
Zheianh	Hefei	95469	9250
Jianshan	Shanghai	77007	7001
Hubei	Wuhang	51443	5340
Hujiang	Changsha	95491	9259
Cgnanfu	Guangzhou	134891	8828
Sichuan	Ghengdu	105897	8098
Guizyunn	Kuming	69388	4876

Table 6. China's Interregional trade flow, export and import under alternative scenarios

Item	Corn	Wheat	Rice	Soybeans	Rapeseed	Cotton	Peanuts	Total
				Base Run: 1,000 tons				
In-region use	66403	85024	158529	7799	4586	2690	4392	329423
as % of domestic consumption	86	84	93	81	91	69	80	90
Interregional trade	10649	1692	10690	1853	477	1221	1083	27665
as % of domestic consumption	14	2	6	19	9	31	20	8
Export (import)	3297	(13707)	1120	1734	—	238	263	6652
as % of domestic consumption	4	14	1	18	<1	6	5	2
China's production	80349	86716	171567	11386	5063	4149	5738	364968
China's consumption	77052	100423	170347	9652	5063	3911	5475	365867
				Self-Sufficiency Run: percentage changes from the base run				
In-region use	-0.29	1.75	0.10	-0.04	-0.26	0.00	-0.41	0.43
Interregional trade	0.74	366.13	0.29	0.00	-0.21	0.00	-0.37	23.03
Export (import)	0.06	-100.00	0.26	0.00	na	0.00	-0.38	-51.62
China's production	-0.14	8.86	0.11	-0.03	-0.26	0.00	-0.40	2.12
China's consumption	-0.15	-6.00	0.11	-0.03	-0.26	0.00	-0.40	-1.64
				Free Trade Run: percentage changes from the base run				
In-region use	-8.04	-12.66	-4.45	-17.86	-0.19	-4.59	-5.06	-4.41
Interregional trade	30.59	717.10	1.61	-0.04	2.06	0.44	4.63	57.11
Export (import)	2.97	4.53	3.97	7.80	na	1.68	19.16	4.51
China's production	0.32	-0.56	0.12	0.43	0.06	0.11	0.45	0.02
China's consumption	0.21	0.14	-0.05	-0.89	0.05	0.01	-0.45	0.03

Table 7. China's exchange earnings, costs of consumption and prices for 7 modelled crops under alternative scenarios

Item	Corn	Wheat	Rice	Soybeans	Rapeseed	Cotton	Peanuts	Total
				Base Run: million yuan				
Exchange earning	1542	-6276	653	2141	0	1146	559	-236
Costs of domestic consumption	27164	47059	59816	7082	4771	15130	5858	166880
Average domestic price, yuan/ton	357	469	373	810	942	3923	1118	466
Port price, yuan/ton	468	458	583	1235	937	4815	2125	na
				Self-Sufficiency Run: percentage changes from the base run				
Exchange earning	0.06	-100.0	0.26	0.00	na	0.00	-0.38	na
Costs of domestic consumption	14.72	52.60	12.93	0.09	0.33	-0.00	0.81	21.91
Average domestic price	14.09	62.35	11.96	0.10	0.59	-0.00	1.11	22.65
				Free Trade Run: percentage changes from the base run				
Exchange earning	2.97	4.53	3.97	7.80	na	1.68	19.16	6.68
Costs of domestic consumption	-2.73	8.42	-2.26	2.56	-0.15	1.13	2.20	1.40
Average domestic price	-2.42	-5.52	-1.85	3.78	-0.15	1.17	3.68	na

Possible Joint Chinese and U.S. Grain Transportation and Distribution Research Opportunities

Roland R. Robinson and Donald W. Larson[1]

Introduction

The purpose of this paper is to examine possible opportunities for international collaborative research in general and suggest some issues for joint research in grain transportation and distribution. These interests and opportunities will be examined in four sections of the paper. The first section describes the organization and administration of publicly supported agricultural research in the U.S., particularly the U.S. Department of Agriculture, the Land Grant Universities and the State Agricultural Experiment Stations (SAES). The second section discusses the concept of regional research programs and the growing interest in international research. The third section discusses the benefits from cooperative research and opportunities for possible joint Chinese and U.S. grain transportation and distribution research. The paper addresses some possible strategies for moving ahead in transportation research using an international collaborative approach in the last section.

Our definition of international collaborative research includes multi-country teams of peer scientists from both advanced and developing countries working together on global problems of common concern where the agricultural industries in each participating country tend to benefit. Also, each country is expected to make appropriate resource and financial commitments to the team effort.

Overview of Publicly Supported Agricultural Research in the United States

Publicly supported agricultural research consists of two major components - the research agencies of the U.S. Department of Agriculture or the Federal system and a State System consisting of the Land Grant/State Agricultural Experiment Stations, the 1890 Institutions and Tuskegee University, the Forestry schools, and the Veterinary Schools. All these institutions and schools receive Cooperative State Research Service (CSRS) administered federal funds. Our discussions of institutional research will be confined entirely to the Land Grant University/State Agricultural Experiment Station complex. The educational or university component was established in 1862 and the research component or Experiment Stations started receiving federal research funds in 1887.

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The U.S. Department of Agriculture

The USDA was established in 1862 with the passage of federal legislation but did not achieve cabinet status until 1889. The original mission of the new Department was to "acquire and diffuse among the people of the United States useful information on subjects connected to agriculture in the most general and comprehensive sense and to procure, propagate and distribute among the people new and valuable seeds and plants" (U.S. Department of Agriculture).

The USDA research system is centrally organized and administered; although certain agencies have decentralized facilities. Each agency has an administrator, and a hierarchy of Deputy Administrators, Managers, Unit Leaders and science staff. The research programs within each agency are centrally planned although the science staffs make significant inputs into the formation of each agency's research agenda. The research agencies of the Department are supported almost entirely with federal funds. The agencies with research programs and research expenditures for FY 1992 of $61 million are shown in Table 1. Marketing/transportation research is a relatively small 10% of total research expenditures. The budgets of the Agricultural Research Service, the Forest Service and the Economics Research Service account for almost 96% of the Department's research expenditures.

The Land Grant University/State Agricultural Experiment Stations

The State System of agricultural research is decentralized with a Land Grant University/Experiment Station complex in each State. Under the Morrill Act of 1862, each State was given public land to establish a college to teach courses related to agriculture and the mechanical arts in order to promote the liberal and practical education of the industrial classes (Robinson and Farris). Federal financial support for the research arm of the complex, was initiated under the Hatch Act, passed in 1887. Experiment Stations were to be established "to conduct original research or verify experiments on subjects bearing directly on the agricultural industry of the United States" (Robinson, Naegele and Farris). The Stations were to be established under the direction of the 1862 Land Grant Colleges. Incidentally, 14 states had 15 experiment stations operating by the time the Act was passed (Robinson, Naegele and Farris). Due to the variation in geoclimatic conditions, soil types, etc., substations were created to conduct research on the adaptation of agricultural enterprises to specific locations.

In addition to education and research, the third major function performed by the complex-extension, was initially federally funded under the Smith-Lever Act of 1914. The purpose of extension was "to aid in diffusing among the people...useful and practical information on subjects related to agriculture and home economics and to encourage its application" (Kerr).

The Land Grant Universities are organized along disciplinary department lines and in most instances the three functions are integrated in some combination and carried out at the Department level. The "split appointment" or the assignment of a combination of functions and supporting faculty salaries from research, teaching and extension sources is a common method of integration. As State Institutions, each Land Grant University/Experiment Station is essentially autonomous and the administrators report to the Legislature in each State. The CSRS is accountable to the Department for the use of federal funds by the Stations and the coordination of research among the Stations and between the Stations and the Department.

The 1992 budget of about $182 million for the Experiment Stations to conduct research by research area is shown in Table 1. Marketing/transportation amounts to about 10% of the research budget. About 74% of the support comes from non-federal sources and 26% from federal sources. The proportion of support coming from non-federal sources is increasing over time.

The Regional Research Program

The cooperative regional research provisions of the Research and Marketing Act, passed in 1946, resulted in part from three major forces (Robinson and Farris). The first was the expanded geographical scope of agricultural problems. For example, areas of agricultural production became increasingly removed from populated areas or areas of consumption. These problems could not be addressed in the isolated State context and with limited individual Station resources. Therefore, for the more comprehensive research of these problems, analyses had to be conducted in a much broader context involving the mobilization and utilization of much larger pools of research resources. A second significant factor was the concern expressed over a number of years by the Congress was the duplication of research efforts by the several Stations and the USDA and the wastage of research funds. The regional research mechanism appeared to be an effective way to achieve the coordination of research thus avoiding duplicative efforts. Finally, USDA and station research administrators had long recognized and articulated the benefits of cooperative research and the need for formal programs supported with federal funds.

Although the regional research program originated with what is referred to as the Research and Marketing Act of 1946, the authorization was carried over and embodied in the Amended Hatch of 1955 (Section (C)3. The definition of the program and the provisions remained essentially unchanged in the transition. The legislation states that not more than 25% of the Hatch appropriations for any given year will be allotted to the States for cooperative research in which two or more State Experiment Stations cooperate to solve the problems that concern more than one State. The Administrators of the Stations and the USDA have spelled out seven criteria for qualifying a project for support with regional research funds. The criteria are both definitional and operational and include the following:

- **Scope of Problem** The problem being investigated must be of concern to more than one State;
- **Research Resource Requirements** The level of research resources required to complete the project must be greater than the level that can be provided by a single Station;
- **Complementarity In Use of Resources** The procedures to be used are appropriate for inter-state and federal-state cooperation, indicate a division of effort and the more effective use of resources.
- **Attracts Additional Support** The project has unique potential for attracting support that is not likely with other research programs.
- **Completion In A Specified Time Frame** The project is narrow enough in scope so that it can be completed in five years or less.
- **Significant Benefits From Research Results** The project solves a problem of fundamental importance to the agricultural industry or develops new knowledge that makes an important contribution to the advancement of science.(U.S. Department of Agriculture).

The Technical Committee

The technical committee consists of an administrative advisor, a CSRS representative, a scientist from each participating institution and one or more representatives from the USDA, other federal departments and from industry.

Each member of the committee has a critical role to play and the success of the endeavor depends on meeting his responsibilities. The administrative advisor organizes the committee to plan the research and develop the regional research proposal; serves as the communication link between the regional association of directors and the technical committee; and advises on administrative and procedural matters. The CSRS representative on the technical committee is trained and experienced in the scientific discipline of the other committee members while on the other hand the administrative advisor usually does not have this relevant scientific background. Therefore, the CSRS representative provides technical and administrative assistance to the committee. The representative also works on projects nationwide while the administrative advisor is assigned only to projects with his region. Among the major responsibilities of the CSRS representative are assistance with developing regional research proposals; coordination of the proposed research with related work underway elsewhere; assessment of annual progress for the total project for the Committee of Nine and the Regional Research Office of CSRS. The scientists on the technical committee are organized into a Chairman, Vice Chairman and Secretary for administrative purposes. Many larger technical committees are also organized in subcommittees. Of course the scientists, the most critical component of the technical committee, conduct the research in a concerted and coordinated manner (Robinson and Farris).

The Project Outline

The project outline is not only a research plan but also serves as a communications and coordination document among technical committees conducting similar research nationwide and between the technical committee and the administrative hierarchy. The objectives and plan of work in the outline set the direction of the research and provide the basis for the assessment of progress. Relevance of the research completed each year and the productivity of the team efforts relative to the stated objectives are the major factors used in the preparation of the annual progress report and the assessment of performance by the administrators. The regional project outline format is an adaptation of the Essentials of Experiment Station Project Outline that evolved over the years in the Experiment Station system. The main components of the outline are: (1) title, (2) duration, (3) justification, (4) related current and previous work, (4) objectives, and (5) procedures.

Changes in the Regional Research Program

Need for National Projects

Regional research is a dynamic program with significant changes occurring over time. One of the first rather fundamental transformations was the expanded scope of problems being investigated and the expanded participation by scientists. The first regional projects focused on regional problems and participation was confined to scientists from institutions within the region, excluding the USDA representatives. The increased participation, came initially from institutions in States adjacent to the originating region and later from institutions elsewhere in the nation. Although, regional projects must originate in a specific region, participation on many projects is now nationwide.

This need for national projects or what was initially referred to as Interregional (IR) projects whose scope transcended regional boundaries, was anticipated soon after the establishment of the regional research program. In fact as early as 1950, the first IR project was approved. The IR approach has not been well received. In 1990, the regional research program was funded at $35.6 million dollars while only about $1.2 million or about 3.4% was allocated to approved IR projects. This low level of participation and therefore financial support for IR projects is due in part to the conflict between the traditional regional project and the IR projects. Support for the IR projects is taken from "off-the-top" of the regional research fund. The expansion of the IR program therefore must come at the expense of the traditional regional program. While all Stations are taxed from off-the-top funding, very few may gain from the new knowledge generated from the research. This disparity must be closed to obtain greater involvement in IR research. A second factor explaining the low level of participation in the formalized or IR research is that the same results can be achieved under the traditional regional research program. Under this arrangement participating institutions tend to sort themselves out and participate on regional projects with a national orientation where there is a closer relationship between costs incurred and benefits received.

Need for International Projects

Another significant development is that an increasing number of projects involve the analyses of global problems or problems that cross national boundaries. While the USDA has for several years had significant international research programs; the more significant involvement of the Stations in this work (except for technical assistance) has been of fairly recent origin. In our judgement the expansion of interest and involvement of Station scientists in this work has been due in large measure to: the emerging global economy and the impact on the U.S. agricultural industry; increasing availability of international data sets; the growth in international professional associations and the increasing contact between U.S. and scientists from other countries, the simple expansion of knowledge and growing sophistication of scientists; expanded capacity in research technology (computers and software systems); and the substantial growth in communications technology that has greatly facilitated global contacts and the exchange of information. These factors also form the basis of increasing opportunities for international cooperative research.

Increasing SAES Expenditures for International Research

There has been a significant increase in expenditures at the SAES in the research areas classified as expanding exports and assisting developing nations. The research in expanding the exports of U.S. produced agricultural commodities is supported by traditional sources of Station funding (primarily CSRS administered federal funds and State appropriations); while the technical assistance to developing nations conducted by the Stations is supported with U.S./AID federal funds. The support for both areas of work increased from about \$2.2 million in 1970 to about \$27.5 million in 1990. Excluding the US/AID funds allocated to the Stations to support technical assistance work, the increase was from about 1.2 million in 1970 to over \$22.6 million in 1990 (CSRS, U.S. Department of Agriculture).

Federal Legislation: International Programs

This growing interest is also reflected in the enactment of federal legislation providing support for international agricultural research and related activities. In the National Agricultural Research, Extension and Teaching Policy Act of 1977, as amended, and the Food and Security Act of 1985, three sections are concerned with the general area of international programs. These sections are 1458, 1458A, and 1420 of the Food Security Act of 1985 (U.S. Department of Agriculture).

Section 1458A entitled " Grants to the States for International Trade Centers" has been funded and their programs are in progress.

Section 1458 entitled International Agricultural Research and Extension has not been funded. The programs covered under this section cut across several existing programs in the federal government including for example the programs in OICD, ERS, Extension Service, CSRS and other programs of the USDA as well as the programs of the US/AID. The provisions of this Section cover not only a broad range of diverse activities in research, extension and education but also provide support for specific programs in sustainable global agriculture and the development, management, and reclamation of arid land for agriculture.

Section 1420, entitled " Agricultural Information Exchange with Ireland", states in part that the " The Secretary of Agriculture shall undertake discussions with representative of the Government of Ireland that may lead to an agreement that will provide for the development of a program between United States and Ireland whereby there will be:

(1) a greater exchange of (A) agricultural scientific and educational information, techniques, and data; (B) agricultural marketing information, techniques, and data; and (C) agricultural producer, student, teacher, agribusiness (private and cooperative) personnel; and

(2) and the fostering of joint investment ventures, cooperative research, and the expansion of United States trade with Ireland".

Under the U.S.-Ireland program, twenty-three cooperative research proposals were submitted for funding in FY 1992, ten in Food Science and Technology, six in animal science, five in plant science and two in agribusiness. These proposed joint ventures are largely between the U.S. Land Grant Universities and Irish Universities and research foundations. Also involved are the USDA and private research firms in both countries.

National Committee on International Science and Education

The Joint Council on Food and Agricultural Sciences was mandated by Title XIV of the Food and Agriculture Act of 1977, as amended. Its primary responsibility is to facilitate more effective research, extension and education programs in the food and agricultural sciences by improved planning and coordination. The Joint Council formally established the National Committee on International Science and Education (NCISE) during its January, 1991 meeting (Joint Council Meeting). The purpose of NCISE is "to enhance the long-term viability and competitiveness of the food and agricultural production (federal, non-federal, private sector and higher education) system of the United States within the global economy by more effectively involving the system in international research, extension, teaching and networking" (Joint Council Meeting).

Increasing Foreign Participation in Regional Research

The regional research program is becoming to a certain extent internationalized by default if not by design. Foreign scientists are increasingly becoming members of regional research projects. The participation comes a great deal from former foreign students, educated at Land Grant Universities where they became involved in regional research as graduate students.

Internationalization of CRIS

The Current Research Information System(CRIS) is a computer-based system for the storage and retrieval of current research in the agricultural and forestry sciences. It is maintained and operated in the Cooperative State Research Service(CSRS) of the USDA. All research sponsored by the USDA is required to be documented in CRIS. CRIS currently contains 35,000 descriptions of current public supported research projects.

The first step in the Internationalization of CRIS is currently underway. The inventory of Canadian Agri-Food Research (ICAR) database is being combined with CRIS and will soon be accessible online. ICAR consists of 4000 projects conducted or sponsored by Agriculture Canada. The combined database covers almost 40,000 projects publicly supported, ongoing and recently terminated research projects in agriculture, forestry, natural resources, food, human nutrition and related fields.

The longer term objective of CRIS management is to expand the scope of coverage to include foreign agricultural research from the European Community (EC), Organization for Economic and Cooperative Development (OECD), and the United Nations' Food and Agriculture Organization-Current Agricultural Research Information System (FAO-CARIS) as well as research from domestic sources not currently covered in CRIS. Arrangements have already been made with EC to add their AGREP file of 30,000 research projects to CRIS.

Given the recent advances in computer technology and telecommunications, it is readily conceivable that eventually there will be a global Current Research Information System. Significant progress in regard to International Collaborative Research should expedite the process.

Opportunities for Joint Chinese-U.S. Cooperative Research in Agricultural Transportation and Distribution

Incentives and Dual Benefits from Cooperative Research

The first part of this paper has described the institutional arrangements and mechanisms for conducting cooperative research among universities and government scholars within the U.S. This research is carried out through the U.S. Department of Agriculture, the Land Grant Universities and the State Agricultural Experiment Stations. The current status of agricultural transportation research in the U.S. as well as the emerging interest in international cooperative research was discussed. In this section of the paper, we will identify the incentives and benefits from cooperative research and identify some of the research opportunities for joint Chinese - U.S. cooperative research in agricultural transportation and distribution.

Academically, the most important benefit of cooperative research is the intellectual exchange of ideas among scholars and the subsequent research activity and research publications that advance knowledge and understanding of important problems of a society. Increased understanding of transportation problems of both societies would be an important benefit of a cooperative research activity. Education of Chinese and U.S. graduate students who would be involved in the research and who would be future scholars of both countries would be another benefit of the research. A secondary benefit of joint research might be the initiation of faculty exchange programs, graduate and undergraduate student exchange programs, and the exchange of textbooks and research materials among the universities cooperating in the research. A Memorandum of Understanding (MOU) between two or more institutions is a common mechanism to facilitate these exchanges. For example, The Ohio State University has an MOU with the Chinese Academy of Agricultural Sciences and MOU's with other institutions in China.

Economically, the opportunity to facilitate trade between China and the U.S. motivates the interest in joint research on grain transportation and distribution. Much can be learned through joint research on issues that identify means to enhance trade between the two countries. As has been discussed in some of the earlier papers, increased specialization and trade between two countries leads to more efficient resource use that benefits consumers and/or producers of both countries. Transportation research can contribute to this increased trade; particularly for bulky, low value commodities such as grains where transportation costs represent a high proportion of the value of the commodity to the producer or the consumer. Increased transportation efficiencies that reduce costs will lead to increased trade and higher farm prices and/or lower consumer prices for these grains.

Some Transportation Issues for Cooperative Research

Grain and Oilseed Production, Utilization and Trade

Transportation research requires accurate estimates of grain production and consumption nationally to obtain estimates of the potential for exports or the need for imports. This information can be useful in very aggregate trade models; however, for countries as large as China and the U.S. further refinement is generally needed. Estimates of the production surplus and deficit by regions and regional movements of grains provides far more valuable information for decision makers and researchers than only national level information. Several criteria should be used to define homogeneous production and consumption regions for large countries. Estimates of the production surplus and deficit by region require accurate data of the production of all grains and oilseeds and consumption by humans, livestock and industry (Wailes and Vercimak).

Once the surplus and deficit by region has been estimated, grain movements by type of transportation (rail, truck, barge, animal or other) and possibly by season of the year need to be estimated. If such data is not readily available, collection can be costly and time consuming. In the U.S., much of this data is available from government sources, but some must also be collected by scholars interested in transportation research. In developing countries this data is generally not available and must be collected for transportation research purposes.

Government policy also has a major impact on the surplus and deficit regions as well as the regional movement of commodities and the movement of grains by type of transportation. For example, in some countries government intervention in markets may alter the natural movement of grains among surplus and deficit regions according to market forces. Some common examples of this include policies that set uniform prices by region, uniform prices throughout the marketing year, or policies that require permits of various kinds. These kinds of policies distort the movement of grains among regions relative to movements based upon market prices.

Carrier Costs, Pricing and Firm Productivity

Substantial opportunities exist for joint studies of carrier costs, pricing and productivity among rail, truck, barge, animal and other transportation alternatives (Sorenson and Tiao). Functional relationships exist between unit costs of transportation service and size of firm, density of traffic, size of vehicle, length of haul, intensity of vehicle use and other factors. The way in which these factors affect carrier costs differs among types of transportation, regions and countries so that models for China might be very different from those for the U.S. Competitive characteristics among different transportation alternatives may also be examined.

In either a very regulated market environment or a free market environment, the price of transportation (transportation rates) compared to transportation carrier costs attracts the attention of policy makers and shippers. Estimates of the elasticity of demand for transportation services and the pricing strategies adopted by firms require further examination in U.S. markets as a result of the de-regulation of transportation services that occurred in the 1980s. In the regulated environment of China, these cost and rate issues may also be important because of the implications for carrier profitability and shipper costs. In a highly regulated environment, controlled rates that are seldom adjusted for inflation or other factors can frequently lead to inefficiency and operating losses among carriers. If the carriers are publicly owned, these losses become a huge drain on fiscal budget of the government. The quality of service may also deteriorate because the carrier and the employees of the carrier have no incentive to provide the shipper high quality service.

Comparative Studies of Costs of Marketing and Transportation

Comparative advantage among regions and countries defines the goods and services that should be exported and imported to obtain most efficient resource use. Comparative studies of costs of production, marketing and transportation for grains and oilseeds will identify opportunities for inter-regional and international trade. Natural resource endowments, technology, management, input costs, infrastructure and government policy all interact to determine costs of production, marketing and transportation. Government policies can enhance or retard the expression of these economic factors. Regions and countries differ substantially on these costs of marketing and transportation (Larson and Rask). Comparative studies of costs of marketing and transportation reveal how costs influence ability to compete in world markets. For example, higher transportation costs to export ports attenuate the lower production cost advantages for soybeans in Brazil compared to the U.S.

Identification of Minimum Cost Logistic Systems

As discussed in an earlier paper of this session by Koo and Fruin, many different mathematical programming and network models can be used to determine the least cost system of transportation, storage and handling of grains and oilseeds or other commodities. The models can be micro firm oriented, regional, national or international in scope. Spatial equilibrium models have been estimated to identify the optimal trade flows that maximize net social payoff in world markets. Railroad reorganization, rail rates and costs under de-regulation, intermodal competition, port capacity constraints and many others have been popular applications in the U.S. in recent years (Koo; McCarl, Hilger, and Uhrig; Ladd and Lifferth; Fuller, Randolf and Klingman; Pautsch, Hamlett and Baumel; Koo, Thompson and Larson; and Barnett, Binkley and McCarl).

Major criticisms of the system models focus on their large data requirements, lack of realism, the high level of aggregation, sensitivity of results to key information such as transportation costs or supply and demand elasticities, and usefulness of results. The challenge is to build better models and to improve the data base on which the models are built. Some of the research opportunities identified in this paper will produce information of value on its own merit and also produce information needed for building better models.

Public Policy Issues of Infrastructure and Regulation

Infrastructure and regulation policy issues represent fertile areas for joint research opportunities because of the importance of the issue, the size of both countries and the regulation policy differences between the two countries. Public policy influences several areas of transportation including infrastructure investment, economic regulation, tax and subsidy policy, mergers and consolidations, air and noise pollution abatement, safety, size and weight restrictions, and others in the U.S. Chinese public policy influences even more areas of transportation such as ownership than in the U.S.

Infrastructure investment is important because it requires large capital investments. Transportation investment is closely linked to economic development and growth because a region's access to markets for inputs and output affects the ability of a region to compete in domestic and world markets. The large investments of the U.S. in building the federal interstate highway system illustrate the benefits of an improved highway system upon grain transportation and rural communities. A lack of adequate infrastructure is frequently viewed as a barrier to economic growth. Improvement and/or expansion of infrastructure will be important to the future economic growth of both countries.

The need for investment is large and the resources are limited. Drucker in a recent article on "Where the New Markets Are" identifies the third new market as the "need to repair, replenish, and upgrade physical infrastructure, especially transportation systems- roads, railroads, bridges, harbors and airports." He argues for privatization of infrastructure because no government in the world today is solvent enough to make the investments either through taxation or through borrowing. The capital is abundant and so are the opportunities for profitable investment.

The U.S. has adopted alternative models of regulation of transport rates, transport services, and control of entry and exit of firms that impact costs, service, competitive conditions and profits. In the last 10 to 15 years, we have moved from a highly regulated and controlled transportation system to a freer, market oriented model. Analysis of the economic performance and income distribution consequences of these changes is a truly challenging field for research. The performance of airlines, railroads and trucking as a result of these changes and the impact on grain and oilseed transportation is an important and timely area for research. Many scholars have addressed these issues yet much remains to be done. Some of these are railroad rate pricing in a de-regulated environment, rail car shortages, user fees in the barge industry, and state and federal regulation of trucking of farm products.

Rural Community Issues

Structural change in U.S. agriculture, population declines, and the de-regulated transportation system have contributed to the decline of services to rural communities and what some have called the crisis of rural areas. The quantity and quality of transportation services to most rural areas has declined and the price has increased. Improved transportation services are needed for local movements of goods and people.

The main issues studied in recent years include rail line abandonment, reduced trucking, bus and air passenger service, rural road and bridge conditions and abandonment, and financing of rural transportation infrastructure. Much of this infrastructure is 30 to 40 years old, and obsolete or in poor condition. Mathematical models have analyzed alternative rural road and bridge systems and investment strategies to identify the optimal system for the future (Pautsch, Hamlett and Baumel). Much more work needs to be done on this important issue.

Our transportation committee has recently discussed the issue of how much infrastructure does rural America need (Fruin and Baumel). Should infrastructure be a supply driven policy or a demand driven policy. Should the policy be "If we build it, they will come"? Is that too costly an approach? We all know examples of that approach that failed. Who should make the transportation investments and who should gain the rewards of the investment? Structural change in U.S. agriculture, transportation and information technologies have reduced the amount of infrastructure needed in rural areas. The challenge will be to assess the implications of future changes for rural infrastructure needs.

Strategies for Moving Ahead

As we see it, there are two major interrelated impediments for moving ahead in international collaborative research. One is in the area of research administration and the other is funding.

Scholars with their international professional associations have an opportunity to interact and exchange information with their counterparts in other countries. To our knowledge, no such international association of agricultural research administrators exists; nor are there sabbatic programs for research administrators to gain experience at institutions in other advanced countries. Therefore, while scholars are gaining international experience and perhaps a better understanding of the relationships among agricultural industries in different countries, these perspectives are not shared for the most part by administrators.

The funding problem logically follows the administrative problem. The key decision makers in the agricultural research system are the administrators. Their responsibilities include preparation of budget information, the justification of public investment in the research programs, and the allocation of research resources. Being a critical actor in budgetary processes both at the state and national level provides the unique opportunity not only to obtain state and federal funding for research but also to redirect programs.

Very briefly, two important processes for conducting international collaborative research are joint projects between institutions in two countries and a formalized multi-country project. In our examination of administrative structures and processes to achieve the latter, we recommend looking closely at the U.S. regional research model for the organization and conduct of multi-country research. Admittedly, our knowledge of structure and processes used in other countries is limited. Significant adaptations of the regional research model would need to be made for it to work in a global context.

We suggest as a starting point that a task force develop a tentative format for conducting international collaborative research. We would further suggest that an international problem in some area of transportation be selected and a project proposal drafted using the format mentioned above. This exercise could produce two benefits. First, international collaborative research will become a reality within the next few years, and it would be a real advantage to have procedures already developed and ready to implement. Furthermore, changes in the U.S. regional research program provide limited "off-the-top" funding of the national research projects. Therefore, financial support through the regional research program for U.S. participants in international research projects is a possibility. Certainly, the interest shown and the resources committed to the project by other country participants would be a critical factor in obtaining approval of such a project.

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Table 1 Funding of State and Federal Research by Economics and Business Research Area FY 1992 (Amounts in thousands).

Research Area	States	USDA	States/USDA
Farm Mgt. & Production Econ.	18,073	3,175	21,248
Marketing/Transportation	14,214	4,016	18,231
Agribusiness Management	2,605	2,207	4,812
Agri. Price/Income/Policy Analysis	12,740	15,850	28,590
Intl. Agri. Trade & Development	20,466	13,973	34,439
Agricultural Finance	3,991	5,266	9,258
Natural Res. & Environ. Econ.	35,060	13,003	48,063
Consumer Economics	4,531	490	5,021
Economic Theory	1,840	1,497	3,338
Research Methods	6,694	2,266	8,960
Total	$120,217	$61,747	$181,965

• USDA/STATES figures include total state expenditures (both Federal and Nonfederal) and total USDA expenditures (ERS, AMS, ACS but excludes FS and ARS). It also excludes community resource economics (2638) and human resources economics (2639).

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STATES figures include total state expenditures (both Federal and Nonfederal). It excludes community resource economics (2638) and human resource economics (2639).

Source: CRIS/USDA

Transportation Research Needs and Issues for Chinese Agriculture: Discussion of Session Presentations

By

Dale G. Anderson[1]

Overview

The five papers in this session have explored Transportation's role in Chinese agricultural development and research needs in support of that role; they have provided a number of important insights:

1) We have an insider's insights into grain transportation and marketing developments and needs in China (Shuo). Many of us from the United States, especially, are not well acquainted with grain markets in China and the opening paper has afforded a picture of how these markets work.

2) We have been given some useful insights into transportation and its signal importance for agricultural development (Lee, et. al).

3) Two papers (Koo and Fruin; Webb, et. al.) report on methodology and findings of research applied to Chinese transport issues, their results suggesting the potential for application of these and other established techniques to problems in China.

4) The final paper affords insights into how publicly-supported agricultural research, including that aimed at resolving transportation problems, is organized and administered in the United States (Robinson and Larson). Successes and failures of the U.S. system have apparent implications for research in China.

I will touch first on some of the highlights, as well as apparent omissions or limitations of each of the papers. Second, I will attempt to draw some inferences for transportation and transportation research needs in China. I should emphasize at the outset the huge difficulty I think we all inevitably have had in dealing rigorously with a topic as complex and difficult to analyze as the one at hand in the span of this one brief session. My comments are offered with this caveat in mind and in a spirit of constructive critique. I do want to stress that even though I may have something close to a final word on this program, what I say and what you have said are not of course the last words on these complex and controversial issues. Investigators of economic issues surrounding the transportation of agricultural products in the United States have yet to concur on solutions to many of America's most pressing transportation problems and we should hardly expect that those of us gathered here today will have all of the answers for China.

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Interprovincial Transportation and Markets in China

The first paper (Shuo) describes a system of grain transport and pricing that has undergone major structural change starting in the 1980s. Prices have become more market oriented and steps have been taken to make the evolving competition workable (see Sicular for further commentary). We weren't told how government price supports are keyed to location and whether, in other words, an incentive for private transport is provided. Chinese grain yields and output have increased sharply, with obvious implications for the transport system. Although regional specialization in the production of grain is no longer discouraged, only 5 to 10 percent of the 200 million metric tons of the average annual grain shipments during the 1980s moved in interprovincial trade.

Trucks are the major mode of transportation, a not surprising finding in light of the apparent low volume of long-haul traffic. Fully 30 percent of movements are by "backward" means—movements by other than truck, rail or water transport. Specific transport problems or transport research needs are not discussed (see Guichen for a brief discussion of transport infrastructure).

Transportation and Development

The second paper (Lee, et. al) appropriately emphasizes the interdependence of transportation and economic development. Transportation and development are dependent upon and reinforce each other; their parallels are specialization and trade. The division of labor upon which advancing productivity is so critically dependent is itself dependent upon the surplus output of each worker, each hectare, each machine being exchanged for the surplus of others. An efficient transportation system is vital to the efficacy of the exchange process, the more so as economies of scale expand with the advancement of technology.

It is logical, I should think essential, that the costs of building and maintaining virtually all roads, both highways and byways, should be borne by government. Drucker (Robinson and Larson) seems to think otherwise, but his dim view of public fiscal accountability has obscured his vision of the larger picture. Not only is the initial investment likely to be enormous relative to the capabilities of private investors in most developing countries, the problems of collecting tolls are simply insurmountable for all except major highways. And in the latter case the costs of highway maintenance are only marginally affected by level of traffic for all except the largest trucks, making tolls a socially questionable means for recouping costs. But while the roads themselves should be public, there are compelling reasons why the vehicles that operate on them should be private. Modest economies of scale, along with enormous complexities in matching shippers and carriers in time, space and type of service make trucking an ideal candidate for operation as private businesses.

Local rather than provincial or national public ownership of rural roads may moderate the over-investment tendencies alluded to by Lee, *et. al* since taxpayer and user groups are more nearly coincident at the local level.

Railroads have significant economies of scale and they face high ratios of fixed to variable costs which tend to foster extensive and deep price discrimination. The result of these conditions may be a natural monopoly over any given long-distance haul, with possible implications either for public ownership or regulation as a public utility. Long regulated as public utilities in the United States, privately-owned railroads were, however, substantially deregulated in 1980, with apparently beneficial results. Both intra- and intermodal competition are likely, however, to be more effective in the United States where systems of rail, highway and inland water carriage are more fully developed. It is also worth reflecting that public ownership has been the choice of all other nations save Canada where one of two major railroads is privately owned.

All major waterways in the U.S. are publicly owned while the vessels that ply them are generally private. The multiple uses and impacts of these waterways (e.g., navigation, irrigation, recreation, flood control, municipal water supply, waste disposal) would seem to mandate their public ownership or control. At the same time, transportation economies of scale are sufficiently modest to provide workable competition among users.

The anticipation that increased incomes will lead to sharp increases in feed grain demand is certainly logical and borne out empirically by countries in the region such as Japan and South Korea. The relative equality of incomes among Chinese consumers will accentuate this effect since the demand for basic foodstuffs is most elastic at lower incomes. These demands must be met either through policies conducive to regional specialization or from growing imports. In either case, demand for food transport services will grow rapidly.

I'm not sure the Lorenz Curve analysis is the most meaningful way of comparing Chinese and U.S. transport requirements. National-level data fail to account for differences in *patterns* of specialization, which, for grains, tend to be regional, both in China and the U.S. Interregional transfers are, of course, most demanding of transport services. Comparing the curves for a combination of grains obscures shipping patterns further since different grains substitute imperfectly for each other. China, for example, grows both rice and feed grains and transport costs will be higher the greater the extent to which the production of each is specialized in different regions.

Transportation Research Methods

The two methods papers (Koo and Fruin; Webb, et. al) are a variation on a single theme—the modeling of product flows in search of some optimum pattern of shipments through time and space and across modes—methods which may be useful when applied to the resolution of important problems, but they are not of course the entire realm of relevant economic methods for transport analysis.

If I understand them correctly, Koo and Fruin are suggesting that their modeling approach could be used to determine optimal regional patterns of agricultural production, taking the existing transportation system as given. Such an approach gets things backward, it would seem to me. Surely the competitive realities of crop and livestock production relationships are more fundamental "givens" than the existing system of transportation, which is largely a man-made contrivance. Examining the efficiency of alternative physical or institutional transport arrangements in meeting consumer needs under given patterns of production would seem to be a more urgent need.

Neither of the models seems to offer much insight into public investment in transport and attendant facilities which, if grain prices are allowed to respond to economic forces, is a critical policy issue for a developing country. It doesn't seem to me that the central problem is in figuring out what should be shipped where, but rather what public investments should be made and where. The market, if it is allowed to do so, will figure out where to grow the grain, where and when to ship it, given transport costs and other supply and demand realities. The critical issue for government is in establishing priorities for transport improvements that are consistent with economic imperatives. The other broad issue the model might be used to address, and this is arguably at least as important, is how alternative public policies may affect the efficiency of transportation and agricultural enterprises. Such questions are of particularly compelling importance in an economy such as China's, where market forces are relatively constrained by government actions. Unfortunately, the limited scope of free market interplay in the Chinese economy also makes price and cost data, which are central to the modeling efforts, potentially arbitrary and of limited analytical value.

The issues examined by Webb, et. al. are "real" and important, although they are not of a "transportation" nature; they are difficult to analyze owing to data limitations and the obvious problems in capturing the dynamics of reality. But trade issues are important and certainly merit economic analysis. Whether the price/cost data are up to the challenge is of course questionable. Again, the meaning of prices and costs in an economy driven only marginally by competitive forces is debatable. Some sort of shadow prices would seem to be essential.

It might also be argued that, if there were something approaching pure competition, the sort of modeling under discussion might be superfluous because competitive forces would yield optimum resource allocation, obviating the need for the model. Such perfection is of course not found in the United States nor anywhere else. Nor are public policies always formed and administered by the most benevolent and enlightened of public servants. But recognizing the constraints may help in identifying the right questions to ask about both data and research objectives.

Some of the Webb results are rather startling, underscoring the importance of China in the community of world traders. China's wheat imports are sufficiently large (20 percent of world wheat market purchases in some unidentified year) that self-sufficiency on its part would lead to an estimated 50-percent decline in world wheat prices. This sort of result needs cautious interpretation as the all-else-constant assumptions of any particular equilibrium model would very soon become fiction with the passage of time.

Scope for Chinese/ American Research Collaboration

Robinson and Larson note and endorse the apparent official support in the U.S. for an international approach to agricultural research. There are growing numbers of such research activities. The theoretical case for "international" research is compelling, as is the case for involvement by regional research associations such as NC-137 in the United States. Problems that cut across international boundaries are likely also to cut across state boundaries in the U.S., making the logical collaboration from the U.S. side regional (or national).

Budget and administrative problems facing those who would undertake such research are also pointedly noted. There would seem to be several other potential difficulties. What about the apparent logistical problems in international research? To what extent can they be bridged by modern communications and data processing systems? Last, but hardly least, official verbal support will not necessarily translate to official funding—on either side of the Pacific.

It is sobering to recognize that the volume of research which has been brought to bear on problems of agricultural transportation has not been large in the United States and has probably been no larger in China. At least some of the U.S. work has, however, had some significant impact. Research, for example, on issues surrounding regulation and deregulation and railroad branch-line rationalization has clearly influenced public policy. Of course, not all of the work was done by agricultural economists, but much has and in some cases general economists and those with agricultural specializations have worked together, pooling their resources to good advantage. Other important studies are underway dealing with rationalization of an over-built and deteriorating system of rural roads and bridges, this work being pioneered by agricultural economists.

There do appear to be lessons in the U.S. experience for research organization in China, including collaborations with U.S. counterparts. Combining what are rather small separate pools of research resources may yield some important economies. Coming as we do from widely differing perspectives suggests unique potential contributions from both sides of the ocean.

Concluding Observations

We can perhaps all agree on the unique importance of transportation to agriculture and to economic development. While every production activity must have a physical location, agriculture alone is dependent upon land as a resource. The result is an enormous dispersal and decentralization of agricultural production across geographic space. Combine this with growing urban-centered demands for food and fiber and the economic reality that the comparative advantage of most agricultural products is geographically limited, and the critical role of agricultural transport is apparent. Development brings still more specialization and growing reliance on purchased inputs which must be transported to their place of employment. Moreover, the products of agriculture tend to be heavy and bulky, making transport costs large relative to delivered product value. Adding to all of this the seasonal nature of most agricultural output and the relative perishability of most agricultural products rounds out the picture of the demands upon agricultural transport.

The potential for adaptation and adoption of Green Revolution technologies is dependent upon there being a market for the surplus. Without adequate and sufficiently low-cost transport, this market will be lacking. New seed varieties generally require large applications of fertilizer and pesticides as well which must be transported to the farm.

The benefits of improved rural transport networks for personal travel should be not be overlooked (Richards). The spill-over effects for improved access to health care, education, market information and mobility of labor, to name a few, can be very large. And all of the latter are critical to the development process.

While the United States transportation experience may be of little importance to China in many respects, certain successes as well as mistakes may be worth consideration. For example, public support for transport infrastructure was a highly important element in the development of U.S. agricultural potential and to the economic development of the nation. The federal government supported construction of railroads, major highways, ports and waterways; state and local governments created an elaborate system of roads and highways.

China is on an early segment of the curve of transport infrastructure development; the time for making the right decisions about long-term needs is now. The building of transport infrastructure in the United States, much of it well before its actual need, did have a major developmental impact. The building of the transcontinental railroad during the second half of the 19th century opened the west for development, setting the stage for exploitation of the vast land resources in the heartland of the American continent. The construction of the interstate highway system in the middle of the 20th century had major impacts on the efficiency of highway transport, bringing markets of the nation and world far closer to all of the nation's citizens. China may not have equivalent crop land potential, certainly not for development of unexploited lands, and the nation certainly has no scarcity of labor relative to land. But China, like the U.S., is a very large country, with a diversity of (agricultural and otherwise) production possibilities, and an apparent potential for making greater use of long-distance rail and water transport.

There was, however, significant over-building of all modes of freight transport in the U.S., with resulting waste that persists even today in the operation and maintenance of these systems. Furthermore, too little attention has been paid in the U.S. to modal interconnections, with resulting excessive fragmentation and erosion of modal comparative advantage over many hauls.

The economic regulation of transportation in the United States has been an enormously controversial issue, and only now, more than a century beyond the beginning of railroad regulation and almost 60 years following the regulation of trucks, is there substantial agreement on the major implications of U.S. government regulatory oversight of transportation through the years. It is clear that, above all, regulation of entry, rates and service requirements led to much misdirection of resources, both public and private. China may be able to anticipate similar problems, recognizing, of course, that the preferred solutions might not be the same as those most appropriate for the U.S. China may be able to adapt if not adopt some of the methods of transport development and oversight that have proved over time to be most workable and efficient in the U.S.

Finally, I will share some biases about what seem to me to be relevant researchable issues, issues which are both of central importance and appropriate for analysis by publicly-supported researchers:

Appropriate Public Policies

China faces tradeoffs, as it moves toward a more market-oriented economy, between pricing efficiency from competition and the regulatory and possible technical efficiency costs of achieving competition. Researchable issues include:

- How to foster competition among transport enterprises in an economy featuring a mixture of both public and private ownership?
- Under what circumstances may competition be expected to work or not to work?
- Who should pay for transport investment and operation (means and incidence of taxation, user fees, etc.)? How to pay and at what level?

Appropriate Investments

Massive investments are required for the creation of a transport system capable of exploiting the local and regional comparative advantages of a nation with the population, size and diversity of China. Issues include:

- Way facilities for rail, highway, water transport: Where to build? When to build? At what level? Using what technologies? These issues can be addressed in rather simple and straightforward terms using procedures described by Tyrchniewicz.
- Rolling stock: Which should be private? Which public? What technologies?

Development vs. Social Objectives

Social and economic goals in transport development may diverge. Roadbuilding can both guide and be guided by development. China has faced and will undoubtedly continue to face the problems of reconciling often conflicting goals (Lardy). Important issues include:

- How to account for social objectives which may, at least in the short-run, conflict with efficiency?
- How to determine the most efficient pattern of transport in the face of various social constraints?
- Analysis of tradeoffs between exploiting comparative advantage and social goals which may call for transport development to encourage development of poorer areas.

Management Issues

Managerial issues also go beyond the realm of purely economic analysis, but have important economic implications and are within the purview of what agricultural economists are calling "agribusiness." Modern transportation systems are highly complex, their oversight requiring attention to modern principles of management; research attention should directed to resolving issues of micro-management concern such as:

- Economics of logistics.
- Appropriate policies for managerial oversight of transport enterprises.

Time, Form, Space Issues

Transportation analysts must think in terms of the interrelatedness of time, form and space. It is essential to recognize the interdependence of systems of transport, storage and processing. Transportation of bulk grain, for example, will fail in achieving most potential bulk efficiencies if storage and delivery activities are keyed to bag handling. Research priorities include:

- Collaborative systems research between transportation specialists and analysts from other disciplines in search of appropriate integrations of transportation systems with other private and public economic activities and investment alternatives.

Trade Issues

In an open economy, the special demands of the importers of one's exports must be considered, timeliness and quality having particular implications for transport efficiency. Research attention should be directed, for example, toward:

- Evaluating the implied implications for transportation investment and upkeep of projected or potential trade activities.

I hope that this session will encourage further exploration of specific avenues for cooperation among researchers on both sides of the Pacific Ocean. We all have vested interests in transport improvements in our own and in each others' nations. China and the United States are both large and diverse nations. Both rely heavily on transportation. Both have potential for expanded trade relations—with each other and with other nations. Research is a critical element in assessing the implications of alternative policies and in determining how transportation systems should be structured and managed. We will gain as professionals from an ongoing interchange of views and ideas. We will all gain in the long-run from expanded trade fostered by improved systems of transportation. We and our respective nations will gain from the sharing of technical experience and know-how and from the trust and friendship fostered by professional exchange.

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