The University of Manitoba

The Economics and Management of the Grain Marketing and Transportation System in Jingmen City, People's Republic of China

A Thesis Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements for the
Degree of Master of Science

Department of Agricultural Economics and Farm Management

by

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The number of people and organizations that contributed to the accomplishment of this research are uncountable. First and foremost, I would like to thank my parents, June and Doug Honeyman, for their unwavering support over my nine years of university study. No better parents exist.

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Xing-bo, Instructor, Department of Agricultural Economics at HAU, who accompanied (and lived with) me on my field research and who was my true friend without question, deserves a medal of courage. Gratitude is owed to my other committee members, Dr. James MacMillan and Dr. Karen Minden, for their friendship and time and effort spent reviewing this thesis. Other academics who should be credited are Dr. William Tai, for his introduction of my research for approval to authorities in Beijing and Dr. Colin Carter, for giving me the initial courage to tackle this research.

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questions and to become his friend in China. Appreciation also goes to foreigners living in China, particularly Philippe Rabaud, and friends in Canada, especially Lori Young, who gave me the personal affections that a person needs when living in a distant foreign land. Last but not least, Chi Yue, who allowed me the most special of insights.

Any errors or omissions contained in this thesis are solely the responsibility of the author.

PREFACE

The fact that the author was even allowed to do this study is somewhat of a breakthrough in cooperation between China and Canada. Since this development project will have high economic returns to China even if only some of the author's suggestions are implemented, then this cooperation can be said to be successful. Many hours were spent by Canadian and Chinese government officials for preparation of documents. The preparation of Chinese documents for permission to do this study was made especially difficult because grain marketing is run by the Ministry of Commerce, which does not seem to communicate easily with agricultural schools.[1]

The author was the first foreign student ever to be admitted into the Department of Agricultural Economics at Huazhong (Central China) Agricultural University and indeed the author knows of no other university in China which has had a graduate student in Agricultural Economics. Beijing Agricultural University, considered the best in the country, has never had a foreign student in this department. The author was told that during the Cultural Revolution, agricultural economics was the first department to be dismantled. To the

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[1] Anyone contemplating attending an agricultural school for purposes of studying agricultural economics in China should contact the author (and is welcome to do so) for a more detailed explanation of how he got to do this study.

author's knowledge, research as found in this thesis has never been conducted before in China. Marketing research is not conducted at Huazhong Agriculture University and the subject is not in the curriculum.

The grain and transportation economies are considered immensely strategic in China and this point was made extremely clear to the author during his 18 month stay. Studying the grain storage and transportation system is likely one of the most difficult research undertakings a foreigner can attempt in China with the exception of military issues. As a result, some data problems exist, but they do not invalidate the important conclusions from this research.

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LIST OF ABBREVIATIONS

FFB = Financial and Fiscal Bureau

GOCC = Grain and Oil Commerce Company

GPP = government price purchase (grain)

GMS = grain management station

HAU = Huazhong Agricultural University

JTC = Jingmen Transport Company

JTS = Jingmen City transfer station

MPP = market price purchase (grain)

SSTS = Shashi transfer station

SYTS = Shayang transfer station

tkm. = tonne-kilometre

TS(s)* = transfer station(s)

¥ = Yuan**

* The author is aware that the plural form of abbreviations should be written with an apostrophe (e.g. TS's) but he has decided not to follow this convention.

** The value of the Yuan during the research period (1987-1990) was 3.71 ¥ to the United States dollar, and 3.0 Yuan to the Canadian dollar, as per the exchange rate between the US and Canadian dollar at any particular time.

ABSTRACT

This study attempts to analyze the economics of grain transportation in China by investigating the Grain Bureau management system in a former county. The study focuses on the economics of grain flow management.

The grain flow network was primarily analyzed using a linear programming transportation-transshipment model. This model was used to determine the optimal grain flow network for 1987 and 1990 under various alternative assumptions. The cost of empty truck hauls is made through an analysis of the Grain Bureau's trucking company.

Several conclusions can be drawn from the analyses of the various results. The more important are:

(1) the quantity of surplus grain that will have to be transported in 1990 will increase by 59% over 1987 given current trends in population, demography, grain yields and cultivated grain area;

(2) the current networking of flows is not an optimal one in terms of a least cost criterion;

(3) the rescheduling of collections and distributions could have saved the Grain Bureau, not including costs for empty hauls, 612,149 ¥ in 1987, and would save them 3.2 million Yuan by the end of 1990, _ceteris paribus_; the saving for empty hauls is estimated to be 368,929 ¥ in 1987 and the cumulative four year extra cost by 1990, assuming a 59% increase in

costs, would be 5.1 million Yuan (1.7 million Canadian Dollars), *ceteris paribus*;

(4) Pressure can be taken off the railway system, and the viability of the Shashi transfer station can be ensured if a 10 km. long road is made available;

(5) the dual rate structure for barge and road shipments is not biasing flows away from the most economic routes;

The identified savings can be captured through better planning of grain transfers as identified in the research. Other impacts of a less quantifiable nature need to be studied in greater detail by those who are involved more directly in the system.

CHAPTER 1

INTRODUCTION

The rural or agricultural sector is now considered by many to be of primary importance in the development process. It is, most appropriately, the leading sector for development. This fact is especially true in China, since 80% of its 1.1 billion inhabitants live in a rural area. Typically, emphasis in agricultural development has been given to increasing production and yields of crops in order to facilitate gains in producer incomes. While this approach is appropriate in most underdeveloped countries, the approach is often carried out without an integrated strategy for marketing (including assembly, storage, transportation, processing and distribution) the increased output. This constrains a nation's capacity to feed itself and export to others. This is the case in the People's Republic of China. Record yields and production in some areas have caused unstorable surpluses which could not be marketed. The existence of a transportation problem was evidenced in 1984 when northern China could neither move its grain to ports nor consumers. It is partially due to this lack of marketing planning that "100 million rural inhabitants still do not have enough to eat."[1]

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[1]Smil, V. "China's Food," Scientific American Magazine, December, 1985.

In October, 1987, at a meeting of the International Association of Agricultural Economists held in Beijing, senior Chinese agricultural economists listed marketing and transportation as key topics of interest in agricultural development strategies. One of the country's leading experts on agricultural marketing said the following about the surplus problems in 1983-1984:

> "It has been effectively proved that ... the cause of the problem really lay with the lack of marketing facilities, with the inability of many villages to gain access to transportation facilities, and with the rigid administrative restrictions placed on marketing."

About agricultural marketing in China, he feels that:

> "The recent experiences emphasize that improving marketing facilities and reinforcing marketing reform are two of the critical problems in China today. The shortage of adequate institutions and administrative ability is even more serious than the shortage of physical infrastructure."[2]

Indeed, the investigation of agricultural marketing institutions and their administrative ability is long overdue. As evidenced above, bottlenecks in China's grain marketing and

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[2]An, Xi-ji, "The Development and Improvement of Agricultural Marketing in China", China's Rural Development Miracle - With International Comparisons, John W. Longworth, Editor, University of Queensland Press, 1989, Page 21.

transportation system have already begun to stifle agricultural and economic development. The root of the problem is thus one of identifying where and why these bottlenecks occur, what is the economic impact of these bottlenecks, and what can be done to eliminate them. The present research deals with the administrative ability of the state Grain Bureau to transfer grain in a least cost fashion.

The problems of the agriculture industry faced by the Government of China are numerous. There is a general lack of knowledge and data concerning the grain marketing system in China. To the author's knowledge, no research exists at Huazhong (Central China) Agricultural University (HAU) concerning the marketing of agricultural products and no one is very familiar with the system there.

It is clear that there is a need for developing a more efficient grain marketing and transportation system in China. The research presented here is necessary since problems exist in the storage and transportation of a vastly increased surplus of grain which exists at some localities in China. An efficient grain marketing system is one that assures the movement of surpluses to consumers in a least cost fashion with a minimum of waste and loss. It is the author's hope that this research will provide China with the means for achieving the desired result.

STATEMENT OF THE PROBLEM

The inability of the marketing system to move grain in a least cost fashion has resulted in unnecessary costs. These costs have increased in importance because new (1988) policies fixed or reduced Grain Bureau budgets and at the same time increased the quantity of grain the Grain Bureau must handle. It is clear that it is going to be more difficult for the Grain Bureau to improve its operations under these conditions unless it can reduce its costs. It is therefore necessary to examine where these reductions may be possible. Under any scenario, the existence of unnecessary costs is an economic inefficiency which can stifle agricultural and economic development. This economic problem exists to a varying extent in most countries and is examined here by investigating the grain marketing system of an area equivalent to a Chinese county, called Jingmen City.

The specific research problem is to determine if the current strategy for shipping grain, especially in terms of the networking of grain flows, is resulting in unnecessary costs to the system. Assuming it is, then the research must estimate the magnitude of these additional costs, currently and in the future, to determine the extent of the current and foreseeable problem. Determining the magnitudes of the additional costs is necessary as the resources available to tackle problems are limited and therefore problems must be prioritized by the perceived net benefit of correcting them. The ultimate objective is to determine what can be done to eliminate these extra costs so that corrective measures can be taken (e.g. determine which routes should be added or discontinued in the network), and thus extra funds made available to be applied to agricultural and economic development projects.

This thesis addresses three issues: (1) estimating foodgrain surpluses and deficits, (2) transporting surpluses in a least cost fashion under alternative scenarios, and (3) system management and marketing policy. The objectives related to each, which follow from the problem statement, are presented and discussed briefly in the following three sections.

RESEARCH OBJECTIVES

There are three specific research objectives:

1. To estimate current and future (1990) surpluses and deficits.
2. To estimate the current and future financial costs of (i) truck dead-hauls, (ii) the inability to use the railway, (iii) mismanaging grain flows, and (iv) redirected grain flows due to a dual rate structure.

3. To analyze policies and institutions which influence the management of the grain marketing and transportation system.

Each objective is discussed below.

SURPLUS - DEFICIT ESTIMATES

To manage a grain marketing system planners need to have a reasonably accurate estimate of the surpluses and deficits that are likely to occur. In China, planners rely on village level officials to report, approximately twenty times a year, their estimate of the harvests. This system does not provide for estimates of future harvests and is costly in terms of the time spent attending meetings. Also, peasants are not reliable if an accurate report is not in their interests.[3]

The objective here is to construct mathematical models of predictive value which can help planners reduce their reliance on subjective accounts of production and consumption that are presently used to predict surpluses and deficits.

The specific objectives are to estimate the increase in surplus grain in Jingmen, and estimate the increase in consumption at deficit points (cities) for the year 1990 so that the predicted surpluses and deficits can be used in the linear programming model described in objective 2 below.

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[3]Zweig, David Agrarian Radicalism In China, 1968-1981, Harvard University Press, 1989.

THE TRANSPORTATION PROBLEM AND OBJECTIVES

The transportation problem, among others, is characterized by a high percentage of dead-hauls for trucks, an overburdened railway system, the mismanagement of grain flows, and the existence of a dual tariff policy involving private and government carriers which could be biasing grain flows towards inappropriate directions. This study attempts to determine the magnitude of these problems in terms of a financial cost criterion.

The first objective here is to determine if there were errors in networking the grain flows and the cost of these errors, if any. This objective is obtained by measuring the transportation cost savings that would be possible if the system were run in a least cost fashion versus the present routing of grain flows. A measurement is also made for estimated 1990 grain flows, assuming management does not change the current network. Together these may be called the current and future costs of grain flow mismanagement.[4] These measurements are made by employing a single period, interregional, multi-modal linear programming transshipment-transportation model that analyzes the supply, demand and transportation network of the foodgrain (wheat and rice)

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[4]The word "mismanagement" is used in this thesis without derogatory intent and is used for ease of explanation only. The author realizes that there may be rational decisions which explain why grain flows are not scheduled according to a least cost criterion, and that these decisions would not, therefore, be considered bad management.

transportation system in Hubei Province generally, and Jingmen City specifically. Three models, one that models the flows that actually occurred in 1987 and two which optimize the network for 1987 and 1990, are compared to determine the cost savings and the dispatches which should be changed. The first comparison measures the two 1987 models against each other. The second comparison is more complicated. The extra cost in 1990, assuming the system flows were the same as in 1987 except 59% larger (the increase in grain surplus for 1990), is estimated by multiplying all the flows that took place in 1987 which should not occur in 1990 (but assuming they do), by the shadow prices from the 1990 optimized model. These flows are the activities which occurred in 1987 but did not enter the solution basis of the linear programming model for the optimal flow network in 1990. In other words, it is the extra cost to the system, in 1990, which would result from using the same dispatches as in 1987. The above therefore represents the running of three variations of the model.

Sub-objectives include running the above linear programming model under alternative assumptions so that the economic impact of a dual tariff policy for road vehicles and barges can be investigated, and a possible infrastructure improvement (construction of a road) can be investigated that would divert grain shipments from rail to water. This investigation leads to determining the cost of the inability to use the railway since this cost depends on whether this road is available or not.[5] The alternative assumptions which apply to three separate runs of the linear programming model are: (a) that an additional road is available, (b) that all transfer stations (TSs) use state-set transportation rates, and (c) that observed rates, not estimated state criterion rates, are used for some of the routes. The section examining the impact of an additional road also includes the determination of the cost of not being able to use the railway. Accomplishing these objectives therefore requires the running of three more variations of the model.

The linear programming model results are not directly used for the analysis of truck dead-haul costs, but could be modified to do so. Time-series data from the Jingmen Grain Bureau's transportation company are analyzed and manipulated in conjunction with data on the 1987 flows to estimate the 1987 cost of dead-hauls.

The magnitude of the benefit can be used to compare with the cost of restructuring the system so as to operate in a least cost manner, and to guide decision makers in determining which problems should take priority in further investigations.

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[5]There is a discrepancy on whether this road exists in Jingmen. The author believes that the simple tourist map showing the existence of this road is in error and that the cartographically produced map is the correct one.

MARKETING AND TRANSPORTATION POLICY

Most components of the marketing chain are under the management umbrella of the government Grain Bureau (GB) and follow its policies. In keeping with the systems approach to solving problems, a final objective is to analyze other components, especially policies and institutions which heavily influence system management, for problem areas and to document the more significant problems, possible causes, economic impacts and problem solutions. National as well as local policies are considered and include grain payments, the grain handling responsibility system, and state allowances for grain handling and losses.

In summary, there are three specific research objectives:

1. To estimate current and future (1990) surpluses and deficits.
2. To estimate the current and future financial costs of (i) truck dead-hauls, (ii) the inability to use the railway, (iii) mismanaging grain flows, and (iv) redirected grain flows due to a dual rate structure.
3. To analyze policies and institutions which influence the management of the grain marketing and transportation system.

The accomplishment of these objectives will either confirm or refute the following hypotheses.

HYPOTHESES

From the above discussion, the following hypotheses are suggested. Jingmen city is not moving grain in a least cost fashion. Secondly, the magnitude of the benefit of moving grain in a least cost fashion is large. Thirdly, management and institutional constraints limit the extent to which the system can be run in a least cost fashion. The first hypothesis is tested by comparing the actual 1987 collection and distribution costs with the optimized network. Clearly the second hypothesis is a matter of some judgement since a "large benefit" is a relative term, but since it was desired to investigate the magnitude of the cost savings which are possible, some hypothesis about this magnitude must be made. Without a better available yardstick, the author has chosen 100,000 ¥ as a "large benefit". The third hypothesis cannot be quantitatively tested and thus qualitative evidence is presented to test this hypothesis.

Non-economic constraints to least cost routings (eg. political) are not dealt with in this thesis. The implications of not dealing with these constraints are perilous. Since political considerations may often take precedence over economic considerations, implementation of the recommendations arising from this research may not be possible.

STUDY SCOPE

This thesis is a case study of a single region in China that is equivalent to a county. The thesis analyzes the economic feasibility of modifying the management of the grain marketing and transportation system by estimating the cost savings that are possible if the current pattern of grain flows is changed. The analysis is limited by incomplete data due to the secretive and strategic nature of the grain system, and the absence of political constraints in the analysis. It can be assumed that political considerations often take priority over economic considerations in the decision making process in China.

Developing the grain marketing and transportation system necessarily requires intersectoral planning and coordination which, in turn, requires knowing the cost of trade-offs and alternatives. To obtain the required costs and other relevant data for the system, the following methodology was used.

The study consists of four major chapters. Chapter 2 is a rather large section on the methodology of the thesis. The unusual nature of this research and the data it uses require detailed explanation. Chapter 3 analyzes time-series data to determine surplus-deficit estimates for 1990. These estimates are used in the linear programming model of chapter 4. Chapter 4 utilizes a linear programming model to determine the cost of present and optimal grain flow patterns in Jingmen City and to determine the present and future benefits of using a least cost route given various assumptions about the system. Chapter 5 contains the discussion of other system management problems which restrict the smooth operation of the system and possible solutions to these problems. In particular, this chapter analyzes the Jingmen Transportation Company and deals with the cost and magnitude of empty truck hauls.

There is no literature review in the thesis since related studies could not be found, except for those that relate to estimating population, land area, production, etc. This literature would only relate to chapter 3 of the thesis. The author has included a bibliography which adequately covers the area of study.

CHAPTER 2

METHODOLOGY

GENERAL METHODOLOGY

Research Location and Study Area Choice

Wuhan, the capital of Hubei Province, is located in central-eastern China at the junction of the Chang Jiang (Yangtze) River and the Beijing (Peking) - Guangzhou (Canton) rail line (see figure 1). Wuhan is a transportation centre in China, has a population of 6.08 million,[6] and has one of the seven national agricultural universities in the country. Huazhong Agricultural University (HAU), Wuhan, was the headquarters for the study. Agricultural marketing, the author's area of expertise, is not included in the curriculum at HAU.

The study areas were Jingmen City (a 4,412 square km. area) and Jiangling County, both of which are located at approximately 112 degrees E longitude and 31 degrees N latitude. Both are located approximately 250 kms. west of Wuhan. Wuhan was originally supposed to be included as per the permission granted by the Ministry of Agriculture, Animal Husbandry and Fisheries but was not studied because city government permission was deemed too difficult to acquire. Jingmen will be the name used to represent the entire area shown on the map while Jingmen City, the capital of Jingmen

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[6]China Business Weekly, 7 February 1988.

MAP OF HUBEI PROVINCE SHOWING JINGMEN CITY

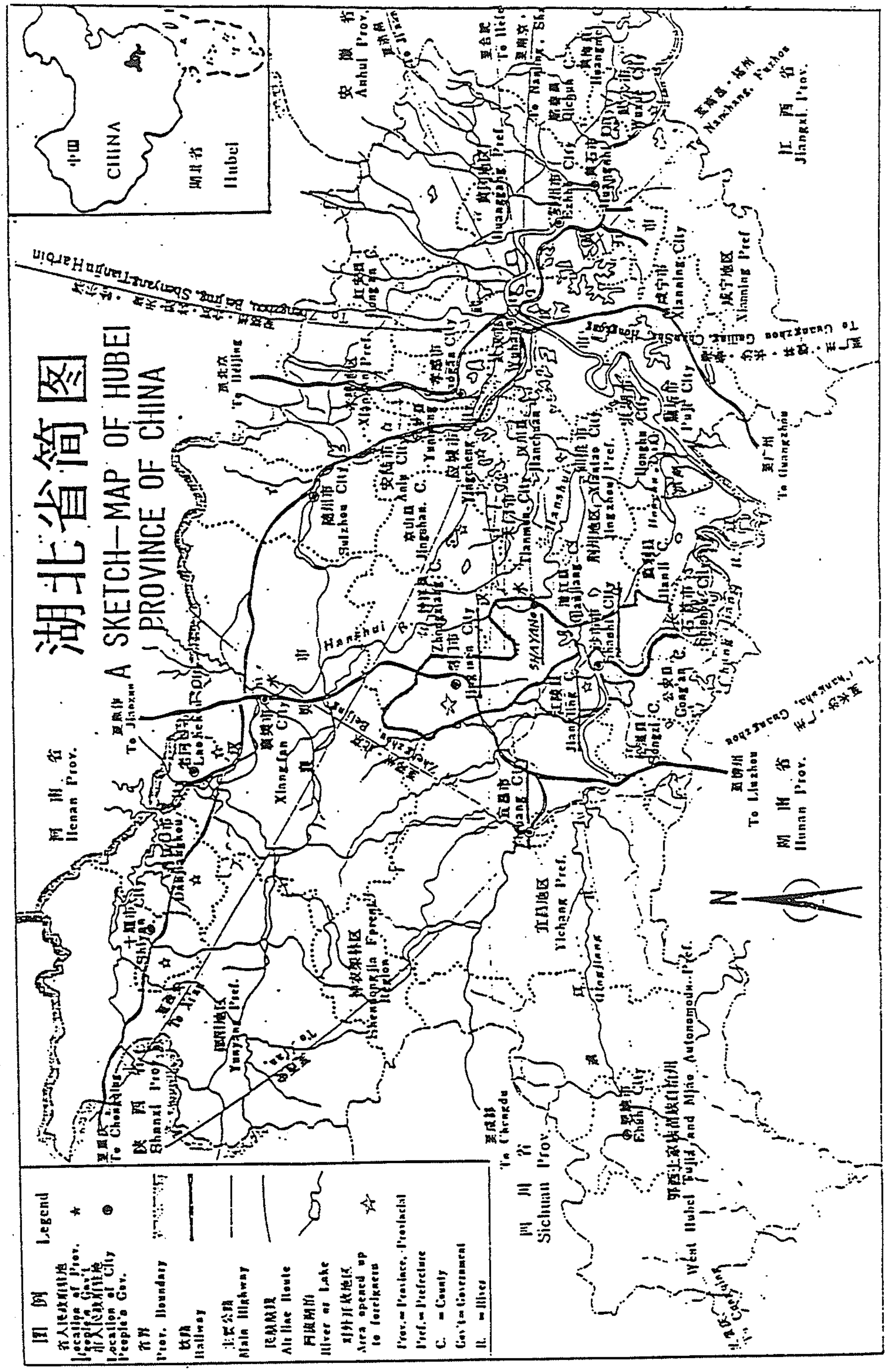

FIGURE 1

City (the capital's name is identical to the area's name), will retain its original name. Jingmen was the primary area of interest while investigations in Jiangling County were mostly limited to corroborating what was learned in Jingmen.

Jingmen was chosen for six reasons. First, it is an area in which HAU had done work before. Secondly, it is an area which is served by both railway and water transportation routes. Thirdly, together with Jiangling County, it is in close proximity to the city of Shashi, itself reported to be the fourth or fifth largest grain market in China. Fourth, it is an area of large rice surplus and has long had the name of "a grain warehouse." Fifth, it is a "Commercial Grain Base" as designated by the national government and has therefore been targeted for receiving greater development assistance in agriculture. Lastly, they were areas open to foreigners. It should be noted that "models" such as the Commercial Grain Bases in China get substantial subsidies from the central government and do not necessarily represent the average unit (e.g. county) in China.

Jiangling County was chosen mainly because it surrounds Shashi and thus borders on the Yangtze River. It borders Jingmen to the south and thus has similarities with Jingmen. It was also chosen because the capital, Jiangling City, is the prefecture capital and thus was expected to have some important decision makers who could be interviewed.

Jingmen occupies the north-west section of the Han-Jiang Plain (between the Han Shui and Yangtze Rivers) in the north-west section of the Middle Yangtze Basin. Jingmen City has a long history as the ancient gate to Hubei province for those coming from the north and the west.

Jingmen was a county a few years ago and is now partially under planning directives from Beijing. A county is normally responsible to its district or prefecture which in turn is under planning from the province. However, since Jingmen has a railway, it must ship goods to many provinces and this planning is done by the central government.

Jingmen currently consists of two Districts (Chinese name unknown), not to be confused with a district (Di Qu) under provincial level, and each is said to have the status of a county. Jingmen City is the capital of one district, while Shayang is the capital of the other. Further divisions include the following: thirty-five Townships, (about) ten Towns, six hundred Villages, 4,700 Production Groups and 17,000 Households. The average household of 5.9 people has on average half a hectare of land which can support rice production and the land can usually be cultivated twice a year.

The General Theoretical Approach

Production, consumption, storage and transportation are spatially distributed activities. The former three are activities which are fixed in particular locations and they are linked through time and space by transportation. The grain transportation system is best studied in terms of producers and consumers, and the markets and transportation links serving them. This theoretical approach is illustrated in figure 2 and was used for this thesis. Production exists around three production markets of different size (villages, township capitals and cities), and flows to its nearest production market or consumption point. Production flows through production markets of increasing size (first level to third level). Once the grain is in consumable form, it enters the consumption chain. The grain then flows through markets of decreasing size until it reaches its final consumption point. The exceptions here are production which is consumed in the villages (by non-grain producers), and production which is sold directly to consumers (without ration coupons) in urban areas, which enters neither production nor consumption markets. These latter flows are shown as flows from production areas directly to more than one consumption area (see double lines in figure 2). Other flows (single lines) represent grain destined for industrial consumption and for ration coupon holders in different administrative levels of the cities. There are no flows between first level production and consumption markets (purchasing stations) and flows can also by-pass second level markets. A more specific example is given in the following section.

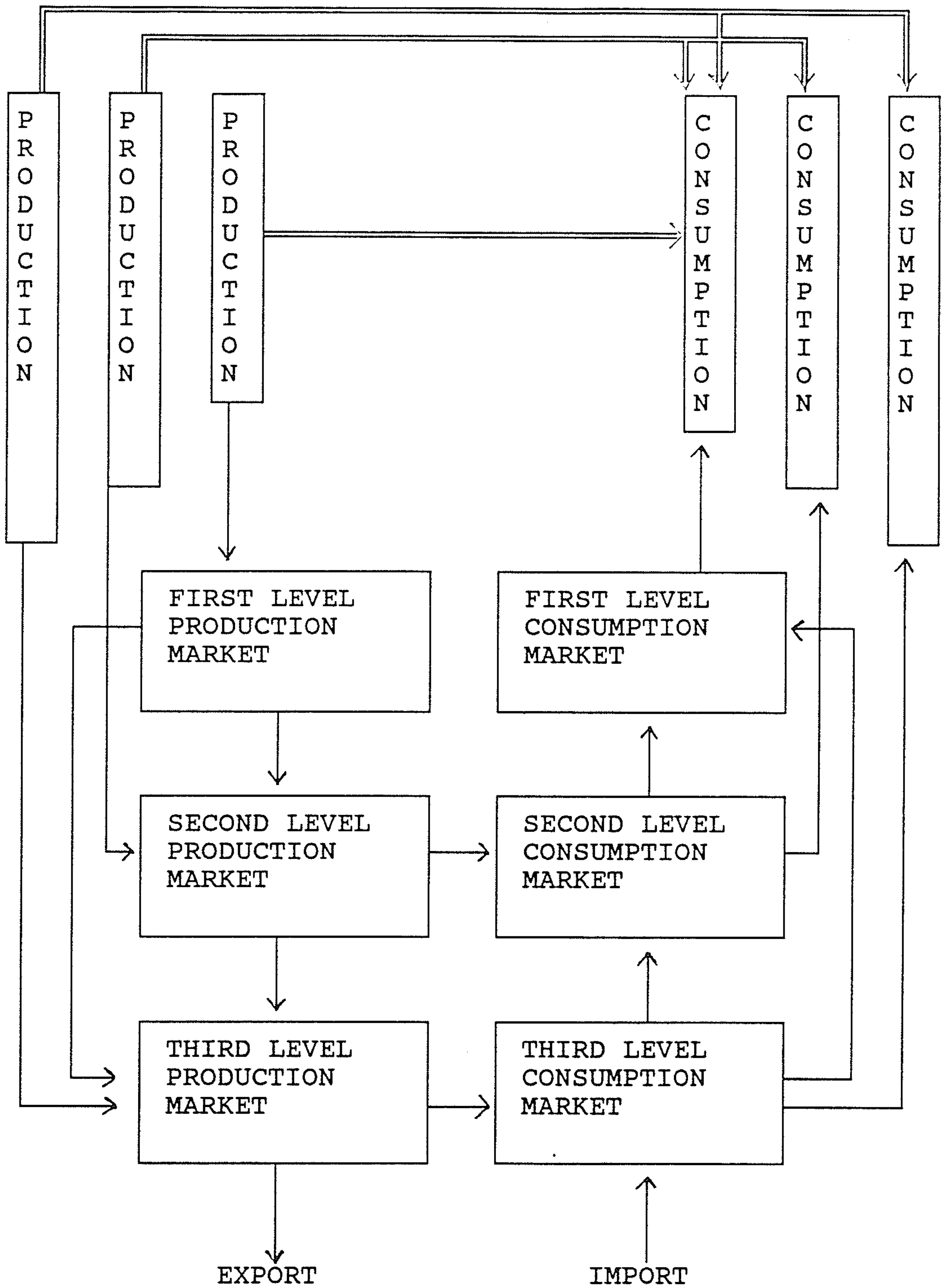

FIGURE 2. FLOWCHART OF THEORETICAL GRAIN MOVEMENTS IN JINGMEN

Defined Geographic Markets and Transportation Links

The abstract schematic diagram of figure 2 can be translated into definable locations and transportation links. The farmers who live in hamlets surrounding the geographic area known as a village or cun deliver their surplus production (first level production) to a purchasing station, a first level production market, or directly (double lines) to someone in the village who has to buy grain (first level consumption). A village consists of a number of hamlets and thus farmers who need to purchase grain usually get it in their hamlet or village. On average, three other villages will also deliver to the station. Transport is generally done by hand wagon, a hand wagon with a horse attached, or the ubiquitous walking tractor. All other production is processed and consumed in the hamlet. From the purchasing station the surplus will travel by walking tractor or a larger tractor to the township capital where the Grain Management Station (GMS) is located (a second level production market) or directly to a third level production market which is a grain transfer station (TS). The latter transfer usually occurs when a truck can be used for transport. Surplus production that is near the second and third level production markets (second and third level production), i.e., near township capitals and cities, will go directly to those markets. For example, there will be about three villages which will deliver directly to the GMS in the township capital. Since townships strive for self -

sufficiency, some of the production entering the GMS will be made available through the "supply and sale" store located at the GMS (a second level consumption market) to residents of this township capital (second level consumption). Residents who have grain ration coupons get their rice and wheat flour here. Some rural households (first level consumption) who do not have grain of their own will buy grain here through a second channel (first level consumption market) where they pay the market price. These rural residents might also purchase directly from first level production (double line). The third level production market (a transfer station or major processing facility) is usually where the grain enters the consumption chain through markets of decreasing size. Production can arrive here from anywhere, and can be distributed to all consumption markets and consumption levels. Third level production (surplus from villages near the cities) might go directly to rural residents or city residents (double lines) but will not likely go to the township residents and thus there is no double line to second level consumption. The grain that does not enter the consumption chain in Jingmen City (the supply and sale stores), is exported via rail to be distributed, eventually, to 240 work units in a number of provinces and municipalities. Shayang and Shashi TSs export via their waterways. Jingmen, officially, does not import any grain but grain does arrive here from outside the region when the price is sufficiently attractive.

The Jingmen Grain Bureau claims that, other than the cities, there are no deficit regions in Jingmen.[7] The deficit areas of major interest are Wuhan and Yi Chang, cities on the Yangtze River, southeast and southwest of Jingmen respectively. Both receive grain from more than one TS in Jingmen and thus yield to a comparative analysis for testing the least-cost flows.

The vast majority of the grain flows are determined according to the state procurement and delivery plan. Grain processing, while mostly occurring before the third level production market, can occur at any of the market levels described.

The above example illustrates the geographic approach used. Production and consumption markets, the transportation links connecting them, and the flows of grain going through them were identified at various administrative levels.

Jingmen's Grain Bureau Marketing System In Summary

The grain bureau (GB) has the responsibility for moving the grain from its 35 GMSs located mostly in the township capitals and from the 152 grain collection stations. The 152 likely includes the 35 GMSs while the remaining 117 are what the author calls purchasing stations and temporary purchasing stations. Figure 3 shows 43 towns and township capitals in

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[7]Gu Cheng Jian, Vice-Director of Jingmen Grain Bureau, Interview by author, translated by Zhang Xing Bo, Jingmen, Hubei, P.R.C., 1 November 1988.

Jingmen. Of these 43, 35 will have GMSs. Using the cultivated (arable) land figure for 1987, this means each and every collection point was responsible for 6.5 square kms. of arable land or 29 square kms. of total land on average.

A previous goal of the Grain Bureau was to reduce the distance a farmer had to travel to less than four kms. to deliver his grain (a distance which, it was said, would allow a farmer leaving at 7:30 AM to be back for a late lunch at 3:00 PM). They claim to have accomplished that goal and indeed one can calculate that the 152 29-square km. market areas (approximated by a circle) will have an average border distance of just 3.0 kms. However this is only an average and some people are delivering to a distance of 7.5-10 kms.[8] This goal was accomplished by the introduction of temporary purchasing stations. Many purchasing stations seem to be simply temporary purchasing stations which have become permanent features of the system. Jiangling County also had another category of stations, which can only be described as a truck stop where the GB sends a truck to pick up grain. Since the 4 kilometre maximum delivery distance goal was achieved a few years ago, farmers must deliver their assigned quota to their designated purchasing station (one of the above four types) at their own cost. The cost of this delivery is purportedly included in the higher price of grain now paid to

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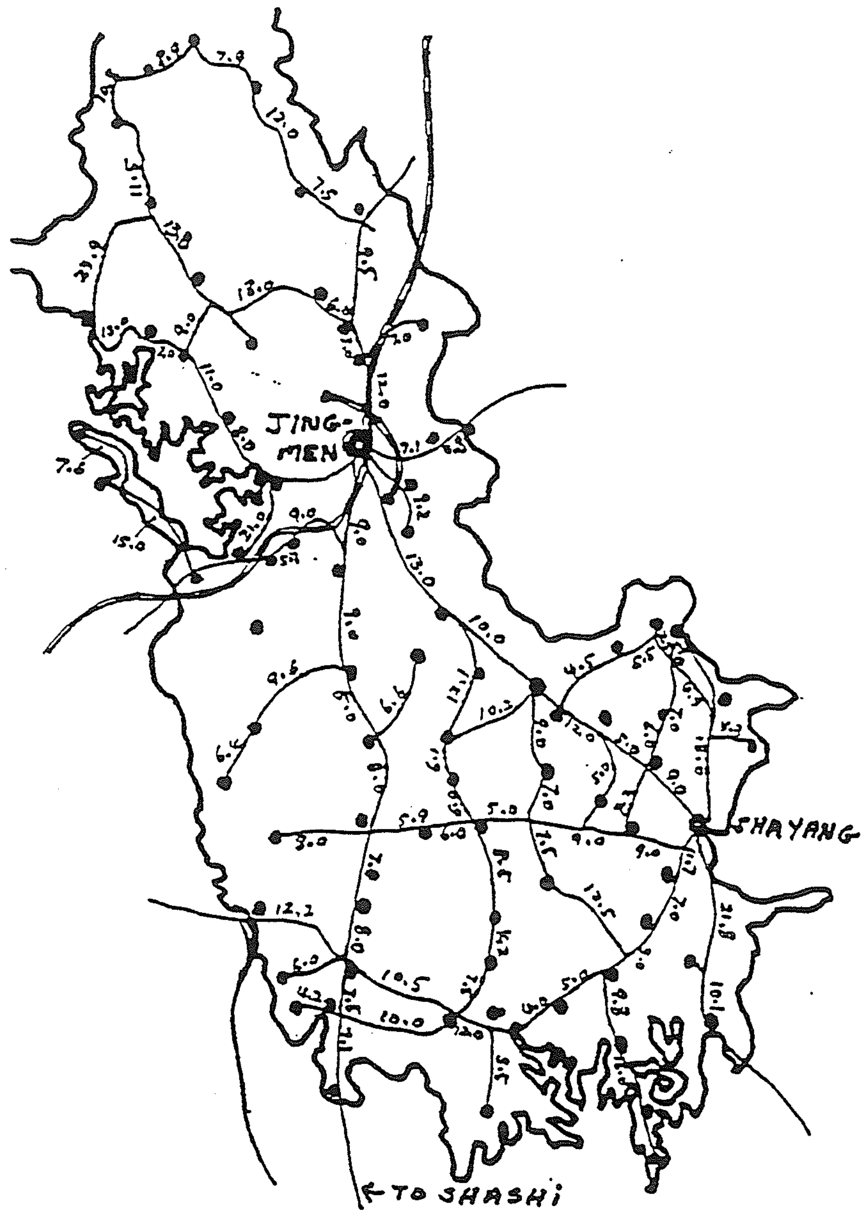
[8]Hu Zheng Guo, Interview by author, translated by Zhang Xing Bo, Shenji GMS, 11 April 1988.

MAP OF JINGMEN CITY SHOWING TOWNS AND TRANSPORTATION ROUTES



KEYS:

- —— Roads
- o District Capitals
- ▬ Jingmen City Boundary
- • Towns and Township Capitals
- ═ Railway Lines
- 10.0 Kilometer Distances

SCALE:
1 Centimetre = 7.5 Kilometres

FIGURE 3

farmers. While it is not clear what situation existed before this goal was accomplished and before the new pricing policy was initiated, I was informed that farmers who had to travel further were compensated to some extent. Perhaps those that must deliver from 7.5-10 kms. away still deserve some compensation if equality in incomes is desired. This recent development seems to run contrary to national plans. Those plans envisioned an increase in the distance between warehouses.[9]

Given various duties performed at the primary collection station, the grain is then usually moved via a truck or tractor belonging to or contracted by the Grain Bureau's transportation company. The vehicle will usually transport the grain to one of the 18 grain processing factories. From there, the refined grain is either sent to one of the three transfer stations for rail and river transhipment, or to one of 18 sale stores for distribution to consumers through smaller sale stores within Jingmen.

The Grain Bureau has three major measures of performance efficiency. The first is tonnes handled per employee. Grain handled, a measure of work done, is currently approximately 1.1 million tonnes (mt.) per year and this figure consists of values for storage, transportation, sale, processing and

[9] Professor Ju, Interview by author, translated by Zhang Xing Bo and Shen Dazun, Wuhan Grain Industry Research Institute, 9 January 1989.

export (Jingmen does not import any grain). Authorities indicate that this represents .55 mt. in and .55 mt. out. In many cases the grain is either adjusted to the processed rate for incoming grain, or the out-going grain is adjusted upwards to reflect the equivalent weight in unprocessed form - this makes the totals equal. This 1.1 mt. number is probably low given that some of the grain was most likely adjusted to 70% of the paddy weight of the rice (processed rice is always adjusted to 70% of the paddy weight). The second efficiency measure is profit rate, which is equal to output less input (value added), divided by input. The third measure is whether the state plan for output and its related costs has been met or not.

Theoretically, grain is collected and stored via two channels. One is grain collected through the state planned purchase channel, often referred to as the government price purchase (GPP), and the other is the market price channel, often referred to as the market price purchase (MPP). The MPP grain receives a price equal to what western analysts recognize as the "above-quota purchase price." The MPP grain price is determined by the Grain Bureau's Grain and Oil Commerce Company (GOCC) after consultation about prices in other localities. The GPP grain price remains fixed in accordance with the state plan while the MPP grain price is allowed to fluctuate to some extent.

The four guidelines for "reasonable" (a description often heard by the author but with no firm meaning) collection of grain. Only one of the guidelines has a definitive meaning as understood by the author and interpreter. That guideline is "always take the grain to the nearest processing point." This leaves open the question of whether it may be more cost efficient to move the grain further to a more efficient processing point. This possibility was not researched.

The government plan for exports is made well in advance. Jingmen has one monthly, and four seasonal plans for managing the storage and transportation flows. In general, each collection station is emptied when it is their turn according to the monthly plan. Though the plan is to have that collection station emptied within that month[10], data would indicate this is not the case[11]. The annual meeting of local leaders on how to formalize the plan is very important because the quotas are determined at this time. The quotas directly affect profitability and are sometimes fixed for a three year period. Furthermore, the monthly plan, which schedules grain procurement, can affect profit through greater storage costs for those stations emptied later in the year.

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[10]Shayang grain processing factory, 5 November 1988.

[11]See table 2 and the discussion of this data for support for this claim.

Products Studied

This analysis covers only the foodgrains of rice and winter wheat. Rice (Japonica and Indica varieties) is the principal crop grown, totalling approximately 80% of the grain produced. Wheat makes up almost all of the remaining 20%. Other important crops in this area are rapeseed and cotton. However, grains other than wheat and rice generally do not enter the commercial grain system and thus were not studied.

Study Years

In order to make projections for production and consumption for Jingmen, and to develop plans for the future, relevant data for as many past years as possible was obtained. Since and including the 1984 crop year, 1986 and 1987 were said to be the most normal years for production considering policy changes and weather.[12] Current conditions were those for 1987, the most recent year for which complete statistical data was available for Jingmen. The year 1990 was chosen for prediction in order to match planning and development scenarios envisioned by the Grain Industry Research Institute in Wuhan.[13]

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[12]Shen Dazun, Department of Agricultural Economics, Huazhong Agricultural University.

[13]The author hopes to publish an article on these development scenarios, which include predictions to the year 2000.

Data Collection and Interviews

Interviews with various participants in the grain storage and transportation network were the main means of data collection. All quantitative data has been converted into metric and/or imperial measures. Interviews were done with the help of a translator/assistant from the Department of Agricultural Economics, Huazhong Agricultural University. The assistant was chosen by the author. The itinerary was decided by Jingmen's Grain Bureau without much input by the author. The itinerary was set to cover the major participants in the system, including transfer stations (inland terminals), Grain Management Stations, Grain Purchasing Stations, grain processing factories, transportation companies, and farmers, all in various townships in the area. Farmers, and the northern area of Jingmen were, in the end, not allowed to be visited. Each interview ended with a request by the author to relate to him the problems they were having but in most instances the interviewees were reluctant to mention anything in detail. Although the author was often perceived to be more of a nuisance to them than a resource at their disposal, every effort was made to make this research valuable to those involved.

COMPONENTS ANALYZED

There were six components analyzed in this study: production, consumption, surplus-deficit position, transportation (modes, volumes and rates), storage (location, capacity and type), and policies and marketing institutions.[14] The methodology in analyzing each is presented below.

Production

Cultivated area (in Chinese statistics, a sum of rice cultivated area and arid cultivated area) and production (broken down in various ways) were the data sets available for this analysis. The cultivated area data is special since sown area data is what is usually available in published documents on China's agriculture. Time-series data is analyzed for production and cultivated area trends and thus grain yield trends and these trends are used for estimating production in 1990.

Production is especially important because the main sensitivity to agricultural planning depends on production projections. Consumption projections are easier to make because changes in consumption tend to follow established patterns and storage at consumption points is similar irrespective of the sources of deliveries. If production projections are lower than actual future production the underestimation would result in more storage needed sooner. If

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[14]Greater elaboration on this approach can be found in: Tyrchniewicz, E.W., Honeyman, D.D., and Zhong, F-N, "Developing Transport and Infrastructure Facilities For China's Agriculture", China's Rural Development Miracle - With International Comparisons, John W. Longworth, Editor, University of Queensland Press, 1989, Pages 264-273.

production were higher than projected, product flows might change direction but the volume moved would be similar. Production tends to fluctuate much more than consumption and thus it is of more importance in making surplus-deficit projections.

Consumption

Consumption is only realized in data sets as the residual of production, less the sum of government price purchase grain plus market price purchase grain (together referred to as surplus production or commercial grain). Thus, to call this number consumption is a misnomer since it includes farm storage, animal feed, seed, and human consumption. These government grain purchases are neither easily definable nor recognizable in western literature since the channels for procuring grain were changed in 1987. Refer to the following section for a more complete discussion of the differences between 1986 and 1987.

Jingmen population data, broken down into rural and urban populations, is used to estimate per capita consumption for rural and urban residents and thus population trends are the basis for estimating 1990 consumption in Jingmen. Population growth and consequently consumption growth are also estimated for Wuhan and Yichang cities.

Surplus Production and Deficits

Surplus production is defined as the amount of commercial grain purchased by the government. Surplus production therefore includes both MPP and GPP grain. Where it is noted in the thesis, the surplus may only represent the GPP grain. The GPP grain quota is almost always fulfilled and in statistics the Grain Bureau considers the GPP grain purchased to represent the GPP quota that must be delivered from that area, as does this study.[15] 1987 commercial grain statistics should represent almost all surplus grain as regulations prohibited non-government sales in this year. Statistics for 1984 represent reliable quantities of grain available, as the market price for grain was below the government above-quota price in this year. This fact means that most of the commercial grain was sold to the state in this year. Thus the amount of grain available in 1984 and 1987 represents the most reliable numbers for the grain surpluses in Jingmen. These figures take precedence in estimating future surpluses in this study. There have always been instances of grain being sold outside the state system and thus the amount of surplus grain available is underestimated.

While this method of estimating the surplus is oversimplified, it adequately provides for a crude estimate of the surplus for Jingmen. Jingmen's own estimate for grain

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[15] Data from a township in Jiangling in 1988 shows this not to be the case.

purchases or surplus was out by 86,100 tonnes in 1987, or 14.6% lower than expected. Therefore, estimates given are not entirely reliable.

Transportation Modes, Volumes and Rates

All modes used for the transport of grain were studied to some extent. The study focused on three aspects: (1) obtaining rates for the various modes on a per tonne-kilometre (tkm.) basis, (2) identifying the origin and destinations of grain flows and the distances between them, and (3) determining the quantity flowing between markets. This is the data necessary to construct a linear programming transportation model. Maps, and interviews with the Jingmen Grain Bureau and the three TSs, were the main sources for this data.

Most attention was given to the trucking mode as it plays the most important role within the area studied. Time-series data was released from the Grain Bureau's transportation company which was analyzed for trends, and to construct efficiency measures.

According to regulations which came into effect in January 1988, shipping, railway and air transport rates must be under the "unified control of the State Administration of Commodity Prices".[16] This statement means that there are price ceilings which cannot be changed without prior authorization. In some localities, these price ceilings are

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[16] China Daily, 20 January 1988.

only "indicative prices." It was not clear how often charges were greater than the indicative price but faster transportation was one of the reasons given for being able to charge a negotiated price higher than the ceiling price. The regulations also call for "less circulation links and direct contacts between producers and cargo owners."[17] In other words, they do not want a proliferation of middlemen who might contribute to rising prices.

Storage

Storage, among other functions, allows seasonal fluctuations in the transport demand to be smoothed out. Storage used as security is also a precautionary measure against natural disasters, wars, and international market fluctuations. Storage questions were not allowed in Jiangling and the questions asked in Jingmen may have been the reason for the termination of the author's research there.[18] Storage is strategic and data was therefore scant.

National, provincial, county and township governments were asked to provide details on the quantity of bag and bulk storage, the type of storage structures used, and the location of storage units. The major interest in carrying out this

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[17] Ibid.

[18] The field research was terminated by the Grain Bureau after about three weeks in Jingmen. When the author subsequently went to Jiangling County for continued research, he was told questions about grain storage were not to be asked.

inquiry was to determine the proportion of open versus closed warehouses and to determine the problems and prospects associated with moving to a more mechanized system of handling grain. No formal analysis of storage exists in this thesis due to lack of data.

Processing

Grain processing was originally judged to require detailed attention. This is because processing takes place at every production market level and because the cost of processing should be included in determining least cost flows given that there are economies of scale in processing. Processing is also important as the movement of paddy rice involves loads which are about 50% heavier than processed rice and paddy is bulkier than an equivalent weight of processed rice.[19]

Processing was analyzed in terms of how much of the commercial grain transported involved paddy rice, and the capacity of plants to process rice and the problems involved. The original methodology was to determine the cost of processing at plants for use in the linear programming model, but certain problems precluded this.[20] Processing capacity is

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[19]FAO Rice Marketing, FAO Marketing Guide No.6, Rome, 1972

[20]Handling cost data was deemed to be unreliable since this data was at times falsified and in general seemed to vary greatly between transfer stations. Additionally, accountants were not able to define the terms used nor how they were calculated.

inadequate, probably because of the frequency with which plants must be shut down due to power shortages.

THE LINEAR PROGRAMMING MODEL

The linear programming (LP) model consists of grain originating from 23 points in Jingmen, each moving via three possible shortest distance road routes to TSs. The TSs have various numbers of consumption centres to which they deliver and only one centre, Wuhan, can receive grain from all three TSs. In total, there are six consumption centres. See figure 4 for a schematic diagram of this model. The model consists of 79 variables and 32 constraints. The formulation of the model is as follows.

Minimize:

$$\sum_{j=1}^{23} \sum_{k=1}^{3} a_{jk} X_{jk} + \sum_{k=1}^{3} \sum_{h=1}^{6} c_{kh} Z_{kh}$$

Subject to:

$$\Sigma X_{jk} \geq S_j$$

$$\Sigma Z_{kh} \leq D_h$$

$$\Sigma X_{jk} = \Sigma Z_{kh}$$

$$\Sigma S_j = \Sigma D_h$$

Where:

a_{jk} = cost per tonne of moving grain from $_j^{th}$ origin point to $_k^{th}$ transfer point

c_{kh} = cost per tonne of moving grain from $_k^{th}$ transfer point to $_h^{th}$ destination point

X_{jk} = quantity of grain moved from $_j^{th}$ origin point to $_k^{th}$ transfer point

Z_{kh} = quantity of grain moved from $_k^{th}$ transfer point to $_h^{th}$ destination point

S_j = supply of grain at $_j^{th}$ origin point

D_h = demand for grain at $_h^{th}$ destination point.

Model Data Definition and Selection

Model Selection

Given the questionable reliability of the data used, it is necessary to justify the use of this model. The model and the results it provides are not intended to offer a definitive solution to the problem, although the author believes the data to be of sufficient quality to provide reasonably accurate results. The model is an example of how data can be easily organized into a framework for meaningful analysis and it is an illustration of what can be done. It has the advantage of being easy to construct, use, and understand. Simple problems can be solved using pencil and paper, which is important for a variety of reasons. Understanding its theoretical basis allows for the general model to be used in other problem

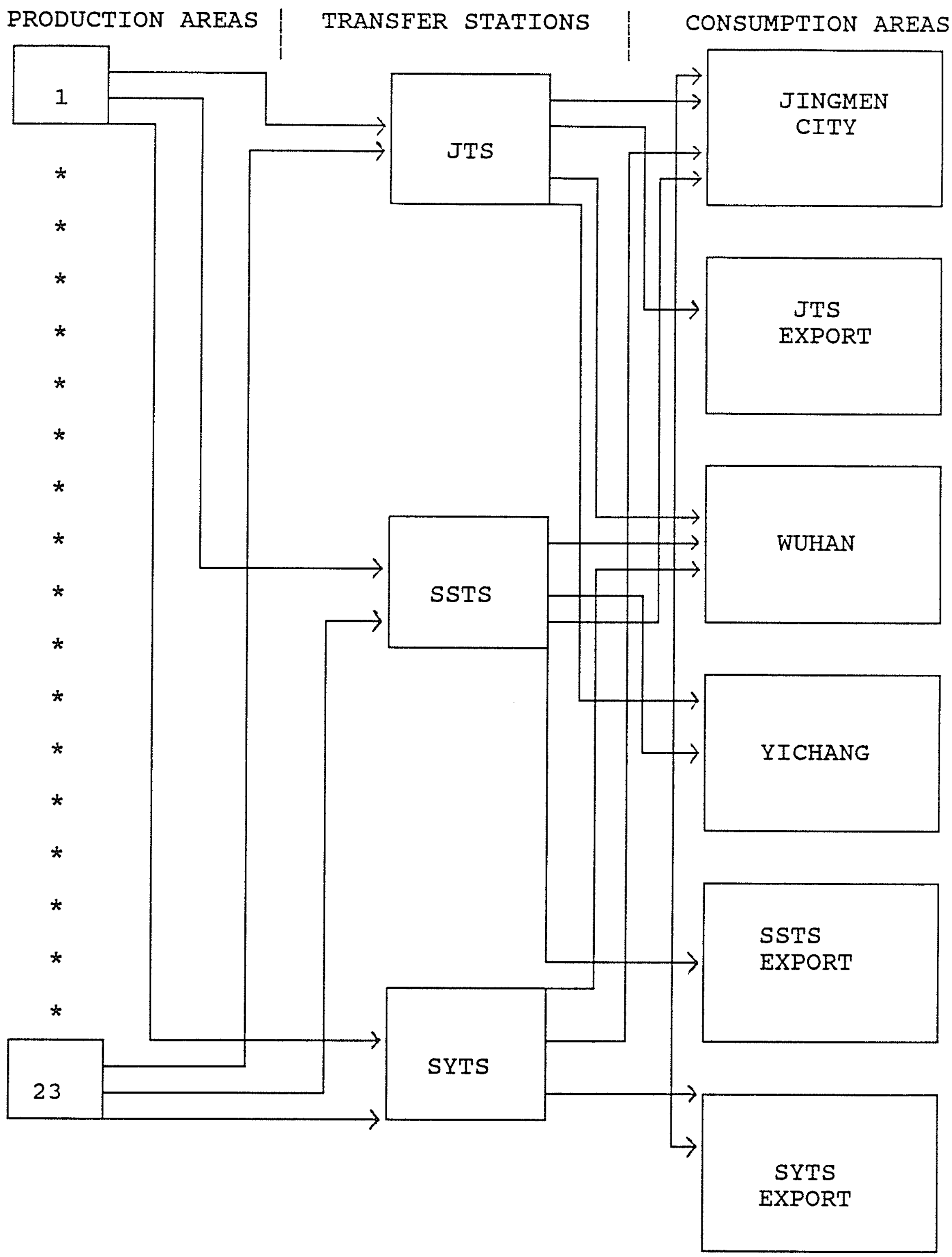


FIGURE 4. SCHEMATIC DIAGRAM OF PROGRAMMED GRAIN FLOWS

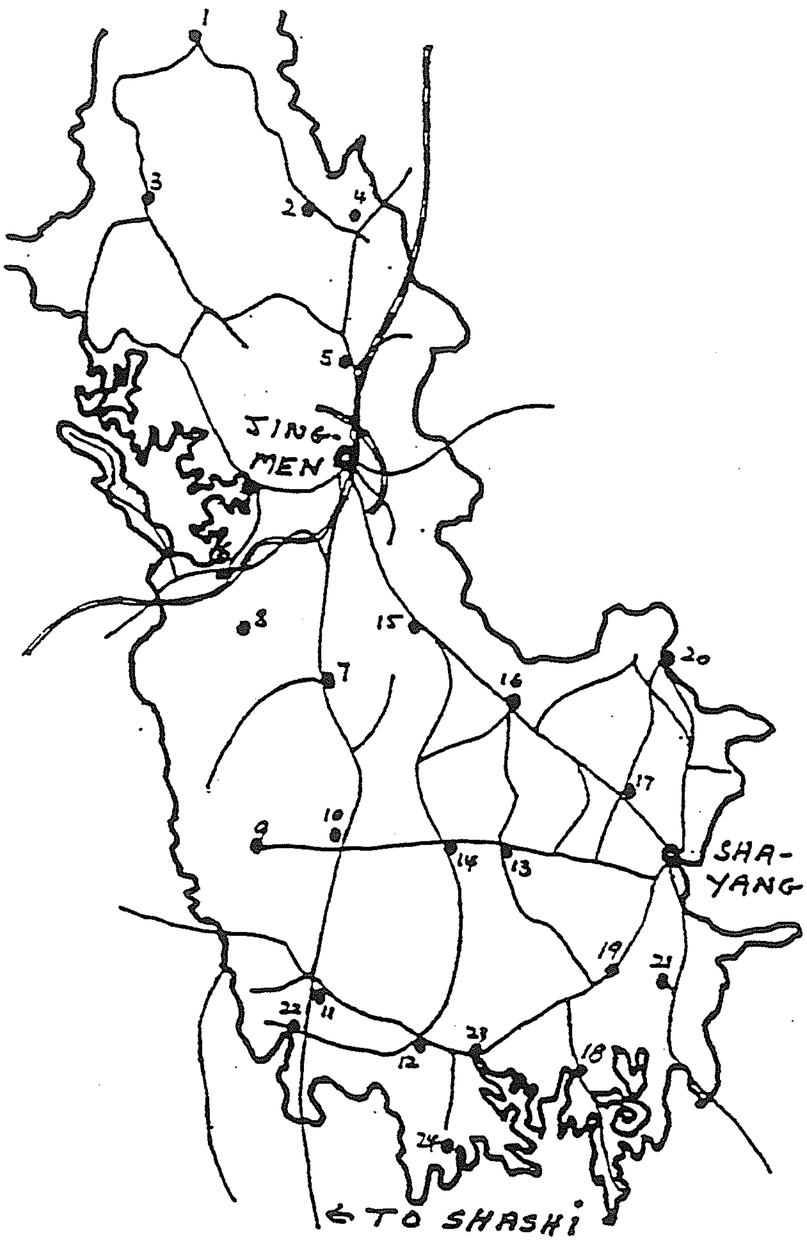
areas (e.g. in feed mix problems, as was demonstrated by the author in Jingmen), and thus its application can result in benefits for other sectors. These benefits justify the use of this model despite the data concerns.

Another challenge is defending the model against the argument that the optimal solutions it provides cannot really be considered optimal unless the political environment is also taken into account. This question is especially appropriate in China. While current movements of grain may not be optimal according to a least cost criterion, they may be optimal if relationships between system participants and the equity issues which permeate Chinese life, are considered. The model cannot take into account the benefits arising from decisions which are intended to benefit a particular group or individual over others.

Origin Points

Figure 5 shows the towns and transportation routes in Jingmen. For clarity and simplicity the names have been left off the map by the author although additional information about a place can sometimes be read from the name (e.g. includes the character for "market"). The numbers indicate those towns (more specifically, grain management stations) or factories that delivered grain in 1987 and which are located outside of the cities where the TSs are located. The actual place names (in pinyin) can be found in appendix 1. There are

MAP OF JINGMEN SHOWING MODELLED SUPPLY POINTS
AND TRANSFER STATIONS



KEYS:

——	Roads
o	District Capitals
▬▬	Jingmen City Boundary
•	Towns and Township Capitals
═══	Railway Lines
10	Supply Station Number

SCALE:
1 Centimetre = 7.5 Kilometres

FIGURE 5

24 grain surplus points on the map which are outside of Jingman City and Shayang. These points are equivalent to deliveries from the GMSs, although the data actually reflects grain which also originated at the purchasing points surrounding the GMSs and which did not go to the GMS first. Altogether there are 41 township capitals and towns (a town is usually a place with a grain processing factory)in Jingmen. Thirty-five of the 41 are township capitals and thus there are probably at least six processing factories which are not in or near the township capitals. There are 21 processing factories in Jingmen which allow much of the grain (approximately 84%) to be processed before reaching the TSs.

The map has a few misleading features. The scale used for the map does not always correspond with the kms. marked beside the links although the km. figures seem to agree with road sign mileage indicators and oedometer checks on the vehicle used when visiting the rural areas. The map's scale is not accurate, but since it is only 1%-2% smaller than a map the author had of Hubei Province, it was given that map's scale. Even with this scale, it can be observed that the relationship between centimetres and kilometres does not hold. The distances shown on the map, in total kilometres, are the ones used in calculations of transportation rates. The major difficulty in reading the map is that it is not clear from which point to which point the km. number refers to. To alleviate this problem, a bus timetable with distances to the various destinations was used as a check against the map. Only the distance to one destination (supply station 20) differed significantly from what the map indicated and the distance in the timetable is considered a misprint as the distance is so much more than seems possible.

Of the 30 towns or factories (collectively referred to as supply stations or just stations) which delivered grain in 1987 (see table 1) only station 8 could not be found on the map. Since the positioning of that town would be arbitrary, it is not included in the model, but it is believed to be in the general area shown on the map. Apparently, station 24 has no major road to use, and the distance from that town to the nearest road was estimated to be 4.5 kms. One capital (southeast corner) has changed its name. Stations 26 through 30 are companies in Jingmen city and are not included in the model. The shipment from station 25 (Shayang) is either oil or feed and is therefore omitted. Thus, for the base model, there are 23 origin points or supply stations.

Route Choice

The quality of the roads in the area will affect the choice of route tremendously since there are large differences in road qualities in Jingmen. While most roads are assumed to be of equal quality, and therefore the cost of using each route dependent only upon distance, the road between Jingmen and Shashi is a newly opened (October, 1988) Class 2 highway

TABLE 1

GRAIN DELIVERED FROM SUPPLY STATIONS TO TRANSFER STATIONS IN 1987 (Tonnes)

Supply Station	Transfer Stations			Totals
	Jingmen	Shashi	Shayang	
1	359	0	0	359
2	5,317	0	0	5,317
3	617	0	0	617
4	1,042	0	0	1,042
5	4,832	0	0	4,832
6	841	0	0	841
7	16,819	0	0	16,819
8	1,917	0	0	1,917
9	1,026	0	0	1,026
10	4,724	2,591	0	7,315
11	7,669	8,753	0	16,422
12	640	21,296	470	22,406
13	4,788	1,049	25,000	30,837
14	1,411	1,074	1,000	3,485
15	754	0	0	754
16	9,383	0	1,200	10,583
17	11,858	0	8,000	19,858
18	409	0	1,000	1,409
19	5,884	0	20,000	25,884
20	1,229	0	0	1,229
21	1,019	0	0	1,019
22	0	22,195	15,000	37,195
23	0	5,194	0	5,194
24	0	8,765	0	8,765
25	576		1,215	1,791
26	80	0	0	80
27	4,120	0	0	4,120
28	5,736	0	0	5,736
29	4,787	0	0	4,787
30	68,821	0	0	68,821
Totals	166,658	70,91	72,885	310,460

Sources: Huang Puyuan, Director, Jingmen Transfer Station, Jingmen. 2 November, 1988. Fan Weixue, Secretary and Director, Shayang Transfer Station, Shayang, Jingmen. 10 November, 1988. Shashi Transfer Station of Jingmen Grain Bureau, Shashi City, Hubei Province. 30 October, 1988. Interviews by author, all translated by Zhang Xing Bo.

and this cannot be ignored as it is of superior quality. As an adjustment, when choosing the shortest route from surplus point to TS, the route using this highway was chosen providing this route was not greater than two kms. more than an alternative route. The road between Shayang and Jingmen city is part of the Wuhan-Yichang highway but is not so modern as to warrant an adjustment.

Grain Supply Available

The available grain supply is that amount which was reported to have been transported in 1987 from the origin points to the TSs. For 1990, each point's surplus is calculated using the expected increase for Jingmen's surplus as a whole.

Grain supply data purportedly represents processed rice, wheat, and a small amount of other grains but since not all shipments are of processed rice, the data does not reflect the full tonnage of grain shipped. Rough estimates put the proportion of paddy shipped at 16 percent of the total. Grain shipped from the origin points to TSs is reportedly only GPP grain.

Grain inflows are only GPP grain since MPP grain flows are essentially impossible to identify because statistics on the origin of some of the MPP grain are not kept. Most of the MPP grain flows are, statistically, those arriving at JTS from station 30, the Oil and Grain Commerce Company, but the grain does not physically pass through this station. The company could not be visited to investigate whether they had any inflow or outflow data. Altogether the three TSs took in .310 mt. and .297 mt. was sent out. Both Shayang Transfer Station (SYTS) and Shashi Transfer Station (SSTS) sent out approximately the same amount as they received so the .013 mt. seems to have been collected at JTS. The last data set received from Jingmen reported a total of 503,850 tonnes of grain purchased by the government. This data took about five months to be released and was supposed to be explicit about which numbers represented processed, unprocessed or mixed grain; there always seemed to be some confusion about this during the data gathering process. The "grain purchase" numbers which were released were termed "natural grain" - a definition unknown to anyone at HAU. There is obviously some problem in the statistical collection techniques when it comes to classifying grain as either processed or unprocessed. Four GMSs were included in this table with the data for Jingmen as a whole. It was discovered, by comparing the author's data on Wuli GMS that "natural grain" refers to unprocessed grain. It would appear that either the .310 mt. collected by the TSs represents processed rice, or a considerable portion of the purchased amount is stored in the countryside. Support for the latter conclusion is strengthened by the fact that stations 1, 10, 15 and 16 purchased 5,280, 33,640, 22,860 and 34,780 tonnes respectively in 1987 (GPP grain purchase was 3,290, 16,820, 11,119 and 16,410 tonnes respectively) but delivered only 359, 7,315, 754 and 10,583 tonnes, respectively, to TSs in that year.

Another explanation might be that a large portion of the grain goes directly into the consumption channel in Jingmen City or Shayang. However, this seems unlikely in Jingman City since JTS delivers back over 124,300 tonnes of grain to Jingmen - three times the estimated maximum requirement of Jingmen City's residents. SYTS delivered a further 38,690 tonnes to Jingmen City. Shayang is a more likely candidate since it collected only 155 tonnes more than it sent out and it made no deliveries to its own citizens, which number about 40,000.

In summary, it cannot be determined with complete accuracy whether the amount of grain delivered to the TSs is processed or unprocessed rice but we carry on with the assumption that it is processed.[21] The real quantity of grain available for urban consumption is further complicated by the fact that it is unknown how much of the purchased grain is wheat and how much is rice. We know that 15.17% of 1987's grain production was wheat (82.7% rice) and perhaps the amount purchased and transported is in the same proportion although wheat cannot normally be substituted for rice in the quota

[21]See the last section in chapter 3 for further support for this assumption.

procurement. This hypothesis is explored at the end of chapter 3.

The processing of rice is very important to an efficient storage and transportation network and will affect the amount of grain available for consumption. Altogether there are 21 food, feed and oil processing plants in Jingmen which together process 250,000 tonnes of paddy (1987). Designed capacity is 400,000 tonnes but processing capacity is severely restricted by electricity shortages. Paddy rice is about 50% heavier than processed rice and much bulkier. All adjustments for calculating the amount of rice stored, transported, etc. use a 70% rate for the processing of rice in Jingmen and it is likely this is used all over China. It is important to determine if this is a good percentage to use as many calculations use this rate. This 70% rate reflects the fact that rice quality standard no. 3, the most common quality, is processed to this rate (quality is also judged according to moisture and cleanliness). There are 5 standards altogether which are based on the "rice rate." The rice rate is the quantity of rice with bran as a percentage of paddy rice. Standard no. 3 has a 75% rice rate (79% for standard no. 1). This rate seems to be correct according to the Food and Agriculture Organization, which wrote that "usually 100 kilograms of paddy provides 20 kilograms of husks, 8 kilograms of bran and polish, 2 kilograms of germ and 70 kilograms of edible rice, including whole and broken grains."[22] However, notice that processing, while yielding the 70 kgs. of edible rice, was reported to yield only 5 kgs. of bran and polish in Jingmen. These standards are also separated according to whether the rice is the early, middle, or late variety. Early and late rice are sometimes mixed if their size is the same, but since the shape of late rice is quite different, this rice is not mixed thereby preventing uneven cooking. The local population prefers not to eat late rice. The wheat flour produced usually goes for processing into noodles.

While it was originally intended to determine the cost of production of variously sized processing plants, this information was purportedly unknown with any certainty. It seems that there is excess capacity overall provided there is sufficient electricity. Many plants are installing their own electric and husk burning generators to alleviate the shortages.

Determining the quantity of grain available for transport, and hence urban consumption, is further complicated by the fact that year to year deliveries from supply stations are not consistent. JTS was also asked for its flows of grain in 1986 so that a year to year change could be analyzed. Table 2 shows the tonnage delivered from the supply points to JTS in 1986 and 1987 and the total tonnage delivered to all three

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[22]FAO, Rice Marketing, FAO Marketing Guide no. 6, Rome, 1972, Page 63.

TABLE 2
COMPARISON OF INFLOWS TO JINGMEN TRANSFER STATION: 1986-1987
(Tonnes)

Supply Station	Jingmen Transfer Station 1987	Jingmen Total Collected In 1987	Jingmen Transfer Station 1986	Jingmen Net Increase (Decrease)	Transfer Station Net Increase (Decrease)
1	359	359	0	359	359
2	5,317	5,317	7,556	(2,239)	(2,239)
3	617	617	0	617	617
4	1,042	1,042	0	1,042	1,042
5	4,832	4,832	2,336	2,496	2,496
6	841	841	656	185	185
7	11,819	16,819	20,699	(3,880)	(3,880)
8	1,917	1,917	0	1,917	1,917
9	1,026	1,026	0	1,026	1,026
10	4,724	7,315	34,596	(27,281)	(29,872)
11	7,669	16,422	12,162	4,260	(4,493)
12	640	22,406	19,710	2,696	(19,070)
13	4,788	30,837	29,828	1,009	(25,040)
14	1,411	3,485	0	3,485	1,411
15	754	754	0	754	754
16	9,383	10,583	28,885	(18,302)	(19,502)
17	11,858	19,858	8,550	11,308	3,308
18	409	1,409	1,441	(32)	(1,032)
19	5,884	25,884	7,370	18,514	(1,486)
20	1,229	1,229	1,174	55	55
21	1,019	1,019	2,004	(985)	(985)
22	0	37,195	11,576	25,619	(11,576)
23	0	5,194	0	5,194	0
24	0	8,765	0	8,765	0
25	576	1,791	3,634	1,843	(3,058)
26	80	80	0	80	80
27	4,120	4,120	5,346	(1,226)	(1,226)
28	5,736	5,736	0	5,736	5,736
29	4,787	4,787	0	4,787	4,787
30	68,821	68,821	0	68,821	68,821
31	0	0	9,101	(9,101)	(9,101)
32	0	0	4,808	(4,808)	(4,808)
33	0	0	199	(199)	(199)
34	0	0	2,536	(2,536)	(2,536)
Totals	166,658	310,460	214,166	96,294	(47,508)

Sources: Huang Puyuan, Director, Jingmen Transfer Station, Jingmen. 2 November, 1988. Fan Weixue, Secretary and Director, Shayang Transfer Station, Shayang, Jingmen. 10 November, 1988. Shashi Transfer Station of Jingmen Grain Bureau, Shashi City, Hubei Province. 30 October, 1988. Interviews by author, all translated by Zhang Xing Bo.

TSs in 1987. The last column shows the increase or decrease in the amounts delivered to JTS in 1987 over 1986. The fifth column shows the increase or decrease in the amounts delivered to all three TSs in 1987 over the amount delivered to JTS in 1986. The table shows that station 10 and station 16 both delivered enormously more to JTS in 1986 than they delivered to all the TSs combined in 1987 and that JTS took in 47,508 tonnes less than in 1986. This smaller quantity is despite the probability that Jingmen had greater production in 1987 than in 1986. These differences cannot be accounted for by changes in production since both years were normal production years. Coincidentally, these two stations were among the four GMSs visited by the author. At station 10 we visited Wang Tian Purchasing Station which has five villages delivering to it. This station collected 5539 tonnes of commercial grain in 1987 but there is no 1986 data from this station to help us explain the large difference in grain delivered to JTS. Station 16 is actually a town and not a township and thus likely has a grain processing facility. In 1987 they purchased 33,640 tonnes of grain in their area but delivered only 7315 in that year versus delivering 34,595 the year before. Assuming that the data is correct, it seems station 10 did not have its warehouses emptied in 1987 and perhaps this was the same for station 16. The author was told that all stations are normally emptied during the marketing year except for the amount which is kept for security storage. Security storage is apparently rotated yearly. This station has 37,520 tonnes of storage capacity and thus has enough space to store all of the commercial grain that is delivered there. Another explanation could be that the administrative boundaries of the area have changed.

The conclusion from this data is that yearly deliveries of grain to the TSs are in no way the same from year to year and that storage in the rural areas may be sufficient to allow flexibility of a year in deliveries to the TSs. Thus, it cannot be concluded that the 1987 flows as used in this thesis represent a typical year although 1987 was a typical year for production.

Transshipment Points: Shashi, Shayang and Jingmen City

Three transshipment points are included in the model. Jingmen City transships by rail and Shayang and Shashi by the Han Shui and Yangtze Rivers, respectively. All TSs were asked to provide figures on the quantity and origins and destinations of inflows and outflows of grain. Additionally, SYTS and SSTS were asked to provide the tariffs for the transfer of these flows. Transshipment costs at the stations are not included in the model as this data was deemed unreliable at Shayang and Shashi, and JTS's data is not comparable to the other two TSs. If we were to include these costs however, it would not have changed the optimal routings in the base model as determined by the linear programming model sensitivity analyses. Shayang and Shashi reported handling costs of 4.89 ¥ and 7.2 ¥ per tonne respectively. Jingmen's is somewhere in the area of 4.97 ¥.(see chapter 5).

JTS in Jingmen City is perhaps the jewel of the system. It surely used to be. Taking three years and 8.2 million Yuan to complete, the facility is the only one to be joined with the rail line and to have processing facilities right at the station. The rice processing facility, capable of processing 100,000 tonnes of paddy per year, is now only processing 20,000 tonnes as per the state plan. The newer Jingmen City rice processing plant has been given priority in receipts of inputs. There seems to have been some misdirected planning. A plant should not normally have to be shut down after only ten years service (it began operation in 1979). Indeed, the processing plant was to have shut its doors already except that the newer plant is having equipment problems. The newer facility is not far from the transfer station, but far enough that an extra motorized transportation link of perhaps one km. is required. This development and the reasons for it were not discussed but it is suggested that if a trial for bulk handling is considered in the future, this processing facility be used in the trial. It was the only mechanized facility observed which can accept bulk grain trucks and will soon be connected with Jiangling County by rail.

SYTS at Shayang is located approximately 56 kms. by roadway southwest of Jingmen city on the Yichang to Wuhan

Highway. It rests on the west bank of the Han-Shui River. This is the second longest river in the province and it is a transportation route which connects the Xiangfan area in the northwest to Wuhan directly. At Shayang boats can take on as much as 500 tonnes of grain for their journey down river. Shayang is the capital of the southern district of Jingmen although the boundary between districts is not clear. It was said that it has the power of a county. Most of the urban population outside of Jingmen City lives here.

The station consists of seven departments which administer and operate the grain processing, warehousing, and barge loading operations. These three parts are considered separate functions at the TS. Of the average inflow of 60-70,000 tonnes of grain, approximately 20,000 tonnes of rice are processed there over a course of a year. This is 8% of the total amount processed in Jingmen and is the exact same amount as was processed at Jingmen TS and may illustrate a type of egalitarianism in the state plan. Shayang has new storage construction of the closed house-type variety and this will increase their present capacity by about 33%.

Shashi is a city about 22 kms. south of Jingmen on the Yangtze River and is a major grain market in China. Eighty percent of the grain SSTS handles comes from Jingmen. Some grain destined for locations up-river are transshipped through here, perhaps because the railway in Jingmen City cannot carry all that is needed in that area. It is unlikely that it is cheaper to transship through this point from Jingmen and so it is not clear why the railway is not used to at least take grain to the city of Yichang if not also to the destinations further up-river.

Storage Capacity

The largest storage facility is the Jingmen City transfer station. Adding the designed capacity of all three of Jingmen's transfer stations (Jingmen City, Shayang and Shashi - 51,000 tonnes, 37,500 tonnes and 1,500 tonnes respectively), results in a total of 89,300 tonnes or 15.8% of Jingmen's total designed storage capacity. Designed storage capacity is that amount which can be stored if all grain is stored in bulk. The average amount in storage at any given time of the year at these three stations is about 60% of the designed capacity. It would therefore appear that Jingmen's security stocks are significant.

Storage figures are calculated by measuring the warehouses at the end of the month. These inventory numbers are used in the following formula to calculate average yearly storage (AYS): AYS = (January to November monthly storage + 1/2 December + 1/2 January monthly storage of the following year)/12.

JTS has eight closed house-type warehouses of 5,250 tonnes total bulk grain capacity (42,000 tonnes total designed capacity) and eighteen-350 tonnes concrete silos equal to

6,300 tonnes. The house-type warehouses are used for security and industry (two warehouses with bulk storage), and for loading rail cars (the other six have bagged grain for this purpose). Four of the warehouses are adjacent to the single 660 metre rail spur. The silos are used in conjunction with the processing plant. Adding up the capacity we can see that it falls 2,700 tonnes (5.3%) short of the 51,000 tonnes reported by both the Grain Bureau and JTS. The actual amount in store at the time of visit was 30,600 tonnes (60.0% of designed capacity) and the warehouses were considered more or less full. This lower figure represents the decrease in storage capacity resulting from the storage of bags rather than bulk. The industry or security storage thus appears to be about 34% (10,500 tonnes) of the amount in store assuming the two warehouses were full of bulk grain. The bags were thought to be in store for a maximum two months. It appears that the circulation of bags through the warehouse depends on the monthly state plan with bags usually moved out within a month and rarely remaining more than two months. This procedure was the evident in Jiangling.

SYTS has 8 closed warehouses of approximately the same size with a total bulk capacity of 37,000 tonnes (6.5% of Jingmen's total storage capacity). Two of the warehouses are new and did not appear useable yet. It is unclear if the capacity figure includes these two. Four of the warehouses were said to be for yearly storage. Yearly storage is a reference to long-term storage (Jingmen transfer station was considered to be only for short term storage). It is likely the new storage is also for long term use.

At the time of visit, SYTS had 18,510 tonnes in store - 16,990 tonnes of rice and 1,520 tonnes (8.2% of the total) of wheat. The 18,510 tonnes was broken down to 6,200 tonnes in storage for three years, 7760 tonnes for two years, and 4,550 tonnes (equivalent to one full warehouse) which had been entered in March 1988. April is considered the marketing year-end for rice in China. This latter figure was considered to be close to the average entered into long-term storage every year (4,500 tonnes in 1987) and I think it can be safely assumed that 4,500 tonnes are taken out each year. Much of the grain here is in bulk, unlike the Jingmen station. Therefore, the fact that they have 18,510 tonnes in long-term storage, plus the likelihood that this is the amount that is always kept in store, means 50% - 67% (four out of either six or eight warehouses) of their useable storage is some type of security storage. Given the author's field observations and the fact that JTS had about 60% of the designed capacity in store, the figure is likely 67%. Since a fair amount of SYTS's grain is shipped out to localities in Jingmen (see tables 3 and 4, pages 62 and 63), it is likely that the other warehouses are used for bag storage, assembly (processing), and distribution (i.e., short term storage). The single warehouse used for loading barges (which is not located on the site) is not included in the figures above and is much smaller than those on the TS site. The warehouse only uses bags for loading boats as was the situation everywhere visited.

It is permissable to use the yearly storage to load boats if a prolonged rainy period halts truck deliveries. The station is otherwise responsible for any boat demurrage costs. The holding capacity of boats loaded ranges between 10 and 500 tonnes with the average about 120 tonnes. The station has its own floating wharf which is about 100 meters from the warehouse.

Shashi TS rents their 1,500 tonnes storage warehouse for 10,000 ¥ per month. These facilities must be rented because Shashi is under a different administrative jurisdiction than Jingmen.

Handling Capacity

This is perhaps one of the more elusive concepts the author encountered. This section will give the reader an idea of how the concept of handling capacity is defined in China. Computer simulations of transportation networks usually involve capacity constraints at transshipment points but are not included in the present model. This exclusion is because the data was not sufficient for determining handling capacity. The model assumes an unconstrained ability to move grain through the transfer stations. The figures from the Grain Bureau's report on handling capacity at the three TSs differ greatly from the separate reports gathered from the TSs. JTS reported the quantity of grain handled (defined as the amount in plus amount out - a measure of work done) as .501 m.t. in 1987. This is 46% of the total amount handled in Jingmen and much more than that reported by the Grain Bureau for all three TSs combined. There is obviously some problem with the data here. A summary of the inflows and outflows of grain handled at JTS in 1986 was calculated as .417 m.t.[23] and .320 m.t. for 1987. Jiangling's Grain Bureau said this figure represents processed grain and indeed most grain appears to be processed in the rural areas. It was not possible to ask for clarification of this discrepancy.

JTS has a maximum storage capacity of about 30,600 tonnes when bags are used. Some figure for storage must be added to the in/out flow of .320 m.t. (1987) in order to calculate the total handling capacity. JTS did not report their storage capacity in a table like the other TSs did and thus to add the 30,600 tonnes to the flow grain number may be inappropriate. This number may not be directly comparable to the storage calculation used in handling statistics. Allowing the assumption that Jingmen's average amount in storage is 30,600 tonnes, this would bring the handling figure to .351 m.t. for 1987. If this figure was for processed rice then paddy weight

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[23]The outflow data is not presented, but documented flows to each province in China were given for 1986. Statistics such as these are no longer available from the Grain Bureau as the GOCC now has this information. Many provinces received grain from Jingmen in 1986.

would be, perhaps coincidentally, .501 mt. There also may be a small amount of local delivery which may not have been reported. Shayang TS neglected to report this small amount. 1987's production likely increased over 1986 yet the in/out flows were 23% less in 1987. This discrepancy cannot be explained if it is true that the warehouses are emptied according to their turn in the monthly plan, although it is possible that the security stocks were increased in 1987. This possibility seems unlikely given that 1986 was a normal year of production.

Without more accurate inventory figures, calculating the handling amount is hazardous. Storage could conceivably enter and leave a warehouse within a month and never be counted in the storage figures and thus handling figures. Given the above discrepancies, conclusions about handling capacity would be without substance.

With the data requests mentioned earlier, a certain table was included at SYTS. This table was not asked for but was considered important enough to present to subsequent TSs to get their figures for these categories. This table was likely presented as a result of the author's questions about handling costs at the TS. These tables included handling, transport, storage and casing (bagging) costs per tonne, and yearly inflows and outflows for as many years as they had, but the tables are not presented in this thesis. It was hoped that the handling costs could be compared with the total amount handled to get some idea of the least cost amount to handle, and that the costs could be used in the linear programming model formulation. Very little can be said about these figures and there were few consistencies in this type of data collected from all TSs. The year 1984 was a record production year but the amount handled at SYTS is strikingly low, as was JTS's. Assuming the previous definition of storage, and that all inflows and outflows are accounted for, these figures can only tell us that on average there is about 20,000 tonnes in storage at SYTS. There is a great deal of suspicion surrounding the accuracy of these numbers and they proved very difficult to get in Jiangling (questions about storage were not allowed in Jiangling). Transport, storage and casing costs are part of the handling cost and are referred to as "flow costs." The inflows do not covariate with production in the area. Accountants at JTS were asked to explain SYTS's numbers and categories but were unable to do so. SYTS could not be re-visited. The simplest observation taken from SYTS, for which the greatest number of years were available, is that 1985 was a very low cost year for handling grain. One might theorise that this may be close to the optimal (least cost) handling amount for the station since the average cost increases with a higher or lower amount handled. The data from SYTS is insufficient for this conclusion but all station data taken together was expected to reveal greater insights so this data was pursued for the rest of the study.

Deficit Points

The six deficit points considered are Wuhan, Yichang (Both are cities on the Yangtze River, east and west of Jingmen respectively), Jingmen City, and three general areas designated as JTS Export, SSTS Export and SYTS Export. These three general areas are used in the model to represent, collectively, the other destinations which received grain from the TSs (see tables 3 and 4 for the flows to specific destinations). The amount which is demanded at JTS Export is not the full amount which was shipped out to other destinations from this TS and was reduced so that the amount supplied equalled the amount demanded in the system. The quantity demanded at Wuhan and Yichang is equivalent to the quantity sent there in 1987. The quantity demanded at Jingman City is 38,690 tonnes. The demand of 38,690 tonne was chosen because it is the amount that Shayang TS sent to Jingmen, and, while the population of 120,000 should only consume 21,600 tonnes (at 180 kgs. rationed per person per year), a fair amount of grain and food processing occurs in the capital. In other words, the demand at Jingmen City was chosen fairly arbitrarily. The estimates for demands at deficit points in 1990 are discussed and derived in chapter 3.

TABLE 3

FLOWS, DISTANCES AND COSTS FROM RIVER TRANSFER STATIONS TO DELIVERY POINTS, 1987

SHASHI	Tonnes	Km. Distance	Yuan per Tonne	Total Cost	Yuan per Tkm.
Wuhan	29,132	550	8.86	258,110	.0161
Yichang	28,597	156	5.89	168,436	.0378
Exizhou	10,188	256	11.60	118,181	.0453
Shennongjia	2,627	231	11.40	29,948	.0494
Total	70,544			574,674	

SHAYANG	Tonnes	Km. Distance	Yuan per Tonne	Total cost	Yuan per Tkm.
Wuhan	32,350	277	8.60	278,210	0.0286
Jingmen	38,690	56	1.18	45,654	0.1980
Nantong	800	1,274	26.64	21,312	0.0209
Shanghai	1,200	1,402	28.99	34,788	0.0207
Total	73,040			379,964	

HAO XUE	Tonnes	Km. Distance	Yuan per Tonne	Total cost	Yuan per Tkm.
Wuhan	3,786	494	8.10	30,667	0.0164
Yichang	925	212	4.65	4,301	0.0219
Nantong	5,541	1,491	15.82	87,659	0.0106
Shanghai	955	1,619	16.82	16,063	0.0104
Jiangsu	345	1,314	15.04	5,189	0.0114
Total	11,552			143,878	

Sources: Fan Weixue, Secretary and Director, Shayang Transfer Station, Shayang, Jingmen. 10 November, 1988. Shashi Transfer Station of Jingmen Grain Bureau, Shashi City, Hubei Province. 30 October, 1988. Lu Ruitao and Li Huanghe, Director and Vice Director, Hao Xue Transfer Station, Hao Xue, Jingzhou County, Hubei. 27 March, 1989. Interviews by author, all translated by Zhang Xing Bo.

TABLE 4

OUTFLOWS FROM JINGMEN TRANSFER STATION, 1987 (Tonnes)

Wuhan	17,593.7
Jingmen	124,341.6
Yichang	112.7
Xiangfan	505.8
Yunyang	987.0
Shiyan	7,064.9
Shashi	5.5
Exizhou	2,569.0
Shennongjia	19.6
Guangxi	399.7
Guizhou	133.3
Total	153,732.9

Source: Huang Puyuan, Director, Jingmen Transfer Station, Jingmen. 2 November, 1988. Interview by author, translated by Zhang Xing Bo.

Truck Transportation Rates

Truck rates, as charged by the Jingmen Transport Company, are .198 ¥ for the first 20 kms. and a 10% surcharge on any distance greater than that. Not all places reported that distances over 20 kms. included a 10% surcharge on the rate, but the transport company is obviously the best source as almost all trucks used are theirs. Their formula for determining the truck transportation cost is, for distances greater than 20 kms.:

tkm. * .2178 - 3.96 = total cost (Yuan per tonne)

and less than or equal to 20 kms.:

tkm. * .198 = total cost (Yuan per tonne).

The above formulas are applied to distances from supply points to TSs, calculated using the road map of Jingmen, a bus timetable with distances from Jingmen City to other places in Jingmen, and a map of Jiangling which could not be included in the thesis.[24] The distances are shown in table 5 and the rates in table 6, which are used in the linear programming base model. The Shashi TS of Jingmen also gave costs for the inflowing grain and can be seen in table 7. This data shows

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[24]This map had to be returned because it was classified as "internal use only." It was a true cartographic map made to show the irrigation system.

TABLE 5

DISTANCES FROM SUPPLY POINTS TO TRANSFER STATIONS
(Kilometres)

Supply Station	Transfer Stations		
	Jingmen	Shashi	Shayang
1	57.0	143.0	113.0
2	35.0	121.0	91.0
3	56.0	142.0	112.0
4	27.5	113.5	83.5
5	13.0	99.0	69.0
6	23.7	100.7	82.7
7	18.0	68.0	50.9
9	42.0	60.0	42.9
10	34.0	52.0	34.9
11	49.0	37.0	49.9
12	59.5	47.5	42.3
13	46.0	68.9	18.0
14	45.9	63.9	23.0
15	20.0	99.0	37.0
16	30.0	84.9	26.0
17	47.0	85.1	9.0
18	89.5	80.3	33.5
19	74.2	75.5	18.7
20	50.5	100.1	24.0
21	77.8	71.7	21.8
22	71.5	59.5	32.7
23	56.5	29.5	57.4
24	75.5	63.5	48.7

Source: Hubei Provincial Survey Bureau Make And Print Brigade, and Jingmen Urban Planning Management Department: tourist brochure-map, date unknown.

Note: Supply station 8 is not included in the model.

TABLE 6

TRUCK RATES FROM TOWNSHIPS TO TRANSFER STATIONS
(Yuan Per Tonne)

Supply Station	Transfer Stations		
	Jingmen	Shashi	Shayang
1	12.019	30.749	24.215
2	7.227	25.958	19.424
3	11.801	30.532	23.998
4	5.594	24.324	17.790
5	2.574	21.166	14.632
6	4.766	21.536	17.616
7	3.564	14.414	10.690
9	8.752	12.672	8.948
10	7.009	10.930	7.205
11	10.276	7.663	10.472
12	12.563	9.950	8.817
13	9.623	14.610	3.524
14	9.601	13.521	4.613
15	3.960	21.166	7.663
16	6.138	18.095	5.267
17	9.843	18.139	2.376
18	19.097	17.093	6.900
19	15.765	16.048	2.970
20	10.603	21.406	4.831
21	16.549	15.220	4.352
22	15.177	12.563	6.726
23	11.910	6.029	12.106
24	16.048	13.434	10.211

Source: Estimated

Note: Supply station 8 is not included in the model.

TABLE 7

TRUCK RATES FROM TOWNSHIP TO TRANSFER STATION:
ORIGINAL RATES TO SHASHI
(Yuan Per Tonne)

Supply Station	Transfer Stations		
	Jingmen	Shashi	Shayang
1	12.019	30.749	24.215
2	7.227	25.958	19.424
3	11.801	30.532	23.998
4	5.594	24.324	17.790
5	2.574	21.166	14.632
6	4.766	21.536	17.616
7	3.564	14.414	10.690
8			
9	8.752	12.672	8.948
10	7.009	11.000*	7.205
11	10.276	9.000*	10.472
12	12.563	10.400*	8.817
13	9.623	13.200*	3.524
14	9.601	14.600*	4.613
15	3.960	21.166	7.663
16	6.138	18.095	5.267
17	9.843	18.139	2.376
18	19.097	17.093	6.900
19	15.765	16.048	2.970
20	10.603	21.406	4.831
21	16.549	15.220	4.352
22	15.177	13.000*	6.726
23	11.910	7.400*	12.106
24	16.048	13.000*	10.211

Source: Estimated

* Denotes rates to Shashi Transfer Station which have been changed from the state criterion rates.

Note: Supply station 8 is not included in the model.

that there are many contradictions or anomalies which exist if the rates are as in the above formula. The rates from Shashi are different than these calculated rates. Station 13 is further away from Shashi yet the charge to Shashi is less than station 14. Perhaps grain from station 13 must travel east because the road link between these stations is very poor or does not exist, but this would still entail a greater cost than from station 14 because of the greater distance involved. The possibility that the road does not exist can be considered because while the Jingmen map shows a road between stations 23 and 12, the more detailed map of Jiangling, though 15 years old, showed not even a secondary road (which are not all shown on the Jingmen map but are on the Jiangling map) between stations 23 and 12. This non-existence would help support why station 12's cost is 3 ¥ higher than station 23's yet appears to be only 10 kms. further than station 23 (i.e. a per tkm. cost for this distance of .3 ¥ per tkm. which exceeds the state criterion of .1278 ¥ per tkm.). Another anomaly is station 10 is 15 kms. further than station 11 and on the same all-weather road yet they only paid only .133 ¥ per tkm. more for this 15 kms. distance. Only two of the eight stations which delivered to Shashi did so at rates less than the state criterion. While the possibility exists that tractors were used and thus charges were higher, some of the per tkm. charges even exceed the stated state criterion for tractors (.25 ¥ per tkm.). The point that transport charges are not levied exactly according to state criterion is clear, but the use of the state criterion rates in the base model is deemed to be a close approximation to the rate actually charged. For investigation purposes, however, a linear programming scenario is also run using the rates provided from SSTS to provide a comparison.

A few private food merchants were asked how much it cost them to transport their goods to Jingmen City. The total costs per tonne for a tractor were, 35 ¥ from 9 kms. away (cabbage) and 22 ¥ from 45 kms. away (peanuts). A truck from Yichang, which is about 150 kms. away by road, cost only 44 ¥. for a tonne (oranges). If these costs are correct, there is certainly a lot of variability in rates charged in the private market. The point is that rates in the private market seem to be much higher than the state criterion and thus it seems that the state criterion does not represent a rate which reflects the real cost of truck transport.

The author was interested in determining what the real cost of transport might be so that these costs could be used in the linear programming model. This proved to be a daunting task and was given up. However, the author visited the local bus station to see what freight rates were available. For many farmers, the only form of transportation available for marketing their goods is the local bus. The local bus station in Jingmen City was visited and was asked for freight rates. Calculating the rates was quite easy since all rates for two

50 kilogram bags are the same as for a passenger. With a sample of 30 observations of distances ranging from 18 to 280 kms.(and for fairly old buses), it was found that it costs a fairly uniform .0275 ¥ per km. for the 100 kgs. or .275 ¥ per tkm. There was no tapering of rates for longer distances travelled. Thus, the bus rates are only slightly higher than that charged by the trucking company. It is the author's opinion that these rates also include some subsidization and thus there can be no estimate of what the real costs of truck transport might be.

Rail Rates

Rail rates were asked for and the book with all the rates was promised to the author (indeed it was seen) but was not made available due to the termination of the author's research. This left the author without rates for JTS to Yichang and Wuhan. However, the author was told of two rates for grain (there are three different rates based on the value of the goods).[25] For less than or equal to 100 km., the rate is 2.0 ¥ per tonne or .02 ¥ per tkm. at 100 kms. and for distances greater than or equal to 1550 kms., the rate is 19.4 ¥ per tonnes or .0125 ¥ per tkm. The charges go up at 40 km. intervals at a decreasing rate of increase. Truck rates are therefore lower than rail only up to distances of about 10

[25]Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988.

kms. This is likely one of the reasons for the high demand for railway services. Rail rates were said to be about the same as river rates at a distance of about 1000 kms. Railway distances from Jingmen City to Yichang and Wuhan were calculated using a map of Hubei Province and were estimated to be 125 kms. and 450 kms. respectively. Using the above rates and interpolating to these distances using a constant rate of increase, it was determined that it costs 2.484 ¥ per tonne (.0199 ¥ per tkm.) and 8.185 ¥ per tonne (.0182 ¥ per tkm.) to ship grain to Yichang and Wuhan respectively. These rates were estimated by first determining the average increase per km. in the per tkm. rate between 100 kms. and 1550 kms. (.0000517 Yuan). This average increase is then multiplied by 350 (the residual of the distance from Jingmen to Wuhan less 100 km.) to get the total decrease in the per tkm. rate (.00181 ¥). Subtracting this decrease from the 100 km. state criterion of .02 ¥ per tkm. gives us the rate of .0182 ¥ per tkm. for a distance of 450 kms., or 8.185 ¥ per tonne. The rate of 2.484 was determined in similar fashion.

Barge Rates

All river distances and barge rates are derived from table 3. This table shows the summary of distances and tariffs for river transport from three TSs. All per tkm. tariffs reported by the TSs were actually costs per tonne for the distance travelled, even after the author reminded them not to make this mistake. The most reliable data came from Hao Xue transfer station in Jiangling county. It is perhaps a coincidence that this was the only TS visited which was (accidentally) not told that I would be visiting. The per tkm. rates in the table are calculated from the distances and the per tonne rates. The distance between SYTS and Wuhan is of special interest to this study and the distance reported by SYTS was corrected as explained in the following paragraph.

The data from SYTS showed that Shanghai is 128 kms. further away than Nantong. Hao Xue transfer station gave, as its original data, an "exported" amount which also went to a place 128 kms. before Shanghai. We can assume that the "export" destination was indeed Nantong. Since Wuhan is on the way to these places from both TSs, it can be concluded from table 3's data that SYTS is 217 kms. closer to Wuhan than Hao Xue transfer station is and that Wuhan is 277 kms. from SYTS, and not 300 as was originally reported by SYTS.

Jingmen's Shashi TS did not include the distances to the delivery points and thus had to be determined using the data from Hao Xue transfer station in order to get the per tkm. rates. Using the classified map of Jiangling County, Hao Xue transfer station was determined to be about 50-60 kms. by river from Shashi. Using the reported number of 494 kms. for the distance from Hao Xue transfer station to Wuhan makes Shashi about 550 kms. from Wuhan (this was the same as an estimate given in Jiangling). Subtracting this 56 km. distance from Yichang's distance of 212 kms. from Hao Xue transfer station yields a distance of 156 kms. from Shashi to Yichang. The distances from Shashi to Exi and Shenongjia were calculated from a map of Hubei Province. These are the two other places which are up-river from Shashi and together represent the destination Shashi Export. The above having been done, the per tkm. rates are easily calculated.

The Yangtze River Shipping Company, state and collectively run companies, and private companies all have about an equal share of tonnage (2-2.4 mt.) of vessels on the rivers of China but only the Yangtze River Shipping Company seems to be able to give the low state criterion rates. The state criterion rate for less than or equal to 250 kms. is 5.3 ¥ per tonne or .0212 ¥ per tkm. (7.1 ¥ at private rates or .0284 per tkm.). For less than or equal to 1600 kms. it is 17.57 ¥ per tonne or .011 ¥ per tkm. (32.68 ¥ or .0204 ¥ per tkm. at private rates). As would be expected, the rate for the 250 km. distance is greater than that for rail while the rate for long distance is less than that for railway transport. Quite clearly it is preferable to have the use of state carriers. Private shipping rates are very similar to what SYTS paid for river transport (see table 3). Shanghai, Nantong and Wuhan, which are 1402, 1274, and 277 kms. away from SYTS respectively, have per tkm. costs of .0207, .0209, and .0286

¥[26] respectively. The following table shows Jiangling County's Hao Xue transfer station's and SSTS's rates, which appear to be state criterion rates.

TABLE 8

BARGE RATES FOR HAO XUE TRANSFER STATION AND SHASHI TRANSFER STATION BY DISTANCE (YUAN PER TONNE-KILOMETRE)

Distance (kms.)	156	212	221	256	494	550	1314	1491	1619
Rate	.0378	.0219	.0494	.0453	.0164	.0161	.0114	.0106	.0104

Source: See table 3.

Clearly either SYTS does not use the state boat company as it said it usually does or the market rate is being charged by the state boat company at SYTS. Table 8 shows that these rates are greater than the state criteria for distances less than 257 kms. and are less than the criteria for the two largest distances (these are rates to Shanghai) but these latter two rates are very close to the state criteria. The first four distances, which correspond to locations up-river, have high per tkm. costs that are likely higher because the rate going up-river is more than down river. As was the case with truck rates, it appears there is some flexibility in how much can be charged according to state criteria. If these

[26]SYTS reported a rate of 8.6 Y for a 300 km. trip to Wuhan or .0286 Y per tkm. We assume this rate of 8.6 Y was calculated using the per tkm. rate of .0286 since this rate is very close to the private rate. Thus the fact that Wuhan is only 277 kms. from SYTS does not change the per tkm. rate and so the per tonne rate is 7.992 Y. to Wuhan.

first four rates are omitted (although the rate for 212 kms is similar to what the rate would be going down river), it can be calculated that the rates increase at a decreasing rate. It appears that since SYTS is not on the Yangtze River where the Yangtze River Shipping Company operates, it cannot get the state rates for river transport. This dual rate structure may be biasing flows towards the SSTS (and away from SYTS) which can use the state boat companies. To test this hypothesis, the linear programming model "Scenario 3" analyzes least cost routings when Shashi and SYTS both use estimated state rates as determined from the data above. These state rates for SYTS are determined in the same manner as those for the railway. The state rate for Shayang to Wuhan was estimated by first determining the average increase per km. in the per tkm. rate between 250 kms. and 494 kms. (.00001967 Yuan). This average increase is then multiplied by 27 (the residual of the distance from Shayang to Wuhan less 250 km.) to get the total decrease in the per tkm. rate (.000531 ¥). Subtracting this decrease from the 250 km. state criterion of .0212 ¥ per tkm. gives us the rate of .0207 ¥ per tkm. for a distance of 277 kms., or 5.734 ¥ per tonne. The rates for the 1274 and 1402 km. distances were determined in a similar fashion except that the average increase is first determined using the 1314 and 1491 per tkm. rates in the table. Interesting to note is that if the average increase per km. in the per tkm. rate was calculated using the 250 km. and 1600 km. rates, the rate estimated for a 494 km. distance would be .0194 ¥ per tkm. This rate is much higher than the rate charged for this distance. This difference in rates means that the distance where the average rate is equal to the real rate is between 250 and 494 kms. and that the rates increase very fast at short distances and then increase at less than the average for at least the next 1,100 kms.

The above table does not include the data from Jiangling's Shashi TS since this data is essentially a complete falsification. This fact was pointed out to the TS at the time the author was given the data. The data from this TS is not used in this thesis.

This chapter has shown that there are many questions surrounding the data. These questions must be kept in mind when evaluating the following analyses. Analyses which are dependent upon questionable data have been qualified where possible, but the reader is cautioned against assuming that all the evidence is factual. Since this work is primarily intended for use by the Grain Bureau, and it is they who have the majority of the data, it is they who will have to make the final judgement on the validity of the research results.

CHAPTER 3

JINGMEN'S SURPLUS TO 1990: A TREND ANALYSIS

The purpose of this section is to estimate the 1990 surplus in Jingmen and the deficits that will occur in the cities in 1990. These estimates are used in chapter 4 to estimate 1990 transportation costs and flows under current and optimal scenarios for the transportation network defined for Jingmen and selected cities of Hubei Province. The analysis in chapter 4 will estimate the cost savings that would be possible if the system were to be run in an optimal manner as against routing grain as is was done in 1987. The conclusions from this section represent the attainment of the first research objective, which is the estimation of future deficits and surpluses.

This section analyzes trends for population (agricultural and urban), production (cultivated, sown, rice and arid land areas and their respective yields), consumption, and per capita production and consumption. Most estimates of trends involve determining the average yearly growth rates determined from 1983 and 1987 data. The years 1983 and 1987 are used because they were considered to represent normal years of production and they were the years for which the author had the most data. 1984 is sometimes used as the base year due to lack of data.

POPULATION

There are four data sources for this and the following sections unless otherwise noted.[27] For ease of reading, individual footnotes have been left out but the sources, and the years they refer to, are as noted previously. The 1985 data source does not actually give the year as 1985 but similar data in that book is for 1985, and 1986 data did not exist in that book. Additionally, the data is assumed to be 1985 data since it does match 1983 or 1984 data.

Even though Jingmen is called a city according to its Chinese character (indeed this practice of calling a large area a city has been criticized in China for inflating the urban population figures and it is suspected that Jingmen is now included in national urban population figures thus biasing these figures),[28] Jingmen's population is now classified as 81.6% agricultural. Jingmen's Grain Bureau originally reported an estimate of 70% for the rural population. It is the purpose

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[27]The following four references are for data years 1984, 1987, 1985 and 1983 respectively unless otherwise noted.

Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988.

Jingmen Grain Bureau, data received from Hubei Provincial Foreign Affairs Department, May 10, 1989.

China Rural Statistical Yearbook, China Statistical Publishing House, Beijing, 1987. (Zhongguo Nongcun Tongji Nianjian, Zhongguo Tongji Chu Ban Shi, Beijing, 1987).

Chinese Communist Party-Jingmen Branch, Story of Jingmen Town, Xue Ling Publishing House, Shanghai, October, 1984.

[28]Zhang, Xing Bo, Instructor, Department of Agricultural Economics, gave this opinion.

of this subsection to clarify Jingmen's population statistics and trends by presenting the data available.

Jingmen's population was 930,000 in 1983. Table 9 illustrates these and other figures. The current population is 973,000 although another source[29] puts the population at 1,010,000. The former source is considered to be more reliable. This means that the population grew by 4.62% from 1983 to 1987, an average 1.16% or 10,750 people per year. China's population growth rate was 1.12% in 1985 and was expected to grow to 1.25% in the following few years.[30] Jingmen's average is thus very close to the national average and may be expected to follow the national trend.

It is important to break down population growth into rural and urban growth rates. These demographic changes are important since food consumption patterns of rural residents are often different than those of city dwellers. The current rural population is 793,800 in Jingmen which makes it 81.6% rural. Jingmen was reported to have 754,000 agricultural residents in 1985. Using an interpolated population of 951,500 for 1985, this would make Jingmen's population 79.2% agricultural in 1985. This is very close to Hubei Province's

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[29]Hubei Provincial Survey Bureau Make And Print Brigade, and Jingmen Urban Planning Management Department: tourist brochure-map, date unknown.

[30]Zhong, Fu Ning, "China's Grain Production and Trade", unpublished M.Sc. thesis, University of Manitoba, 1986.

TABLE 9

JINGMEN POPULATION STATISTICS FOR 1983, 1985 AND 1987

Year	Total Population	Agricultural Population	Urban Population	Jingmen City Population
1983	930,000	818,400 (88.0%)	111,600 (12.0%)	100,000 (10.8%)
1985	951,500[a]	754,000 (79.2%)	197,500[b] (20.8%)	N/A
1987	973,000	793,800 (81.6%)	179,200 (18.4%)	120,000 (12.3%)

Sources: Jingmen Grain Bureau, received from Hubei Provincial Foreign Affairs Department, May 10, 1989. China Rural Statistical Yearbook, China Statistical Publishing House, Beijing, 1987. (Zhongguo Nongcun Tongji Nianjian, Zhongguo Tongji Chu Ban Shi, Beijing, 1987). Chinese Communist Party-Jingmen Branch, Story of Jingmen Town, Xue Ling Publishing House, Shanghai, October, 1984. Foreign Affairs Office of the Hubei Provincial People's Government, booklet, 1988.

Note: Parentheses indicate percentage of total population.

[a] Interpolated from 1983 and 1987 data.

[b] Residual of total population less agricultural population.

average[31] and thus using the interpolated population seems to be a reliable method. Thus, by 1987, Jingmen's population was 2.4% more agricultural than in 1985. The 1983 source which reported 930,000 residents also said that 12% of the population (111,600) was urban. Thus the agricultural population was 818,400 in 1983. This represents an 8.8% decrease in the proportion of agricultural residents from 1983 to 1985, opposite in direction to the trend in the following two years. The agricultural population decreased by 64,400 from 1983 to 1985 and then increased 39,800 from 1985 to 1987!

Given the wide population swings and because the total population statistics for 1985 were not available, this study uses only the data from 1983 and 1987 for estimating the population trends. It is concluded that the agricultural population as a proportion of the total population is decreasing at a rate of 1.60% per year and that the rural population is decreasing at a rate of .75% per year (6,150 people). The urban population was 179,200 in 1987 and 111,600 in 1983. This urban growth represents an average yearly increase of 15.14% (16,900 people).

Since the cities are of major interest as consumption points and do not necessarily have the same growth pattern as Jingmen, their population growths should be investigated. The

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[31] Hubei's population in 1985 was 78.7% agricultural - see State Statistical Bureau, P.R.C., Statistical Yearbook of China 1987, Published by Economic Information and Agency, Hong Kong, 1987.

cities of Jingmen City, Wuhan and Yichang are investigated as they are the deficit points in the linear programming model. "City proper dwellers" were reported to number 120,000 in Jingmen.[32] Jingmen City was thought to be about 200-250,000 in 1988 but that figure likely includes the temporary city residents who are statistically counted as agricultural. There are residents in every township capital who are considered urban (800 of 31744 residents or 2.5% of the population were considered urban in Baling township)[33] and these residents are not likely included in the 120,000 as they do not live in what is considered a "city."[34] This 120,000 likely refers to Jingmen City alone. The other large urban area, Shayang, was estimated to be about 40,000. If 2.5% of the rural population are urban residents then there are 19,845 urban residents in township capitals. Adding these three urban populations results in a total of 179,845 which is very close to the reported total of 179,200 for 1987. The 1983 source reported that Jingmen City had 100,000 people. Assuming that Jingmen City is now 120,000, Jingmen city has grown by an average

[32]Foreign Affairs Office of the Hubei Provincial People's Government, booklet, 1988.

[33]Hou Shi Jun, Interview by author, translated by Zhang Xing Bo, Baling GMS, Jiangling County, 28 March 1989.

[34]Definitions of rural and urban populations, cities and towns can be found in China's statistical yearbooks. See, for example, State Statistical Bureau, P.R.C., <u>Statistical Yearbook of China 1983</u>, Published by Economic Information and Agency, Hong Kong, 1983, page 576.

5.00% per year since 1983. We can compare Jingmen City's growth with that of Wuhan. Wuhan had 6,080,000 residents in 1986[35] and 6,293,400 in 1987[36] for a growth rate of 3.50%.

The fact that the urban population is growing at a rate of 15.14% in Jingmen while the major city is growing at only 5.00% would indicate that much of the increase is occurring in the township capitals and/or Shayang. Jinan Township in Jiangling County grew from 30,000 to 50,000 people between 1986 and 1988. It was determined earlier that the urban population was increasing by 16,900 people per year. It appears that 5,000 of the increase was in Jingmen and if Shayang was also increasing at a rate of 5% per year, then 800 of the increase would be in Shayang. This indicates that 11,100 of the increase occurred in the countryside. This represents an increase of 56% in the urban population in the townships if a base population (1987) of 19,845 is assumed. The high growth of the urban population represents an added expense to the Grain Bureaus of the province (and country) as these people are entitled to subsidized grain which must be shipped in. The non-city residents living in the city must purchase their grain at the market price.

Since 1983 Jingmen has restructured its administrative boundaries and some of its xiang (townships) have become towns

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[35]China Business Weekly, 7 February 1988.

[36]Foreign Affairs Office of the Hubei Provincial People's Government, booklet, 1988.

(<u>zhen</u>). The incidence of this type of restructuring is considered by some to be an indication of overall development in the area. This restructuring may account for some of the rapid increase in urban population although it is not clear if resident status changes. A place becomes a town by having a certain number of permanent residents of whom a certain percentage must be non-agricultural residents. Another reason for the rapid increase may be rural-urban migration although these people theoretically are still registered as rural and are only temporary urban residents. Many farmers are also peddlers (a word commonly used in the Chinese press) and consider their farming occupation as temporary.[37] A peddlar is a person who has procured a certificate from his village committee and who has received permission to conduct business from the commercial administration of his township or county. Many of the workers in the enterprises visited were classified as temporary. The temporary worker is often from the rural area as is the peddler, and this flow of peasants may be a major reason for the decrease in agricultural population in Jingmen. The 1987 policy of restricting commercial grain sales by the private sector may be to stem this flow of peasants to the cities and rural towns. Their land may or may not be cultivated while they are away depending on the contracting policy in their area and the disposition of the farmer. The amount that has been left uncultivated is a concern to Chinese

[37] <u>China Daily</u> 20 February 1988.

planners and it is a major reason for the continuing development of the land contracting reform. Wuhan was reported to have 10% of its land held by others with contracts (i.e. rented).

PRODUCTION, AREA AND YIELD TRENDS

The main sensitivity to future plans depends on production projections. Changes in consumption tend to follow established trends while production tends to fluctuate much more than consumption. It is therefore critical to have a reliable picture of production patterns if future plans are to be made.

We saw in the last section the difficulty in getting reliable statistics and the resultant piecemeal approach that has to be made. The same must be done in this section and one should keep in mind that original statistics of production usually start with the farmer counting how many bags of grain he has and that he is likely to underestimate his production rather than overestimate it. Table 10 shows production, area and yield statistics for Jingmen. The 1985 production year is located in table 12 in the following section on surplus and consumption. The analyses below concern these data.

Production Trends

Grain production grew by an average 5.19% between 1983 and 1987 and increased by 8.34% in 1984 alone (table 10); from

TABLE 10

JINGMEN AREA AND YIELD STATISTICS FOR 1983, 1984 AND 1987
(Tonnes and Hectares)

	Years 1983	Years 1984	Years 1987	Average Yearly Increase (Decrease)
Production	705,000	763,800	851,480	5.19%
Harvested Area	151,146[a]	136,580	140,853	1.04%[b]
Cultivated Area	106,666	96,387[a]	99,400	(1.70%)
Yield Per Harvested Hectare	4,664[a]	5,592	6,045	2.70%[b]
Yield Per Cultivated Hectare	6,609	7,924[a]	8,566	7.40%
Rice Production	634,500	N/A	703,910	2.73%
Rice Cultivated Area	86,666	N/A	80,826	(1.68%)
Rice Yield Per Rice Cultivated Hectare	7,321	N/A	8,709	4.74%
Arid Cultivated Area	20,000	N/A	18,574	(1.78%)
Non-Rice Production	70,500	N/A	147,570	27.3%

Sources: Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988. Jingmen Grain Bureau, received from Hubei Provincial Foreign Affairs Department, May 10, 1989. Chinese Communist Party-Jingmen Branch, Story of Jingmen Town, Xue Ling Publishing House, Shanghai, October, 1984.

Note: Percentages are the average of 1983 and 1987 except as noted below.

[a] These numbers are estimated using a multiple cropping index (MCI) of 1.417. This MCI is as determined for 1987.

[b] These percentages are the average between 1984 and 1987.

1984 to 1987 the growth was only an average 3.83% per year (29,233 tonnes per year). From 1985 to 1987 it was 4.24% per year. The years 1984 and 1987 are used for estimation of future production and therefore production is expected to grow from 851,480 tonnes in 1987 to 949,357 tonnes in 1990.

The year 1984 is used for estimation of future production since 1984 is generally regarded as having been an outstanding year for production in China and this should yield a more conservative estimate of future growth. 1987 is the most recent year of available data.

Rice production grew by an average 2.73% from 1983 to 1987 (17,352 tonnes), 1.46% less than that for all grain. In 1983 rice represented 90.0% of the grain produced while in 1987 it was only 82.7%. Non-rice grain production grew by 109% from 1983 to 1987 or 36.4% (19,268 tonnes) per year on average. Of non-rice grain production, 91.2% was winter wheat in 1987.[38] It is likely that the wheat as a percentage of non-rice grain production was also high in 1983 and that therefore wheat production, and wheat production as a percentage of total production, has increased rapidly. However, one cannot assume that a large proportion of the increase was wheat as other non-rice grains have prices which are not government controlled and are thus generally more profitable to produce than wheat. Rice production appears to

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[38]Jingmen Grain Bureau, received from Hubei Provincial Foreign Affairs Department, May 10, 1989.

be losing its importance relative to other grain production. This is despite the fact that wheat cannot be substituted for rice in the delivery quota under normal circumstances and that local residents prefer to eat rice rather than wheat products.

Jingmen is able to have stable production in the face of drought. From observation of the area and a map that could not be included in the thesis because it was classified[39], the canal system for drainage and irrigation seems to be highly developed.

Area Trends

Cultivated land (originally reported as arable land), i.e., the actual area that a farmer has to work on, was 99,400 hectares in 1987. This land includes 80,826 hectares of "rice land" (81.3%). Rice land is the classification Jingmen and Jiangling use in their land statistics and denotes land which can support rice production. In 1983 cultivated land was 106,666 hectares including 86,666 hectares of rice land (81.2%). Cultivated land and rice land decreased by an average yearly rate of 1.70% and 1.68% respectively between 1983 and 1987. Data from grain purchasing stations also show rice land to be in the area of 82% of the total cultivated land with the residual being arid land (see below). This shows that the percentage of land which is rice land has changed very little

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[39]This map had to be returned because it was classified as "internal use only." It was a true cartographic map made to show the irrigation system.

despite the shrinking land base. As expected, marginal (i.e. arid) land has been declining relative to rice land as the land base shrinks, albeit slightly.

Arid land does not support rice production and is often used for cotton production. A more tenuous conclusion, but one that seems likely given the fact that smaller administrative units (e.g. grain management stations) collect their land data as either rice land or arid land, is that arid land also decreased by 7.13% from 20,000 to 18,574 hectares during this time period, or 1.78% per year on average.

Harvested area was 136,580 hectares in 1984 and 140,853 hectares in 1987 for an average yearly growth of 1.04%. Data was not available for 1983 and thus this rate of growth uses a different base year than the analysis above. Since harvested area is increasing while cultivated area is decreasing, land is being cultivated more intensely than in the past. Assuming that cultivated area decreased by 1,816 hectares (25% of the four year decrease) from 1983 to 1984, then the multiple cropping index (harvested or sown area/cultivated area * 100) for Jingmen would be 130 in 1984. The MCI in 1987 was 142. This MCI compares with 200 for Hubei as a whole (1983).[40] This discrepancy between Jingmen's MCI and Hubei's MCI is odd but the provincial statistics on cultivated area are not released in China and only sown area is provided so there is

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[40]Zhong, Fu Ning, "China's Grain Production and Trade", unpublished M.Sc. thesis, University of Manitoba, 1986.

no way to check how these provincial figures are calculated. Harvested area statistics were unknown in townships and it thus appears that provincial statistics of sown areas depend on county level estimates.

The 1987 figures for different types of land did not come close to the total area given but much of the land could have been entered into other categories not mentioned. It was not possible to re-check the figures with the Grain Bureau in Jingmen due to termination of the author's research by the Grain Bureau.

Yield Trends

Yields are compared using various denominators and numerators. Jingmen produced 5,592 kilograms of grain for each harvested hectare in 1984 and 6,045 kilograms in 1987. This is an average yearly growth rate of 2.70% in yield. From 1983 to 1987, grain yield per cultivated hectare grew by an average yearly rate of 7.40%. The 1983 source reported that 90% of that years production was rice. This production represents .6345 m.t. or 7,321 kilograms of rice per cultivated rice land hectare. This quantity compares with 8,709 kgs. in 1987, or an average yearly growth rate of 4.74% in rice yield per cultivated rice land hectare.

Rice in Hubei province is classified as either early, middle or late according to when the grain is harvested. In a crop rotation, early and late rice are grown together in a year (harvested in July and November respectively) and middle rice usually is in a rotation with winter wheat. Yields for the three types in 1985 and 1983 in Hubei Province are shown below.

TABLE 11

EARLY, MIDDLE AND LATE RICE IN HUBEI PROVINCE

	1983			1985		
	Early	Middle	Late	Early	Middle	Late
Production (m.t.)	3.690	6.370	3.645	4.128	7.390	4.193
Yield (tonnes per sown hectare)	1.336	2.894	1.181	1.487	3.456	1.391
Production (percentage of total)	27	46	27	26	47	27

Sources: Chinese Communist Party-Jingmen Branch, Story of Jingmen Town, Xue Ling Publishing House, Shanghai, October, 1984. State Statistical Bureau, China Agricultural Yearbook 1986, State Statistical Publishing House, Beijing, 1986.

The interesting part of this data is that the proportions of the total production which belong to each type are almost identical in the two years. On the surface, this would indicate that cropping practices of this sort have not changed very much recently. However, one percent of production has gone from early rice to middle rice and this may be significant. The yields, if weighted by their respective proportions of production, result in average yields of 2.013

and 2.387 tonnes per sown or harvested hectare for 1983 and 1985 respectively. This yield increase represents an average yearly growth rate of 9.29% but the rates for the different types are quite different. The average yearly growth rate for early rice yield was only 5.65% while that for middle rice was 9.71%. Late rice, the rice which is not generally eaten in the area, had a growth rate of 8.89%. These differences in yield growth may be one of the reasons for the large growth in non-rice crop production because middle rice - the type of rice with the largest increase in yield and greatest yield overall - is grown in rotation with wheat and other non-rice crops. On the other hand, yield increases in non-rice crops could also be a reason for the enhanced production of middle rice. Unfortunately, these provincial yields cannot be compared with Jingmen's as sown area statistics for rice are, somewhat astoundingly, not calculated. This lack of data seems to put provincial statistics of this sort in jeopardy.

Arid land represented 18% of the total cultivated land in 1987 but the yield of this land cannot be determined since statistics on the amount of production which came from this land are not kept. This land was said to be unable to grow rice and commonly grew cotton, wheat and corn. Corn does not seem to enter the commercial grain system in any significant quantities. Corn is mostly kept on the farm to feed animals and the stalks are used for fuel and to construct wind shelters.

COMMERCIAL GRAIN AND ON-FARM CONSUMPTION

Table 12 shows grain production, government price purchases, market price purchases, and the residual amount that was defined as on-farm consumption (food, seed and animal feed).[41] Commercial grain is the sum of government price grain and market price grain purchased. Commercial grain is defined as grain that can be eaten directly by consumers and thus the quantities should be for rice calculated at a 70% processed rate in most statistics presented. This 70% rate is applied everywhere to calculate the amount of commercial grain, even when paddy is delivered to the first storage point. Commercial grain essentially refers to only wheat and rice, which are also referred to in statistics as "thin grain".[42] Quotas, which were defined and vehemently defended as equivalent to the quantity of GPP grain procured,[43] are not always equivalent to the GPP grain quota.[44] Quotas are also supposed to reflect this

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[41]Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988.

[42]The Rural Economic and Social Statistics of China, Information Department of the Ministry of Agriculture, Animal Husbandry and Fisheries. A book presented to the author at the annual meeting of the International Association of Agricultural Economists, Beijing (published date unknown) October, 1987, page 99.

[43]Jingmen Grain Bureau, received from Hubei Provincial Foreign Affairs Department, May 10, 1989.

[44]Many villages in Jiangling County had GPP grain deliveries which were less than their quota in 1988.

TABLE 12
PRODUCTION, CONSUMPTION AND COMMERCIAL GRAIN IN JINGMEN

Year	Grain Production (10,000 Tonnes)	Government Purchase (10,000 Tonnes)	Market Purchase (10,000 Tonnes)	On Farm Consumption (10,000 Tonnes)[a]
1976-78 (average)	N/A	12.50	N/A	N/A
1978	56.05	21.58 (38.5%)	12.16 (21.7%)	22.31 (39.8%)
1979	55.69	22.96 (41.2%)	N/A	32.73[b] (58.8%)
1983	70.50	41.50 (58.9%)	N/A	30.00[b] (61.1%)
1984	76.38	42.99 (56.3%)	3.00 (3.9%)	30.39 (39.8%)
1985	78.50	51.23 (65.3%)	N/A	27.27[b] (34.7%)
1987	85.15	24.00 (28.2%)	26.39 (31.0%)	34.76 (40.8%)
1987[c]	85.0	25.0 (29.4%)	32.0-34.5 (38-41%)	25.5-28.0 (30-33%)

Sources: Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988. Jingmen Grain Bureau, received from Hubei Provincial Foreign Affairs Department, May 10, 1989. China Rural Statistical Yearbook, China Statistical Publishing House, Beijing, 1987. (Zhongguo Nongcun Tongji Nianjian, Zhongguo Tongji Chu Ban Shi, Beijing, 1987). Chinese Communist Party-Jingmen Branch, Story of Jingmen Town, Xue Ling Publishing House, Shanghai, October, 1984.

Note: Parentheses indicate percentage of production.

[a] This column's numbers are the author's calculation of production less government and market purchases.

[b] These residuals are perhaps inaccurate since no numbers are available for Market Purchase in these years.

[c] This was an estimate of the Jingmen Grain Bureau before the true data was released.

70% processed rate.

Production was analyzed previously but the pre-1983 figures were not discussed and are presented here only to provide to the reader the maximum information that was available. Conditions up to 1979 were very different in China since the agricultural reforms had not yet taken place and thus these figures were considered inappropriate to include in the previous trend analysis. For this reason, the 1978 figures for commercial grain and on-farm consumption are also ignored in the analysis of trends. However, it is interesting to note that the percentage of total production which was consumed on the farm in 1978 and 1984 is identical at 39.8% and is very close to the percentage in 1987, the only other year for which full information was available.

Sources that report the amount of grain that the government purchased are not always clear on what they are referring to but complete information was available for 1984 and 1987. These years are used to construct the trend for on-farm consumption because of the full information available. These are also good years to use since: (1) 1984 was a year in which the MPP grain price was higher than the open market price for most of the year and thus the commercial grain reported in that year should be close to the actual amount that was available, i.e., not much grain was sold outside the state system and, (2) 1987 was a year in which non-government sales were banned, and owing to the suddenness of the policy move and the penalties that were being imposed on offenders, it is likely that not that much was sold outside the state system and therefore the commercial grain reported in that year should also be close to the actual amount that was available. An argument against using these years is that on-farm consumption may have been greater in these years because farmers most likely stored more and/or used more to raise animals due to the low prices and/or the inability of the state system to receive grain (as was the case in 1984 in some areas).

We can thus conclude from the figures that on-farm consumption increased by an average 4.80% yearly (14,567 tonnes per year) between 1984 and 1987.

Very interesting is that Jingmen's Grain Bureau originally estimated on-farm consumption to be .255 mt. to .280 mt. (30-33% of the estimated .85 mt. of production) in 1987. This estimate looks logical when past years are examined and assuming 1986 also saw an increase. If 1986 on-farm consumption was also in the .26-.30 mt. range it makes it even more remarkable that rural consumption was so large in 1987. They consumed 87,600 tonnes more than expected! It must be questioned whether 1987 was a typical year for rural consumption. While we have already stated that the removal of the free market in 1987 likely gave rise to greater storage and use on the farm, the large increase in the agricultural population from 1985 to 1987 is the likely cause of such a large increase in the consumption. These vast changes in agricultural population, a decrease of 64,400 from 1983-1985 and an increase of 39,800 from 1985-1987 likely also caught the Grain Bureau off guard since they predicted a consumption of about .27 mt. in 1987 and originally estimated the rural population to be about 700,000. The estimate of 700,000 would not be unreasonable if one were looking at the 1983 and 1985 agricultural population figures.

The large differences in the quantity of rural and urban consumption and the large swings in agricultural population over time make estimations of future consumption very difficult. Further information about how an agricultural resident can become an urban resident and vice versa is needed to make an appropriate analysis and information on migration patterns is also needed.

PER CAPITA PRODUCTION AND PER CAPITA CONSUMPTION

Per Capita Production

Jingmen registered a per capita grain production of 875 kgs. in 1987 (calculated from tables 9 and 12). This was up from 825 kgs. in 1985 (using the interpolated population of 951,500) and up from 758 kgs. in 1983. This represents an average yearly increase of 3.34% between 1983 and 1987.

Estimates on a rural per capita basis are more useful since city size biases overall per capita estimates. Jingmen had a rural per capita grain production of 1,073 kgs. in 1987.

This was up from 1,041 in 1985 and up from 861 kgs. in 1983. This is an average yearly increase of 6.13% between 1983 and 1987 (the 1985 figures are not used for estimation because of the aberrantly low agricultural population in this year). Rural per capita production of rice increased by only 3.59% during this period. Hubei's per capita grain production for rural population was 578 kilograms in 1983 and 571 kilograms in 1985.[45] Rural per capita grain production in Hubei province is high compared to the national average, and thus Jingmen seems to be doing well compared to the rest of the province and country.

For estimating future production, it is assumed that the rural per capita grain production is increasing at a rate of 6.13% per year.

Per Capita Consumption

The consumption of 347,630 tonnes (table 12) on the farm by 793,800 people (table 9) would be equivalent to a rural per capita consumption of 438 kilograms per year in 1987. Other sources put the consumption at 367 kilograms in 1983 and 362 kilograms in 1985. Consumption in 1984, using an interpolated agricultural population of 786,200, would be 387 kgs. per year. While it can be questioned whether 1985's consumption is an overestimation because there was no value available for the

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[45]Zhong, Fu Ning, "China's Grain Production and Trade", unpublished M.Sc. thesis, University of Manitoba, 1986.

market purchase in that year, the figure is deemed to be relatively accurate since the purchase of GPP grain was huge in that year and almost surely includes the market purchase. There are a number of explanations (discussed earlier) which could account for the much greater consumption in this year. The disappearance of free markets in 1987 likely contributed to the large per capita consumption as people hoped for a change in policy in 1988. Since both 1984 and 1987 were years where there were likely greater amounts stored or consumed on-farm than would normally occur, and since 1983's and 1985's per capita consumption is almost identical, the per capita consumption of about 365 kgs. of unprocessed grain seems to be the most accurate figure for per capita consumption in a normal year in the past. The average of the two most recent years for which data were available generates a per capita consumption of 400 kgs. per year however.

This study continues with the assumption that future per capita consumption will be 400 kgs. per year. The following shows that while this estimate may not be accurate, it is at least reasonable.

The above figures represent an average yearly growth in rural per capita grain consumption of 5.93% between 1983 and 1987 and a growth of 10.5% between 1985 and 1987. For China, rural per capita consumption of grain was 235 kilograms in

1983[46] but 367 kgs. (257 kgs. at a 70% rice processing rate) in Jingmen in that year. Thus it appears that Jingmen, as with production, also consumes much more than average in the form of feed, food, storage and losses.

A hard working non-agricultural labourer in China would receive about 15 kilograms of grain ration coupons per month. It is impossible to estimate urban consumption but we can be close to it by saying that each person consumes their rationed 15 kgs. per month or 180 kgs. per year. This is the most common amount given for a hard labour position in urban areas and this policy is likely to continue in the near future. This is equal to approximately 70% of what the average rural resident in Jingmen consumed in 1987. While most farm families have animals to feed, the 438 kilograms per capita yearly consumption (307 kgs. in processed form) in 1987 seems excessive if it is measured against urban grain consumption. Another source gave the peasant household consumption of unhusked grain as 267 kgs. per year in 1984 and thin grain (only wheat and unprocessed rice) as 209 kgs. per year.[47] These figures are very low and can perhaps be explained as per

[46]Zhong, Fu Ning, "China's Grain Production and Trade", unpublished M.Sc. thesis, University of Manitoba, 1986.

[47]<u>The Rural Economic and Social Statistics of China</u>, Information Department of the Ministry of Agriculture, Animal Husbandry and Fisheries. A book presented to the author at a meeting of the International Association of Agricultural Economists, Beijing (published date unknown), October, 1987, page 99.

capita and not per household consumption. There are 5.9 people to a household in Jingmen and this household consumption would not feed a household in Jingmen. Hubei's farmers consumed, in 1982, 1983, 1984 and 1985, 303, 299, 316 and 295 kgs. per person respectively.[48] The 1985 rural per capita consumption of this source is the same as that for households reported above, which supports the hypothesis that the household consumption is an error. Again the abundant harvest in 1984 probably gave rise to the larger consumption in 1984. Also interesting was the statement made that Jilin Province would provide 8.5 mt. of grain to the state after deducting 700 kgs. of grain per person and enough grain for other consumption.[49] This data shows some kind of overall estimate of per capita consumption at a provincial level. Another article stated that some cities consume as much as 450 kgs. per person.[50]

Baling GMS presented estimates they use to predict on-farm consumption in a year. Most estimates were first given as ranges which were very large. The following are their best estimates which were not necessarily in the middle of the range. These yearly estimates are: 450 kilograms for human food consumption per person (81.52% of the total); 40 kilograms for seed per person (7.25% of the total); and 250

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[48]State Statistical Bureau, China Agricultural Yearbook 1984 and China Agricultural Yearbook 1986, State Statistical Publishing House, Beijing, 1984 and 1986.

[49]China Daily, 10 November 1987.

[50]China Daily, 22 January 1988.

kilograms per household for animal feed. With 7638 households in Baling and a rural population of 30,944, this means 4.1 people to a household and a per capita animal feed consumption of 62 kgs. (11.23%of the total). Total per capita grain consumption is 552 kilograms. This data indicates that Jingmen's rural per capita consumption of 438 kgs. may not be excessive for the general area but these estimates from Baling cannot be taken too seriously given the large ranges which were first reported to the author.

The research continues with the assumption that on-farm consumption will be 400 kgs. per person in 1990 or .31014 mt.

The information presented shows that not a lot seems to be known about the consumption patterns in this area by the people in the Grain Bureau and that farmers may be quite flexible in the amount they deliver to the state. The latter conclusion is made clear by the fact that farmers kept about 85,000 tonnes that the Grain Bureau thought it could collect in 1987 (table 12).

SURPLUSES AND DEFICITS IN 1990

To estimate the quantity of surplus which would be transported to the TSs in 1990, predictions must be made for: (1) agricultural and urban populations, (2) rice and wheat production, and (3) per capita consumption for rural and urban residents.

Based on the average increases in the agricultural and urban population between 1983 and 1987, it is expected that the agricultural population will be 775,350 (a decrease of 18,450) and the urban population will be 229,900 (an increase of 50,700) in 1990. These estimates result in average growth rates, which are higher (-1.33%) and lower (9.43%) for rural and urban populations respectively, than from 1983 to 1987. These estimates result in a population which is 77.1% rural in 1990. Using the decrease in the ratio of urban to rural population from 1983 to 1987 would result in a population which would be 76.8% rural. The predictions result in an average total population growth rate of 1.10% per year. It is clear that the predictions cannot be very accurate given the large swings in agricultural and rural populations and that the estimates of future consumption will suffer as well.

Production in 1990 will consist of a greater proportion of wheat relative to rice than in 1987 since rice production is growing at a slower yearly rate (2.73%) than non-rice grain production (36.4%). This change in the composition of production will affect the amount transported in 1990. The calculations below show that it is at least feasible that the quantity of rice shipped out from GMSs is in a similar proportion to that produced.

Based on the average increase in grain production between 1984 and 1987, grain production is expected to reach 949,337 tonnes in 1990.[51] In 1987, 82.67% of production was paddy rice and 15.17% was wheat. If the .31 mt. of grain which was shipped to the TSs was also 82.67% rice, then .2563 mt. of rice was included in the shipments. Re-calculating the .2563 mt. back into paddy rice yields a quantity of .36616 mt. of paddy equivalent was shipped. Assuming that all of the wheat produced (.13463 mt.) was shipped out (it is not processed on the farm), paddy rice added to the quantity of wheat produced yields a total of .50079 mt. or just 3,110 tonnes less than the total purchased amount in 1987. This 3,110 tonnes is close to what the urban residents in the townships (2.5% of the rural population) would consume assuming a consumption of 180 kgs. per year. A very small amount of corn is also shipped. The estimated proportion of wheat and rice produced in 1990 is therefore used to adjust the quantity of grain shipped out in 1990 as shown below.

It was earlier determined that the rural per capita consumption would be approximately 400 kgs. in 1990. On-farm consumption would therefore be .31014 mt. and, subtracted from production, would yield a quantity purchased of 639,197 tonnes. Urban consumption in the township capitals would also increase since the urban population there would increase. The urban population in township capitals is expected to increase to 9.7% of the rural population (a yearly growth rate of 56%

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[51]The increase is calculated as 3.83% of 1987 production multiplied by 3 or 97,842 tonnes.

as determined previously). Assuming that the grain rations to this population remain the same, the quantity available for purchase will be reduced by 13,561 tonnes to 625,636 tonnes. This purchase is in terms of paddy rice while the grain inflows are calculated in terms of processed grain. The purchased amount is adjusted to reflect this fact in the following paragraph.

Between 1983 and 1987 non-rice production increased an average 19,268 tonnes per year. Wheat production was 91.2% of this production in 1987. It is estimated that wheat production in 1990 will be three times the average non-rice production increase (57,804 tonnes) less 8.8% of this total (to reflect the proportion which is not wheat production and which assumes that other non-rice grain will increase at the same rate). Thus wheat production in 1990 is expected to be 52,717 tonnes greater than in 1987 for a total production of 187,347 tonnes. This estimate would result in a slowing of the growth in non-rice production relative to rice production due to the necessity of delivering rice quotas.[52] Subtracting wheat production from the quantity purchased yields a rice purchase of 438,289 tonnes or 306,802 tonnes in processed form (a 70% processing rate). The processed rice plus the wheat results in a total amount shipped of 494,149 tonnes or 1.594 times the amount shipped in 1987. This estimate assumes that all wheat

[52]The percentage of non-rice production out of total production is 10%, 17.3% and 19.7% in 1983, 1987 and 1990 respectively.

is transported, and that all rice transported is in processed form. Thus, the amounts shipped out from the GMSs in 1990 and which are used in the linear programming model are 1.59 times the 1987 amounts.

The demand in 1990 is estimated using the population growth rate in Wuhan from 1986-1987 (3.50%). Wuhan, Yichang, and Shashi Export demands have been increased by 3.50% per year for these years. Jingmen City's demand has been increased by 5.0% per year. Shayang export was not increased and Jingmen export consumes the residual so as to make the L.P. a balanced transportation problem for this scenario.

SUMMARY

The estimated surplus in Jingmen could be calculated in many different ways using the numbers presented. Normally consumption is considered to fluctuate less than production over time, but with the limited data consumption as defined here results in numbers which reveal no obvious trend. While production appears to be predictable, problems in estimating consumption cause predictions of surpluses to be of tenuous validity.

The author has estimated that the surplus in Jingmen will be 59% greater in 1990 than in 1987 but this estimate should not be taken as a scientific conclusion. If it is desirable to estimate the 1990 surplus so that the future costs of the mismanagement of grain flows can be estimated, the author suggests that the Grain Bureau use the above analyses as a guideline only. The proper analyses can only be done with more data and further discussion of the analyses of this data.

CHAPTER 4

ANALYSIS OF LINEAR PROGRAMMING RESULTS

This chapter deals with the results of the linear programming transportation model and the interpretation of these results. There is one base model with the original network flows (1987) and one base model with the optimal flows for 1987. There are four scenarios which will be discussed and compared to the relevant base model. Changes in flows to and from TSs, the shadow prices of unstable activities, and the rates necessary to change the solution basis, will be analyzed and presented in tabular form. The analysis of the last characteristic, the rates which would change the solution basis, can be accomplished with the special attribute of the software program (LP88) used.

The LP88 program[53] does sensitivity analyses which show: (a) the maximum value (cost per unit) -- where the solution basis will change if the variable's cost per unit exceeds the maximum value, and (b) the minimum value -- where the solution basis will change if the variable's cost per unit is reduced below the minimum value. The use or this attribute is more helpful than doing the traditional sensitivity analyses using the reduced cost (shadow price) of the non-basis variables.

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[53]Eastern Software Products, Inc., "LP88 Users Guide - Version 4.11", P.O. Box 15328, Alexandria, Virginia, November, 1984.

The shadow price interpretation is as follows: if the chosen route is not utilized, the route which is to be used will increase the total system cost by the amount called the shadow price, which is in terms of Yuan per tonne. The shadow price applies to the first tonne shipped only and the shadow price may change after that, i.e., the second tonne may have a different shadow price, although this is not common. The shadow price can also be used to determine how much a rate must change before there is a change to the solution basis. For example, there are three TSs which a supply station can deliver to. There is usually a station with the lowest shadow price (except for that one which is in the basis and therefore has a 0 value for its shadow price) or perhaps the two will have the same shadow price. This shadow price informs us of how much its rate must decrease before it can enter the basis and, conversely, how much the basis variable's rate must increase before its value will decrease in the solution basis. This relationship holds true only when the supply station delivers all of its grain to one TS. If a station delivers to two or more TSs, the above does not hold true and it cannot be determined from the shadow price of the third, non-basis TS, how the rate would have to change before there were a greater/lesser amount being transported from the basis supply stations. This is where the maximum/minimum sensitivity analysis information becomes especially useful.

The solutions are considered sensitive (unstable) if the shadow prices are less than one yuan or, in the case of stations which are delivering to more than one station, if the absolute value of the cost per tonne less the maximum or minimum value, is greater than one yuan. The criterion of one Yuan was chosen arbitrarily.

The dual values are important if decision makers would like to know the effect of increased/decreased surplus at a particular station or the effect of greater/lesser demand at the deficit points. The information which the dual values provide can be used directly in decisions of where to provide incentives for production and for land use planning.

The conclusions from this section represent the attainment of three of the four sub-objectives of the second research objective. These sub-objectives were stated as follows.

> To estimate the current and future financial costs of: (i) mismanaging grain flows, (ii) the inability to use the railway, and (iii) redirected grain flows due to a dual rate structure.

The fourth sub-objective, the financial cost of truck dead-hauls, may be considered to be part of the cost of mismanaging grain flows but is examined in chapter 5 because more than the linear program results are required to estimate this cost.

Given various assumptions, the following analyses show that the 1987 cost of mismanaging the grain flows was 612,149

¥ (see table 26, page 143, for summary of LP results) and that the total four year cost to 1990 would be 3.2 million ¥, _ceteris paribus_. Most of the increase in cost is due to grain leaving an inappropriate TS for its final destination rather than the cost of flows to TSs. In particular, all grain destined for Wuhan should be sent through SYTS rather than all three TSs. The fact that grain from JTS did not go by rail to Yichang resulted in an extra cost of 22,477 ¥ to the system in 1987. This is the cost of the inability to use the railway. The solution for scenario 2 shows that this cost can be substantially reduced if a road were built in the south-west area of Jingmen. This road addition results in an optimal flow network which re-routes 97% of the grain through SSTS to Yichang and which essentially eliminates the extra cost of 22,477. The road also reduces system cost by 37,977 ¥ for the optimal network and thus would have reduced the total cost in 1987 using the current flows by about 60,000 ¥. Since SSTS is currently not an economical transshipment point, this result is also significant if it is politically or otherwise desirable to continue using SSTS to ship grain to Yichang.

The dual rate structures do not result in altering the optimal network flows. Despite the higher than state criterion barge rates at SYTS, the station does not suffer any reduced flows from the higher rates since it is much closer to Wuhan and therefore still has the lowest rate to that destination. The observed rates from supply stations to SSTS do not result in altered optimal flow patterns and the cost is just .12% greater than for the 1987 optimal network model which used estimated, distance based, rates.

Station 5, since it is closest to Jingmen City tends to have the lowest dual value and station 24 the greatest (22.56 ¥ and 36.04 ¥ respectively for 1987 optimal flows) in all scenarios. Thus if one more tonne were available at station 5, the deficit requirements could have been met with a reduced cost of 22.56 ¥. Alternatively, had one less tonne been available, the cost of meeting the requirements would have increased by 22.56 ¥. The dual value for station 24 can be interpreted in a similar fashion. It is therefore clear that if one tonne could be substituted from station 5 to station 24 there would be a net decrease in system cost of 13.48 ¥. The dual values are not discussed further in this analysis and the values for the other activities are not presented.

THE BASE MODEL - ORIGINAL NETWORK FLOWS

A base model was run to determine the total cost of transportation in 1987. This total cost will be used to compare with the total cost of other scenarios examined. All grain which was delivered from stations 1-24 (except station 8) is modelled according to those flows which actually occurred in 1987 (see table 1, page 43). Some outflows are not equal to the outflows from TSs in 1987 (original outflows are in tables 3 and 4, pages 62 and 63). The flow to "JTS Export" is lower than that which occurred to produce a balanced (ie. all inflows equal all outflows) transportation problem but is 997 tonnes greater for the base model, original network flow, than the base model, optimized network flow (see following section), so that the inflows equal outflows at JTS in this model. The amount to "SSTS Export" is 373 tonnes greater than that in 1987 so that inflows equal outflows at SSTS in 1987 (ie. 373 tonnes were, for example, stored at SSTS in 1987). The amount to "SYTS Export" is 1370 tonnes less for the same reason (ie. 1370 tonnes came out of storage at SYTS). Rather than change the model to reflect the amounts that went into or came out of storage at the TSs, the cost of transporting out the stored amounts from Jingmen and Shashi is deducted, and, conversely, the cost of the amount which should have been sent out of Shayang is added from/to the total system cost. This adjustment allows the two base models to be compared directly since both have the same quantity of inflows and outflows. The subtracted costs were 9,970 ¥ and 4,308 ¥ from Jingman and Shashi respectively, and the added cost from Shayang is 17,671 ¥ for a total increase in system cost of 3,393 ¥. Thus the total system cost for the base model is 3,780,013 ¥. It should be noted that this model requires SYTS to deliver 38,690 tonnes to Jingmen City as occurred in 1987. This amount is sufficient for the grain consumption rationed to residents in Jingmen City with an additional 17,090 tonnes left over.

Almost all the towns which deliver to Shayang and Shashi also deliver to Jingmen TS. The only exceptions are stations 22, 23 and 24. Stations 23 and 24 only deliver to SSTS while station 22 delivers to both SYTS and SSTS but does not deliver to JTS. The model has 20 places delivering grain to JTS. Of these 20, station 10 and 11 also delivered to Shashi and stations 16-19 also delivered to Shayang. Stations 12-14 delivered to all three TSs. Observing the location and flows of station 21 shows that all of its grain was sent to JTS although SYTS is much closer and intersects the route. Given unlimited demand and capacity at the TSs, this means that grain is probably not being transported at least cost according to the distance travelled along major roads, ceteris paribus. While the amount coming from station 21 to JTS may be a required amount under the state plan, it would represent a lower cost to the system if JTS, for example, substitutes station 14's and/or station 13's grain with station 21's to satisfy the demand at JTS. These observations confirmed the need to build a linear programming model which would show how the grain should have been transported according to a least cost criterion. The delivery from 21 may have just been in haste to fill a train as is sometimes the case in Jiangling (it was shipped to Wuhan) but is not likely given the stored quantity at JTS. Of course there are different reasons other than the adherence to the state plan which could account for the use of routes which are longer and therefore uneconomic according to a distance criterion. The differences in the quality of roads could explain the use of these routes and of course there are political considerations.

Shadow prices are not meaningful in this model because of the structure of the model. The most costly deliveries (in terms of reduced cost per tonne as determined for the base model, optimal flow network) made in 1987 were the deliveries from station 13 to SSTS and station 16 to SYTS, with reduced costs of 7.607 and 7.19 ¥ respectively. These were the only deliveries made which had reduced costs over 7 ¥. These deliveries are not the most important in terms of total cost however since the amount delivered is a relatively small amount. It appears the greatest mistake in sending grain to TSs was sending station 13's grain to SYTS which resulted in an extra cost of 50,050 ¥ to the system. Station 9's delivery to SSTS also cost the system an additional 16,948 ¥ and appears to be the second most costly delivery in 1987. The delivery from station 21 to SSTS, while having a shadow price of only .393 ¥, cost the system 8,723 ¥ because of the large quantity of grain sent there.

THE BASE MODEL - OPTIMAL NETWORK FLOWS

The minimum cost for satisfying all demands is 3,164,471 ¥. This is 612,149 ¥ or 16.2% less than the estimated cost (base model, original network) in 1987 for identical supplies and demands. The solution outflows (see table 13) show that

Shashi should not be shipping grain to either Yichang or Wuhan and only the grain which is needed for "Shashi Export" is sent to SSTS . Therefore, only station 23 sends all its grain to SSTS while station 24 represents the cut off point (part of the supply goes to each of JTS and SSTS) between JTS and SSTS (see table 14 for optimal inflows). Stations 1-16 and 20 send all of their supply to JTS and station 17 is the cutoff between JTS and SYTS. The cutoff between SYTS and SSTS is somewhere between station 22 and 24 or 12.

The stability of the solution in general increases as the distance from the cutoff points increases. The solutions for stations 11, 12, 17, 22 and 24 are not stable (see table 15). The solution shows activities J22, SS11, SS12 and SS22 (where J=Jingmen, SS=Shashi and SY=Shayang and numbers designate supply stations: e.g. J12 denotes grain flowing from station 12 to Jingmen Transfer Station) have shadow prices of less than one Yuan. This low shadow price means that these activities could enter the basis with only a small increase in total system cost. Especially interesting is that the shadow prices for J22 and SS22 are identical at .393 ¥ and that the solution basis would change if either of these activities had their costs per unit reduced by .393 ¥. This situation of identical shadow prices is a good chance to see how the solution basis will change. One might be tempted to think that both J22 and SS22 would enter the solution at the same time if the rate to SYTS was increased by .393 ¥. What

TABLE 13

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM TRANSFER STATIONS TO DEFICIT POINTS: BASE MODEL - OPTIMAL NETWORK FLOWS

SHASHI

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.86	6.379	2.481	None
Yichang	0	5.89	.786	5.104	None
Export	12,815	11.55	0.000	None	22.609
Total	12,815				

SHAYANG

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	79,076	7.922	0.000	None	14.301
Jingmen	0	11.800	3.539	8.261	None
Export	2,000	28.050	0.000	18.061	None
Total	81,076				

JINGMEN

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.185	8.324	-.1390	None
Yichang	28,710	2.484	0.000	None	3.270
Jingmen City	38,690	0.200	0.000	None	3.739
Export	61,917	10.000	0.000	None	19.989
Total	129,317				

Source: Estimated

TABLE 14

GRAIN DELIVERED FROM SUPPLY STATIONS TO TRANSFER STATIONS
BASE MODEL - OPTIMAL NETWORK FLOWS
(Tonnes)

Supply Station	Transfer Stations			Totals
	Jingmen	Shashi	Shayang	
1	359	0	0	359
2	5,317	0	0	5,317
3	617	0	0	617
4	1,042	0	0	1,042
5	4,832	0	0	4,832
6	841	0	0	841
7	16,819	0	0	16,819
8	0	0	0	1,917
9	1,026	0	0	1,026
10	7,315	0	0	7,315
11	16,422	0	0	16,422
12	22,406	0	0	22,406
13	30,837	0	0	30,837
14	3,485	0	0	3,485
15	754	0	0	754
16	10,583	0	0	10,583
17	4,289	0	15,569	19,858
18	0	0	1,409	1,409
19	0	0	25,884	25,884
20	1,229	0	0	1,229
21	0	0	1,019	1,019
22	0	0	37,195	37,195
23	0	5,194	0	5,194
24	1,144	7,621	0	8,765
Totals	129,317	12,815	81,076	223,208

Source: Estimated

actually happens is that these changes result in 4,289 tonnes being re-routed to SSTS from SYTS. This amount is the same quantity which would be re-routed if either the rates to JTS or SSTS were lowered by .393 ¥ per tonne. Increasing the rate at SYTS has the effect of producing multiple solutions for stations 17 and 22. Both J22 and J17 have shadow prices which are zero although they are not in the basis. Also, the maximum and minimum are identical for activities SS22, SS24 and J24 and are in error. The author will return to this problem in the 1990 scenario since this is where the problem directly affects the solution. Stations 17 and 24 split their deliveries between TSs which is a clue that their solutions are not stable. This is true but the solution for station 24 is also extremely unstable. The change in the rates which is necessary to create a change in flows can be observed from table 15. If the rates from stations 11 and 12 to JTS or the rate from station 24 to SSTS were increased by even one cent, there would be a different solution basis. The same impact would occur if the rate from station 24 to JTS or the rates from stations 11 and 12 to SSTS were reduced. Thus the solution is extremely sensitive to the rates charged for these three stations.

For out-flowing grains, the sensitivity of rail rates is of special interest because these were the most difficult to accurately construct. The rate from JTS to Wuhan has neither

TABLE 15

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM SUPPLY STATIONS TO TRANSFER STATIONS: BASE MODEL - OPTIMAL NETWORK FLOWS

Activity Code[a]	Tonnes Shipped	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
J11	16,422	10.28	0.0	-19.989	10.283
SS11	0	7.66	.003	7.660	None
SY11	0	10.47	8.251	2.219	None
J12	22,406	12.56	0.0	-19.989	12.570
SS12	0	9.95	.010	9.940	None
SY12	0	8.82	4.318	4.500	None
J17	4,289	9.84	0.0	7.841	10.236
SS17	0	18.14	10.917	7.223	None
SY17	15,569	1.78	0.0	1.389	3.784
J22	0	15.18	.393	14.787	None
SS22	0	12.56	.393	12.167	None
SY22	37,195	6.73	0.0	-28.050	7.119
J24	1,144	16.05	0.0	16.047	None
SS24	7,621	13.43	0.0	12.644	13.433
SY24	0	10.21	2.221	7.989	None

Source: Estimated.

[a] Codes are J=Jingmen, SS=Shasi and SY=Shayang. Numbers designate supply stations (e.g. J12 denotes grain flowing from station 12 to Jingmen transfer station).

a maximum nor a minimum (the minimum is a negative value) and therefore grain should never be shipped on this route, ceteris paribus. The activity representing shipments from SSTS to Yichang has a reduced cost of .786 ¥. If the rate from JTS to Yichang was greater than 3.27 ¥ or if the rate from SSTS to Yichang was less than 5.10 ¥, there would be a change the basis resulting in SSTS being used to transfer grain to Yichang. One would likely find that the real cost of rail transport would be much greater than the 2.484 ¥ charged for the 125 km. distance from JTS to Yichang. If the rail rate was 3.27 Yuan or greater, grain destined for Yichang would be re-routed through SSTS. Other rates from TSs to destinations would have to change substantially for there to be a change in the basis.

SCENARIO 1 - FLOWS IN 1990

The estimation of 1990 inflows and outflows and of the increase in demand at deficit points was calculated previously in chapter 3. All 1987 inflows were increased by a factor of 1.59 (see table 16) and are used in this scenario.

The total cost for the optimized solution is 5,685,201 ¥ which is more than 1.59 times the cost in 1987. This figure includes the cost of a very large quantity of grain going to Jingmen Export however. If we subtract the cost of this quantity (1,743,770 ¥, see table 18, page 125) the total cost is reduced to 3,941,431 ¥. The total cost for 1987 optimized

TABLE 16

GRAIN DELIVERED FROM SUPPLY STATIONS TO TRANSFER STATIONS IN 1990 (Tonnes)

Supply Station	Transfer Stations			Totals
	Jingmen	Shashi	Shayang	
1	571	0	0	571
2	8,453	0	0	8,453
3	981	0	0	981
4	1,657	0	0	1,657
5	7,682	0	0	7,682
6	1,337	0	0	1,337
7	26,741	0	0	26,741
8	3,048	0	0	3,048
9	1,631	0	0	1,631
10	7,511	4,119	0	1,1630
11	12,193	13,916	0	2,6109
12	1,018	33,859	747	3,5623
13	7,612	1,668	39,748	49,028
14	2,243	1,708	1,590	5,541
15	1,199	0	0	1,199
16	14,918	0	1,908	16,826
17	18,853	0	12,719	31,572
18	,650	0	1,590	2,240
19	9,355	0	31,798	41,153
20	1,954	0	0	1,954
21	1,620	0	0	1,620
22	0	35,288	23,849	59,136
23	0	8,258	0	8,258
24	0	13,935	0	13,935
25	916	0	1,932	2,848
26	127	0	0	127
27	6,550	0	0	6,550
28	9,120	0	0	9,120
29	7,611	0	0	7,611
30	109,419	0	0	109,419
Totals	264,970	112,751	115,880	493,601

Source: Estimated

flows was 3,164,471. Subtracting the cost of the quantity which went to Jingmen Export in that model (see table 13, page 116) results in a total cost of 2,545,301 ¥. Using this cost results in a 1990 cost which is less than 1.59 times the cost in 1987. This calculation shows that while the flows increased by a factor of 1.59, the total cost may or may not be 1.59 times the cost in 1987. It is likely that the cost savings in 1987 which could have been secured had the system been run in an optimal manner would, in 1990, be at least 1.59 times or approximately 973,255 Yuan. Another way to estimate the extra cost in 1990 if the system flows were the same as in 1987 is to multiply all the flows that took place in 1987 (multiplied by a factor of 1.59) which should not occur in 1990, by the shadow prices from the 1990 model. Calculations show that there would be an extra cost of 217,302 ¥ for inflows (shadow prices for all the 1990 inflows have not been reported, but the quantities can be found in tables 1 and 14, pages 43 and 117) and an extra cost of 786,739 ¥ for outflows (see table 3, 13 and 18, pages 62, 117 and 126 respectively) or a total cost of 1,004,041 ¥ in this case. This total cost is only slightly greater than the previous estimate and is used in the thesis. The flows from JTS and SSTS to Wuhan represents an increased cost of 557,483 ¥ alone and thus this is the cost of not using SYTS for delivering grain to Wuhan. By far, the most inappropriate inflow would be the estimated 37,748 tonnes being sent to SYTS at an extra cost to the system of over 95,000 Yuan.

The optimal flows for this scenario are presented in table 17. The table shows that only stations 17, 22 and 24 have different flows than in 1987 (other than those for which the flow is simply 1.59 times larger). Station 17 now delivers to only JTS whereas it previously delivered to both JTS and SYTS. Station 22 now delivers to all three TSs but only delivered to SYTS before. Station 24 now delivers to only JTS but delivered to both JTS and SSTS before.

The optimal outflows are the same as in the base model except that they are larger quantities (see table 18). In other words, the TS that previously serviced a particular deficit still serves that deficit. However, the solution would undoubtedly be different if, in 1990, it was decided to divert some of the grain going to Jingmen Export to Wuhan instead. Investigating this diversion is suggested for further research so Jingmen Grain Bureau can be prepared for a government plan which requires greater deliveries to Wuhan.

Using the 1987 and 1990 costs determined above, we can interpolate the amount that could be saved in 1988 and 1989 if Jingmen were to transport its grain in a least cost manner rather than continue to move grain as it did in 1987. Assuming a loss in 1987 of 600,000 and a loss in 1990 of 1,000,000 ¥, 1988 and 1989 would have interpolated losses of 733,000 ¥ and 866,000 ¥ respectively or a total four year loss of

TABLE 17

GRAIN DELIVERED FROM SUPPLY STATIONS TO TRANSFER STATIONS
SCENARIO 1 - OPTIMAL FLOWS IN 1990
(Tonnes)

Supply Station	Transfer Stations			Totals
	Jingmen	Shashi	Shayang	
1	571	0	0	571
2	8,453	0	0	8,453
3	981	0	0	981
4	1,657	0	0	1,657
5	7,682	0	0	7,682
6	1,337	0	0	1,337
7	26,741	0	0	26,741
8	3,048	0	0	3,048
9	1,631	0	0	1,631
10	11,630	0	0	11,630
11	26,109	0	0	26,109
12	35,623	0	0	35,623
13	49,028	0	0	49,028
14	5,541	0	0	5,541
15	1,199	0	0	1,199
16	16,826	0	0	16,826
17	31,572	0	0	31,572
18	0	0	2,240	2,240
19	0	0	41,153	41,153
20	1,954	0	0	1,954
21	0	0	1,620	1,620
22	8,527	5,950	44,660	59,136
23	0	8,258	0	8,258
24	13,934	0	0	13,935
Totals	128,179	179,263	113,948	421,390

Source: Estimated

TABLE 18

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM TRANSFER STATIONS TO DEFICIT POINTS: SCENARIO 1 - OPTIMAL FLOWS IN 1990

SHASHI

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.86	6.772*	2.088*	None
Yichang	0	5.89	.786	5.104	None
Export	14,208*	11.55	0.000	None	22.216*
Total	14,208*				

SHAYANG

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	87,673*	7.922	0.000	None	14.694*
Jingmen	0	11.800	3.146*	8.654*	None
Export	2,000	28.050	0.000	18.454*	None
Total	89,673*				

JINGMEN

	Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.185	8.717*	-.532*	None
Yichang	31,831*	2.484	0.000	None	3.270
Jingmen City	44,789*	0.200	0.000	None	3.346*
Export	174,377*	10.000	0.000	None	19.596*
Total	250,997*				

Source: Estimated

* Denotes values which are different from the Base Model, Optimal Network Flows.

approximately 3.2 million Yuan. It is safe to say that there is a considerable need to manage flows more effectively. Even if future estimates are not very accurate, there are still large savings that could have been secured in 1987.

The solution has the same unstable activities as the base model. What is interesting is that station 24 could send its grain to SSTS rather than JTS without any penalty, i.e., it has a zero shadow price although it is not in the basis solution. Disturbing is the fact that the computer calculations of the minimums and maximums are in error. Activities J22, J24 and SS22 were calculated by the LP88 computer program to have minimums and maximums which are exactly the same as their cost per unit. The author having noticed this anomaly in the previous analysis of the 1987 optimal flows, varied the costs per unit and found no change in the basis when SS22 and J24 had their costs reduced and when J22 had its cost increased. When SS22 and J24 had their costs reduced by .01 ¥, the minimums were reduced to the numbers in table 19. Activity J22's cost was increased by .01 ¥. to get the new maximum shown in the table for that activity. It appears that since there is more than one optimal solution (activity SS24 could enter the basis with a zero shadow price and the 1987 optimal flow model had two activities which had multiple solutions), there is an effect of this type of error.

TABLE 19

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM SUPPLY STATIONS TO TRANSFER STATIONS: SCENARIO 1 - OPTIMAL FLOWS IN 1990

Activity Code[a]	Tonnes Shipped	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
J11	26,109	10.28	0.0	-19.596*	10.283
SS11	0	7.66	.003	7.660	None
SY11	0	10.47	8.664*	1.826*	None
J12	35,624	12.56	0.0	-19.596*	12.570
SS12	0	9.95	.010	9.940	None
SY12	0	8.82	4.711*	4.106*	None
J17	31,572*	9.84	0.0	-19.596*	10.236
SS17	0	18.14	10.917	7.223	None
SY17	0*	1.78	0.393*	1.389	3.784
J22	8,527*	15.18	0.0*	15.180*	15.996*[b]
SS22	5,950*	12.56	0.0*	11.774*[c]	12.560*
SY22	44,660*	6.73	0.0	3.580*	7.119
J24	13,934*	16.05	0.0	-19.596*[d]	16.050*
SS24	0*	13.43	0.0**	13.430*	None
SY24	0	10.21	2.614*	7.596*	None

Source: Estimated.

* Denotes values which are different from the Base Model, Optimal Network Flows (i.e. values which are not simply an increase of 1987 flows and have not been redistributed to other supply stations).

** Denotes a shadow price of zero although the activity is not in the basis, i.e., an alternative optimal solution activity.

[a] Codes are J=Jingmen, SS=Shasi and SY=Shayang. Numbers designate supply stations (e.g. J12 denotes grain flowing from station 12 to Jingmen Transfer Station).

[b] This is the maximum when the cost per tonne is increased to 15.19 Y.

[c] This is the minimum when the cost per tonne is decreased to 12.55 Y.

[d] This is the minimum when the cost per tonne is decreased to 16.04 Y.

Activity SS24 was forced into the basis using a function of the LP88 program and resulted in minimums and maximums being the same as the cost per unit for activities J22, J24 and SS24. Activity SS22 no longer has sensitivity analysis results which are wrong but activity SS24 has taken its place. Again, one of either the minimum or maximum is likely wrong for each of these activities. The solution cost was the same, as expected, and 5,750 tonnes were diverted by station 24 to SSTS from JTS. Tolerance controls for the software program were set at .00001 or lower but the fact that five digit (four with a decimal) numbers are the maximum that can be entered into the program appears to limit the usefulness of the program and perhaps influenced the occurrence of multiple solutions. In other words, had the costs been all to the third decimal point, there likely would be fewer multiple solutions, as evidenced by the very small changes (thousands decimal place) in rates that would be necessary to alter the solution basis. The fact that the program produces some incorrect results does not seriously affect the author's confidence in the numerical findings since the costs were varied and the results were similar. The author will not try to explain the error further but it is clear that the solution is very sensitive to deliveries originating from stations 22 and 24 and that there is a relationship between multiple solutions and the error. All other models were checked for similar malfunctions.

SCENARIO 2 - ROAD ADDITION

Scenario 2 envisions a road connecting stations 12 and 23. The road was shown on the Jingmen map but was absent from the Jiangling map and was assumed not to exist in the base models. In this section is an estimation of the extra cost to the system as a result of not being able to ship grain from JTS to Yichang by rail. The magnitude of this extra cost depends heavily on whether or not this road exists. The problem is first approached assuming the road does not exist.

As a result of this road addition the rates from stations 12-14, 18, 19, 21, 22 and 24 to SSTS are reduced (see tables 20 and 21 for new distances and rates, respectively). There are stations which might use this road but which did have their rates reduced because it was deemed impossible for them to deliver to SSTS in an optimal solution. The inflows and outflows for this case are in tables 22 and 23, respectively. This case differs from the base model, optimal network, in the following ways.

The total cost for this scenario compared to the base model, optimal network flows, is reduced by 37,977 ¥ to 3,126,494 ¥. Station 12 no longer delivers to JTS and now delivers all of its grain to SSTS. Station 17 now delivers all of its grain to SYTS whereas it previously delivered to both JTS and SYTS. Station 24 delivers to SSTS rather than to both JTS and SSTS. Station 22 delivers to both SSTS and SYTS rather

TABLE 20

DISTANCES FROM SUPPLY POINTS TO TRANSFER STATIONS
SCENARIO 2 - ROAD ADDITION
(Kilometres)

Supply Station	Transfer Stations		
	Jingmen	Shashi	Shayang
1	57.0	143.0	113.0
2	35.0	121.0	91.0
3	56.0	142.0	112.0
4	27.5	113.5	83.5
5	13.0	99.0	69.0
6	23.7	100.7	82.7
7	18.0	68.0	50.9
8			
9	42.0	60.0	42.9
10	34.0	52.0	34.9
11	49.0	37.0	49.9
12	59.5	39.5*	42.3
13	46.0	63.7*	18.0
14	45.9	58.7*	23.0
15	20.0	99.0	37.0
16	30.0	84.9	26.0
17	47.0	85.1	9.0
18	89.5	71.3*	33.5
19	74.2	66.5*	18.7
20	50.5	100.1	24.0
21	77.8	63.7*	21.8
22	71.5	51.5*	32.7
23	56.5	29.5	57.4
24	75.5	55.5*	48.7

Source: Hubei Provincial Survey Bureau Make And Print Brigade, and Jingmen Urban Planning Management Department: tourist brochure-map, date unknown.

* Denotes distances that changed with the new road.

TABLE 21

TRUCK RATES FROM TOWNSHIP TO TRANSFER STATIONS:
SCENARIO 2 - ROAD ADDITION
(Yuan Per Tonne)

Supply Station	Transfer Stations: Jingmen	Shashi	Shayang
1	12.019	30.749	24.215
2	7.227	25.958	19.424
3	11.801	30.572	23.998
4	5.594	24.324	17.790
5	2.574	21.166	14.632
6	4.766	21.536	17.616
7	3.564	14.414	10.690
8			
9	8.752	12.672	8.948
10	7.009	10.930	7.205
11	10.276	7.663	10.472
12	12.563	8.207*	8.817
13	9.623	13.480*	3.524
14	9.601	12.390*	4.613
15	3.960	21.166	7.663
16	6.138	18.095	5.267
17	9.843	18.139	2.376
18	19.097	15.130*	6.900
19	15.765	14.090*	2.970
20	10.603	21.406	4.831
21	16.549	13.480*	4.352
22	15.177	10.820*	6.726
23	11.910	6.029	12.106
24	16.048	11.690*	10.211

Source: Estimated

* Denotes rates different than in scenario 1 (optimal solution). These rates have been rounded off to the second decimal place except for the rate for station 12.

TABLE 22

GRAIN DELIVERED FROM SUPPLY STATIONS TO TRANSFER STATIONS
SCENARIO 2 - ROAD ADDITION
(Tonnes)

Supply Station	Transfer Stations			Totals
	Jingmen	Shashi	Shayang	
1	359	0	0	359
2	5,317	0	0	5,317
3	617	0	0	617
4	1,042	0	0	1,042
5	4,832	0	0	4,832
6	841	0	0	841
7	16,819	0	0	16,819
8	0	0	0	1,917
9	1,026	0	0	1,026
10	7,315	0	0	7,315
11	16,422	0	0	16,422
12	0	22,406	0	22,406
13	30,837	0	0	30,837
14	3,485	0	0	3,485
15	754	0	0	754
16	10,583	0	0	10,583
17	0	0	19,858	19,858
18	0	0	1,409	1,409
19	0	0	25,884	25,884
20	1,229	0	0	1,229
21	0	0	1,019	1,019
22	0	4,289	32,906	37,195
23	0	5,194	0	5,194
24	0	8,765	0	8,765
Totals	80,621	70,917	71,670	223,208

Source: Estimated

TABLE 23

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM TRANSFER STATIONS TO DEFICIT POINTS: SCENARIO 2 - ROAD ADDITION

	SHASHI Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.86	5.032	3.828	None
Yichang	27,839	5.89	0.000	5.101	6.451
Export	12,815	11.55	0.000	None	23.956
Total	40,654				

	SHAYANG Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	79,076	7.922	0.00	None	12.954
Jingmen	0	11.800	4.10	7.70	None
Export	2,000	28.050	0.00	17.50	None
Total	81,076				

	JINGMEN Tonnes	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
Wuhan	0	8.185	7.763	.422	None
Yichang	871	2.484	0.000	1.923	3.273
Jingmen City	38,690	.200	0.000	None	4.300
Export	61,917	10.000	0.000	None	20.550
Total	101,478				

Source: Estimated

than just SYTS. The most interesting result is that SSTS now satisfies 97% of Yichang's demand whereas it didn't even deliver there before the road was available. This result has implications if it is deemed politically or otherwise necessary to keep the throughput at SSTS near current levels. More important is that if a road were to be built and the system were to be run in an optimal manner, the new road would take pressure off the already overburdened railway system since under the optimal scenario, Yichang's grain was sent by rail from JTS. Using SSTS in 1987 rather than JTS to send grain to Yichang resulted in an increased cost of 22,477 ¥ [a shadow price of .786 ¥ (table 13) times the 28,597 tonnes (table 3) that should not have been shipped from SSTS to Yichang] to the system. This additional cost would increase by whatever grain increase was demanded at Yichang in 1990 (35,736 ¥ in 1990 at a 59% increase). The above extra cost resulting from shipping grain through SSTS rather than JTS is the cost of the inability to use the railway to ship grain to Yichang. Determining this cost result satisfies objective 2(ii). With the road in place, routing the grain through SSTS as they did in 1987 would have resulted in an increased cost of only 425 ¥ (a shadow price[54] of .561 ¥ times the 758

[54]This shadow price can not be taken directly from the primal solution since shipments are made from both JTS and SSTS to Yichang. The shadow price is determined by subtracting the minimum cost needed to change the solution basis (see introduction to this section for an explanation of the minimum) for the activity for shipping grain from JTS from the per unit cost for this activity.

tonnes which should have gone through JTS but went through SSTS) which is the cost of not being able to use the railway if the road were available. It can therefore be seen that the cost is quite different if the road is available. If they were to have this road in 1987 and had shipped in an optimal manner, they could have reduced the system cost by approximately 60,000 ¥.[55] in 1987. Assuming the 1990 savings are 59% greater than the 1987 savings with the road in place (37,977 ¥ using the optimal network scenario for 1987), and interpolating the costs for 1988 and 1989, this road could save 196,794 ¥ over a four year period <u>ceteris paribus.</u> The savings would be much more than that if the 1990 flows remain the same as in 1987. This area has three stations which together supplied 30.6% of the grain delivered to TSs in 1987. The cost of road construction can be compared to the cumulative savings to assist planners in deciding if a new road is economically warranted. It would appear that since this area has a large amount of surplus, it is a prime area for infrastructure improvement.

The solution is again not stable. There are five activities which can be considered unstable. These are flows originating from stations 11, 12, 17, 22, and 24 and these are the same stations as in the base model, optimal network case. Activities SS11, J12, J17, J22, and J24 have shadow prices less than one Yuan (see table 24) and the implications of

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[55]Calculated as 37,977 + 22,477 - 425 = 60,029 ¥

TABLE 24

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM SUPPLY STATIONS TO TRANSFER STATIONS: SCENARIO 2 - ROAD ADDITION

Activity Code[a]	Tonnes Shipped	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
J11	16,422	10.28	0.0	-20.550*	11.069*
SS11	0	7.66	.789*	6.874*	None
SY11	0	10.47	7.690*	2.780*	None
J12	0*	12.56	0.947*	11.613*	None*
SS12	22,406*	8.21*	0.0*	-23.956*	9.154*
SY12	0	8.82	4.704*	4.113*	None
J17	0*	9.84	0.561*	9.282*	None*
SS17	0	18.14	12.264*	5.876*	None
SY17	19,858*	1.78	0.0	-28.050*	2.343*
J22	0	15.18	.954*	14.226*	None
SS22	4,289*	10.82*	0.0*	9.379*	11.381*
SY22	32,906*	6.73	0.0	6.165*	8.167*
J24	0*		.954*	15.096*	None
SS24	8,765*	11.69*	0.0	-23.956*	12.644*
SY24	0	10.21	2.614*	7.596*	None

Source: Estimated.

[a] Codes are J=Jingmen, SS=Shasi and SY=Shayang. Numbers designate supply stations (e.g. J12 denotes grain flowing from station 12 to Jingmen transfer station).

* Denotes values which are different from the Base Model, Optimal Network Flows (i.e. values which are not simply an increase of 1987 flows and have not been redistributed to other supply stations).

these outcomes are clear as presented earlier - grain could be diverted to these TSs at a minimal extra cost per tonne to the system. Station 22 splits its deliveries between SSTS and SYTS. If the rate to SSTS were reduced by 1.441 ¥ or more or, conversely, if the rate to SYTS was increased by 1.441 ¥ or more, more grain would be sent to SSTS from this station. On the other hand, if the rate to SSTS was increased by .561 ¥ or more or, conversely, if the rate to SYTS was decreased by .561 ¥ or more, more grain would be sent to SYTS from this station.

SCENARIO 3 - ORIGINAL RATES TO SHASHI

In this scenario the model uses the actual rates which were given for stations delivering to Shashi (see table 7, page 67) and are henceforth referred to as observed rates. The rates for stations 10-14 and 22-24 were changed. These observed rates are considered to represent one of the dual tariff structures since they are both higher and lower than the state rates and are thus not calculated on the basis of distance alone, as are the state criterion rates. It was not determined why these rates are different than the state criterion rates reported for transport costs at SSTS and JTS. There are various reasons why they might be different but none of the authors guesses can account for all the differences alone. Tractors are sometimes used at a rate of .25 ¥ per tkm. but one rate is even higher than this. An allowance may be made for differences in road travelled but two stations on the same road had very different rates. There are apparently no influences from backhaul opportunities as rates are charged the same regardless. Perhaps it is simply a result of negotiation.

To find out if the flow solutions would change it is necessary to compare only the new rates with the minimums and maximums of the base model, optimal flow network. However, to determine if the sensitivity of activities changed requires running the model again. The flows are identical to the base model, optimal network flows, and therefore this dual rate structure does not appear to be biasing flow direction. It was expected that the flows would be identical because the base model, optimal network, analyses of maximums/minimums showed that the basis would not change with these rates. The cost for this scenario is only 3,844 ¥ (.12%) greater than the base model and thus the use of the state criterion rates appears to result in a fairly close approximation of what might occur with variable rates. This result helps support the model's validity. However, if the observed rates are run with the base model, current network flows, there is an increase in system cost of 34,266 ¥. or a .91% error in the 1987 system cost.

The solution for this scenario is more stable than the base model (see table 25). The solutions for stations 12, 17, 22, 24 and the activity representing shipments from SSTS to Yichang are unstable. The solution for station 11 is no longer

TABLE 25

FLOWS, RATES, AND SENSITIVITY ANALYSES DATA FOR GRAIN FROM SUPPLY STATIONS TO TRANSFER STATIONS: SCENARIO 3 - ORIGINAL RATES TO SHASHI

Activity Code[a]	Tonnes Shipped	Yuan per Tonne	Shadow Price	Minimum Rate	Maximum Rate
J11	16,422	10.28	0.0	-19.989	10.283
SS11	0	7.66	.003	7.660	None
SY11	0	10.47	8.251	2.219	None
J12	22,406	12.56	0.0	-19.984*	13.450*
SS12	0	10.40*	.890*	9.510*	None
SY12	0	8.82	4.318	4.500	None
J17	4,289	9.84	0.0	7.841	10.236
SS17	0	18.14	11.347*	6.793*	None
SY17	15,569	1.78	0.0	1.389	3.784
J22	0	15.18	.393	14.787	None
SS22	0	13.00*	1.263*	11.737*	None
SY22	37,195	6.73	0.0	-28.050	7.119
J24	1,144	16.05	0.0	15.160*	16.406*
SS24	7,621	13.00*	0.0	12.644	13.890*
SY24	0	10.21	2.221	7.989	None

Source: Estimated.

[a] Codes are J=Jingmen, SS=Shasi and SY=Shayang. Numbers designate supply stations (e.g. J12 denotes grain flowing from station 12 to Jingmen transfer station).

* Denotes values which are different from the Base Model, Optimal Network Flows.

unstable. Again, stations 17 and 24 split their deliveries between TSs although the change in rates necessary to change the basis are different. The implications for stations 12 and 22 are the same as in the base model, optimal network case.

SCENARIO 4 - STATE RATES AT SHAYANG

Scenario 4 determines if the use of state rates at SYTS results in a different optimal network. It appears that the current rates used at SYTS are market determined rates while other TSs use state subsidized rates. The base model informs us that the basis solution will not change with decreases in the rates for grain being shipped out of SYTS to destinations outside of Jingmen. The current rate structure is not biasing grain flows away from SYTS. All of Wuhan's demand is still met from SYTS. The current rate to Wuhan would have to almost double (to 14.30 ¥) before this was the case. Of course, the system cost decreases (by 78,902 ¥) with the lower rates, and the penalties for sending grain to Wuhan through SSTS and JTS, as is currently the case, are greater (by about 2.2 ¥ per tonne). All other activities are as sensitive as in the base model.

SUMMARY

The following hypotheses were suggested for this thesis. Jingmen is not moving grain in a least cost fashion. Secondly, the magnitude of the benefit of moving grain in a least cost fashion is large. Thirdly, management and institutional constraints limit the extent to which the system can be run in a least cost fashion. The conclusions from this section confirm the first hypothesis, confirm or at least support the second, and are conflicting for the third. The first research objective has been accomplished. The conclusions from this section also represent the attainment of three of the four sub-objectives of the second research objective, which are:

> To estimate the current and future financial costs of: (i) mismanaging grain flows, (ii) the inability to use the railway, and (iii) redirected grain flows due to a dual rate structure.

Since estimates for objectives 2(ii) and 2(iii) are essentially estimates of the impact of a policy to subsidize rates on state carriers, they contribute to the investigation of the third research objective and hypothesis.

The above type of analyses are very useful in China. The construction of this type of linear program is very easy in China because the policy of self sufficiency prohibits a large number of movements (from township to township and county to county) that would otherwise have to be included in the modelled network. It is especially easy to model the flows now (1987) that all grain must be delivered to the government again. The MPP grain will now go to the closest delivery point. Assuming the monopoly for marketing grain continues, the various arms of the Grain Bureau should start keeping better statistics on the quantity and origin of MPP grain. These statistics are apparently unavailable at TSs, most likely because the shipments arriving there are not planned for and could come at any time and from any place. These unplanned shipments will no longer be prevalent now that the MPP grain deliveries will be planned by the Grain Bureau and the data can be used to construct a more complete model.

Based on the data available, the foregoing grain flow analysis suggests that current management is not economical, and a different schedule could result in substantial savings. The returns to this kind of research appear to be exceptional. The 1987 cost of mismanaging grain flows was 612,149 ¥ (table 26) and the total four year cost to 1990, assuming a 59% increase in flows, would be approximately 3.2 million ¥, ceteris paribus. Most of the increase in cost is due to grain leaving an inappropriate TS for its final destination rather than the cost of flows to TSs. All grain destined for Wuhan should be sent through SYTS. The fact that grain from JTS did not go by rail to Yichang resulted in an extra cost of 22,477 ¥ to the system in 1987. This is the cost of the inability to use the railway. The solution for scenario 2 shows that this cost can be substantially reduced if a road were built in the south-west area of Jingmen. A road addition results in an optimal flow network which re-routes 97% of the grain through SSTS to Yichang and which essentially eliminates the extra cost of 22,477. The road also reduces system cost by 37,977

TABLE 26

SUMMARY OF LINEAR PROGRAMMING RESULTS

Scenario	Total Cost (Yuan)	System Savings (Yuan)	Unstable Solutions (Station)
1987 Base Model - Original Network Flows	3,780,013	N/A	N/A[a]
1987 Base Model - Optimal Network Flows	3,164,471	612,149	11,12,17,22 24 and Shashi to Yichang
Scenario 1 - Optimal Flows In 1990	5,685,201	1,004,041	11,12,17,22 24 and Shashi to Yichang
Scenario 2 - Road Addition	3,126,494	37,977	11,12,17,22 24
Scenario 3 - Original Rates To Shashi	3,168,315	-3,844	12,17,22,24 and Shashi to Yichang
Scenario 4 - State Rates At Shayang	3,085,569	78,902	11,12,17,22 24 and Shashi to Yichang

Source: Estimated

[a] The structure of the model is such that unstable activities are unavailable.

Yuan for the optimal network and thus would have reduced the total cost in 1987 using the current flows by about 60,000 ¥. Since SSTS is currently not an economical transshipment point, this result is also significant if it is politically or otherwise desirable to continue using SSTS to ship grain to Yichang.

The dual rate structures tested do not result in altering the optimal network flows. The unaltered optimal flow means that the policy of subsidizing state carriers is not directing flows away from the most economic transfer station. Despite the higher than state criterion barge rates at SYTS, the station does not suffer any reduced flows from the higher rates but these rates do result in a cost which is 78,902 ¥ greater than if the state rates were used. The non-state criterion rates used for supply stations to SSTS do not result in altered optimal flow patterns either and the cost is just .12% greater than for the 1987 optimal network model. On the other hand, the rail rates from JTS have no comparable market rates and thus were not tested. It is quite possible that the low rail rate to Yichang biases grain away from SSTS. The rate from JTS would only have to increase from 2.48 to 3.27 for SSTS to become competitive for Yichang deliveries. Since the 125 km. rail rate is equivalent to only a 12.5 km. truck trip at state rates, the rail rate appears to be extremely low. The low rail rates are presumably inhibiting the performance of the system and has led to a rail system which is heavily overburdened.

Since the trained personnel and computers (not to mention electricity) are generally unavailable in Jingmen, and since the same is assumed in other rural areas, it is suggested that a training program be initiated at HAU to train rural managers of the Grain Bureau so that such models can be built. The models could be maintained in either the rural areas or in Wuhan. The feasibility of this proposition is hampered by the lack of trust and coordination between government and university institutions but these differences must be overcome if research is to have a meaningful impact in China. Information is jealously guarded in China for a variety of reasons, so there is some question of whether Grain Bureau officials really want others to know of their activities. This propensity also hinders the feasibility of this suggestion, but the model could be used exclusively by the grain bureau after initial training. National policy makers have already indicated their desire for universities to become more financially self-sufficient and this type of cooperation could help universities achieve this goal if the system savings could be used to compensate the university for its services. The Grain Bureau would likewise have to be allowed to keep a significant portion of the cost savings in order for the project to be successful. While the author did not get the full information needed for a precise model, this information was collected but could not be released to the author, and the data was subsequently thrown away by the Grain Bureau. It is assumed that the data base currently exists for this type of model building.

Most solutions are unstable for the five supply stations in the south-west corner of Jingmen. This instability means there is a fair amount of flexibility in where these stations can send their grain. Given the large amount of grain at stations 22 and 24, and given that Jingmen wants to use its Shashi station even though it is (arguably) presently uneconomic to do so, planners may want to consider if it is in their interests to build a bridge or provide barge service from station 24 south to Jiangling County. Scenario 2, the addition of a road between stations 12 and 23, showed that SSTS became a viable TS for grain deliveries with this road addition and the addition of a bridge or barge service would likely do the same. The road addition showed a cost savings of 37,977 ¥ in 1987 and assuming that the network is run in an optimal manner from 1987 to 1990, and if the flows were 1.59 times greater in 1990, then the savings would be 60,420 ¥ in 1990, <u>ceteris paribus</u>. Interpolating the costs for 1988 and 1989 and adding them to the 1987 and 1990 savings would result in a four year savings of 196,794 ¥, <u>ceteris paribus</u>. These savings can be used as a guideline to determine if there is cause for another transportation route to be built. The south-west area is especially important since the sum of the flows from stations 12, 22 and 24 represent 30.6% of the total flows originating at supply stations in Jingmen.

Solutions show that Jingmen is not making optimal use of the geographic position of SYTS. SYTS currently sends out much less than it would under an optimal conditions. Storage capacity is sufficient at SYTS to receive greater deliveries in the future and the size of boats on the Han Shui river, at a maximum 500 tonnes capacity (SSTS is 1,000 tonnes), is not a limiting factor to increase flows at SYTS. It appears that Jingmen should stop sending grain to Wuhan by railway.

This chapter has shown the economic impact of not routing grain shipments in a least cost fashion for 1987 and the impacts that might occur under other scenarios. It has also identified where shipments should or should not be occurring according to a least cost criterion thus identifying specific routings which could be corrected. Many other scenarios can be examined with the linear programming model. The author suggests that planners analyze the projected grain demand for Wuhan and consider the benefits of shipping from the three transfer stations in Jingmen. This analysis would be especially useful if similar models for other areas of Hubei Province could be constructed and integrated so as to provide a provincial model for optimal grain shipments.

The foregoing analyses are severely impaired by data limitations. At almost every turn of a page there can be found qualifications which surround the data. The author realizes that analyses as conducted here require accurate data and that the results would not be very useful if the data were incorrect. Every effort was made to ensure data integrity but in light of the author's experiences in China, the results cannot be too precise. The reliability of the results can only be assessed by the Grain Bureau in Jingmen and the author could not get the Grain Bureau to respond to the data questions raised in this thesis. Because of these data problems, the linear programming model is best considered as an illustration of what could be done in China to enhance the management of its grain transportation system.

CHAPTER 5

INSTITUTIONS AND POLICY: CRITICAL COMPONENTS OF THE SYSTEM

Regional development projects must consider government policy objectives. This chapter outlines some of China's major institutions affecting the grain storage and transportation system as of 1988.

The conclusions from the following four sections are directed towards the investigation of the third hypothesis: that management and institutional constraints limit the extent to which the system can be run in a least cost fashion. The Jingmen Transport Company is an institution; it was established for the specific purpose of transporting grain. An institution is also an established custom, law, or relationship in a community so the policies which are mentioned may also be considered institutions.

The primary objective of the first subsection is to estimate the extra cost from empty hauls which could have been avoided in 1987 had the system been run in an optimal manner. The 1990 cost is also estimated. These represent the last sub-objective of objective 2 to be investigated, the others having been accomplished in chapter 4.

The second to fourth subsections cannot provide quantitative support like the previous investigations. The second subsection presents the background behind the new policy to again monopolize the grain marketing system. This section has made a number of postulations for what might be the effect of the return to a monopolized grain marketing system but the effect can only really be determined with time. The third subsection provides an overview of how the system of payments is accomplished according to the new system implemented in 1987. It shows how the GPP and MPP purchasing channels are related to system participants and how the payment system may be influencing the operation of the marketing system. The fourth subsection describes the state goals for marketing costs. Some of these goals will be discussed in this section in terms of their possible economic impacts.

For the conclusions of this section, the reader is directed to the end of each subsection. There are certainly management and institutional constraints which are inhibiting the efficiency of the grain marketing system. It was shown earlier that there were such management constraints but the investigation of the dual rate structures did not confirm that there were institutional constraints. This section shows that there are institutional constraints which are limiting the ability of the system to operate in a least cost fashion, but only in a qualitative manner.

JINGMEN TRANSPORTATION COMPANY

Company management reported that the major methods used to increase efficiency at the company were to increase the length of haul, decrease inputs, and decrease the number of empty back-hauls. Actually, Jingmen Transportation Company (JTC) wants to decrease the number of empty front-hauls, since the empty haul occurs when the truck leaves for the supply station, but it is referred to in this thesis as a dead-haul. Another objective is to remain below the state quota for fuel consumption. The data in table 27 was manipulated to produce efficiency measures (see table 28) which can be used to: (1) analyze the performance of the fleet over time, (2) find the average tonnage carried per truck and therefore the cost of empty hauls, and (3) determine the number of truck trips made by the fleet and thus the average hauling distance. This section thus estimates (a) the trend in the use of labour, total tonnage of truck capacity, and fuel (the only input data available) on a per unit output basis, and trend estimates for some other performance indicators are also discussed, (b) the present and possible (under the optimal network scenario of chapter 4) magnitude and cost of empty hauls, and (c) the present average length of haul. Some of the data presented in the tables is not discussed in any detail and is primarily presented so that JTC can estimate the trend in the average length of haul on its own. The analysis here shows how the average length of haul might be estimated for 1987 but estimates for other years are left to the reader.

The analyses indicated that the average tonnage carried per truck is 8.62 tonnes. Using this average, empty hauls cost JTC an estimated 2,238,490 ¥ in 1987 assuming fully loaded trucks cost the same to run as empty trucks.[56] For the grain flows modelled (see chapter 4), and under the same assumption, the cost was 1,835,823 ¥ in 1987. If the system had been run in an optimal manner in 1987, the cost would have been 368,929 ¥ less for the flows modelled (a reduction of 280,113 kms. of empty hauls). This saving of 368,929 ¥, added to the saving that could have been accrued to full trucks running under the optimal scenario discussed in chapter 4, means that the Grain Bureau could have saved an estimated 981,078 ¥ in 1987 by simply re-routing its grain flows.

JTC belongs to the Grain Bureau and carries a large percentage of the total commercial grain in Jingmen (92% of the quantity delivered to TSs in 1987). Of this tonnage, 98% was grain and oil in 1987 and almost all of it was reportedly grain (see column 11, table 28). The truck fleet in latter 1987 consisted of 14 Mitsubishis (9 tonnes carrying capacity each), 6 other Japanese trucks (7.5 tonnes each), and 32 Dongfeng and Jiefeng trucks with trailers (6 tonnes in the box

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[56] It is realized that this assumption is likely invalid and that the cost of running a full truck is likely greater. It is also realized that it is nearly impossible to always have full trucks on both front and back hauls so that some of this cost is unavoidable.

TABLE 27

INPUTS AND OUTPUTS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987

Year	(1) Capacity Of Trucks (Tonnes)	(2) Possible Working Days	(3) Actual Working Days	(4) Total Kilometres Travelled	(5) Total Tonne-kilometres Travelled
1980	295.0	12,654	10,392	2,907,943	6,371,501
1981	248.5	7,421	6,445	2,314,875	5,232,218
1982	256.1	9,932	8,030	2,648,595	6,431,702
1983	385.5	12,594	10,341	3,520,035	9,029,090
1984	447.6	15,725	12,970	4,450,529	12,023,303
1985	440.2	14,718	13,052	4,835,966	13,593,848
1986	472.5	14,917	13,280	4,743,273	15,733,062
1987	485.6	14,903	13,456	4,307,539	15,293,818

Source: Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

TABLE 27

INPUTS AND OUTPUTS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987 (Continued)

(6) TRUCK	(7) TRUCK	(8) TRUCK	(9) WAGON	(10) WAGON	(11) WAGON
Kilometres Travelled With Goods	Kilometres Travelled Empty	Total Tonne-kilo-meters	Kilometres Travelled With Goods	Kilometres Travelled Empty	Total Tonne-kilo-meters
1,035,019	704,186	4,025,331	670,334	498,404	2,346,170
770,516	523,205	3,145,888	.585,688	435,466	2,086,330
891,629	558,627	3,792,791	695,815	502,524	2,638,911
1,197,136	746,207	5,304,580	942,085	634,607	3,724,510
1,444,769	927,755	6,779,008	1,227,597	850,408	5,244,295
1,610,943	1,168,794	8,475,374	1,160,476	899,353	5,118,474
1,763,583	1,302,616	11,156,608	935,103	741,971	4,576,454
1,701,282	1,266,759	11,582,566	746,040	593,458	3,711,252

Source: As above.

Note: Data is from 1980 to 1987 as in above table.

TABLE 27

INPUTS AND OUTPUTS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987 (Continued)

Year	(12) Total Tonnes Of Freight Carried	(13) Total Tonnes of Grain+Oil Carried	(14) Fuel Quota (kilo-grams)	(15) Fuel Used (kilo-grams)
1980	162,846	134,704	373,670	441,347
1981	122,310	110,939	284,229	307,261
1982	164,845	154,864	354,571	326,052
1983	213,196	200,867	460,409	411,825
1984	276,539	247,202	553,967	519,755
1985	299,364	292,122	631,771	639,253
1986	306,249	301,715	675,789	695,919
1987	285,067	279,586	641,393	661,969

Source: Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

TABLE 28

PERFORMANCE INDICATORS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987

Year	(1) Gas Used per Tonne Truck Carrying Capacity	(2) Average Tonnes Carried Per Truck	(3) Average Tonnes Carried Per Wagon	(4) Percentage Of Kilometers Truck Runs Empty	(5) Percentage of Kilometers Wagon Runs Empty
1980	1,496	3.89	3.50	40.5	42.6
1981	1,236	4.08	3.56	40.4	42.6
1982	1,273	4.25	3.79	38.5	41.9
1983	1,068	4.43	3.95	38.4	40.2
1984	1,161	4.69	4.27	39.1	40.9
1985	1,452	5.26	4.41	42.0	43.7
1986	1,473	6.33	4.89	42.5	44.2
1987	1,363	6.81	4.97	42.7	44.3

Source: Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

TABLE 28

PERFORMANCE INDICATORS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987 (Continued)

Year	(6) Percentage Of Total Kilometres Wagon Is With Truck	(7) Percentage Of Total Loaded Kilometres A Truck Travels When It Has A Full Wagon	(8) Oneway Distance Of Truck Travel (Kilometers)	(9) Percentage Of Oneway Distance Which Is A Front Or Back Haul	(10) Kilometres Travelled Per Tonne Of Truck Carrying Capacity
1980	67.2%	64.8%	869,603	19.0%	9,857
1981	78.9%	76.0%	646,861	19.1%	9,315
1982	82.6%	78.0%	725,128	23.0%	10,342
1983	81.1%	78.7%	971,672	23.2%	9,131
1984	87.6%	85.0%	1,186,262	21.8%	9,943
1985	74.1%	72.0%	1,389,869	15.9%	10,986
1986	54.7%	53.0%	1,533,100	15.0%	10,039
1987	45.1%	43.9%	1,484,021	14.6%	8,871

Source: Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

TABLE 28

PERFORMANCE INDICATORS OF JINGMEN TRANSPORTATION COMPANY: 1980 - 1987 (Continued)

Year	(11) Percentage Of Tonnes Carried Which Is Grain And Oil	(12) Fuel Used Per Tonne-kilometre (Tonnes)	(13) Percentage Of Days Actually Worked	(14) Tonne-kilometres Accomplished Per Tonne Of Truck Capacity
1980	82.7%	0.069	82.1	21,598
1981	90.7%	0.059	86.8	21,055
1982	93.9%	0.051	80.8	25,114
1983	94.2%	0.046	82.1	23,422
1984	89.4%	0.043	82.5	26,862
1985	97.6%	0.047	88.7	30,881
1986	98.5%	0.044	89.0	33,297
1987	98.1%	0.043	90.3	31,495

Source: Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

and 4 tonnes in the trailer or 10 tonnes total capacity), for a total carrying capacity of 491 tonnes for the 52 trucks. The 491 tonnes is slightly higher than the number shown in column 2 of table 28 because the table's numbers are monthly averages and two trucks were bought and six sold during the year. The figures for tonnage in table 2 reflect carrying capacity of the truck fleet including wagon trailers.

Average Truck Carrying Capacity

Inspection of table 28 (column 6) reveals that 45.1% of the kms. travelled by truck included a wagon in 1987. 43.9% of the kms. travelled with goods included a wagon with goods if we assume that when a wagon is carrying goods the truck is also carrying goods (column 7). The assumption is acceptable since it is normal to load only the truck and not the trailer if there is not enough to fill both. It can also be noted that the percentage of total kms. the truck runs empty and the total percentage of kms. the wagon runs empty are very similar and covariate closely over time. This observation also supports the above assumption. Dividing the total tkms. accomplished for trucks and wagons by their respective kms. travelled with goods we can calculate the average tonnage carried as 4.97 tonnes and 6.81 tonnes (columns 2 and 3) for every km. travelled for wagons and trucks respectively in 1987. Wagons are only suppose to carry 4 tonnes and thus seem to be overloaded. Since only the 6 tonne trucks can use the wagons (and all of these have wagons), and assuming that the truck is not also overloaded, these truck-trains carry an average 10.97 tonnes. Assuming that 43.9% of the time a truck is carrying goods it also has a full trailer in tow and that all trucks travel an equal distance, 43.9% of the kms. travelled with goods are being travelled with, on average, 10.97 tonnes. Weighting the two theoretical truck sizes of 10.97 tonnes and 6.8 tonnes with their respective proportion of kms. travelled with goods (.439 and .561 respectively) yields an average 8.62 tonnes carried per truck and truck-train combined for every km. travelled with goods.

Cost and Magnitude of Empty Hauls

The primary objective of this section is to estimate the extra cost which could have been avoided in 1987 had the system been run in an optimal manner. The 1990 cost is also estimated. These represent the last sub-objective of objective 2, the others having been accomplished in chapter 4. The estimate performed previously, the average truck load (8.62 tonnes), is necessary to make this section's estimates.

The company reported that the empty rate of truck travel was 45% for 1987. In table 28 (column 4) we see that it was 42.7% (1,266,759 km.) and that this percentage has been increasing yearly since 1983 (four years of increase). The percentage of wagon kms. travelled empty has also been increasing since 1983 and was 44.3% in 1987 (column 5) -

almost the same as for trucks. Multiplying the total kms. travelled without goods by trucks of average carrying capacity by a cost of 1.767 ¥ (.205 ¥ per tkm. times 8.62 tonnes - a rate that would be close to the average for full trucks) results in an estimated cost of 2,238,490 ¥ for the empty hauls. The estimates assume that the empty haul cost is the same as for a loaded truck. The estimates can be lowered to reflect the cost of an empty haul by simply multiplying the estimate by the percentage of the loaded cost which is equal to the empty cost (i.e., if the empty haul cost per tonnes or tkm. is 50% of the cost of running full, multiply the estimate by .5).

We have determined that the average quantity a truck carries is 8.62 tonnes. We return to the data on the flows that occurred in 1987 and the estimation of the optimal flows in 1987 (see last chapter) to determine the total distance and cost of empty hauls. The distance and cost can be reduced substantially if the system is run in an optimal manner. These cost estimates depend heavily on the size of truck used and treat partial loads to be equivalent in cost to full loads.

To estimate the cost, the tonnes shipped in tables 2 and 14 (pages 49 and 117 respectively), which are the tonnes shipped under the current and optimal flows for 1987, are divided by the average truck load (8.62 tonnes) to get the number of one-way trips. 14.64% of these trips have back-hauls[57] so this percentage of one-way trips is subtracted from the total number of one-way trips to get the residual, which is the number of return empty hauls. The number of return empty hauls is multiplied by the cost per tonne for the haul from the supply point to the TS it delivered to and then multiplied again by the 8.62 tonnes. All of the shipments are then summed up. For deliveries to SSTS, the cost of travelling to the supply point and back to Jingmen City is added for every two trips from the supply point to SSTS. During the busiest time of year, JTC sends part of its fleet to Shayang (as a type of separate brigade) so these trucks do not have to return to Jingmen City. All trucks stationed in Jingmen City are suppose to return each night. The calculations show that the cost of returning empty in 1987 was 1,835,823 ¥ and the cost under the optimum flow scenario was only 1,466,893 ¥ or 368,929 ¥ less than the actual 1987 cost. This reduction in cost is due to the reduction in distance travelled empty when the network is run in an optimal manner. The optimal flow network reduces the number of kilometres travelled empty to 830,711 from 1,110,824 or a reduced distance of 280,113 kms. Incidentally, the total distance travelled from the supply

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[57]Backhauls are estimated by first calculating half of the total distance travelled by trucks, i.e., the theoretical one-way distance. This number is then subtracted from the total distance travelled by trucks with goods and the residual is then divided by the theoretical one-way distance to yield the percentage of the return journey kilometres that have trucks carrying goods. The result, for 1987, is that 14.64% of the return kilometres are kilometres where the truck was carrying goods.

points to the TSs (with goods) was also reduced by 377,532 kms. under the optimal scenario.

The 1990 cost might be expected to increase approximately 59% (the same as the increase in surplus grain) over 1987. The cost of empty hauls was 60% of the cost savings for full trucks in 1987 and so results in an essentially identical estimate if it is alternatively assumed that this percentage will remain constant to 1990. The first assumption would result in a 1990 cost of 586,587 ¥ or a four year cumulative extra cost of 1,911,052 ¥, ceteris paribus. This number added to the cumulative extra cost of full trucks estimated in chapter 4 results in a total 5.1 million Yuan which will be lost if grain flows are not re-routed.

The linear program models 80% of the quantity of grain transported by JTC. The estimates for the empty haul costs using the linear programming model appear to be relatively accurate since the total cost for empty hauls is also near 80% at 82% of that estimated for JTC. The estimated kilometres travelled empty for the model is 87% of the total for JTC. It would be expected that this last percentage would be higher than the percentage of tonnes shipped since the tonnage which was modelled in chapter 4 did not include the short movements which were from place to place in Jingmen City and would thus include a higher percentage of the empty hauls, assuming there are greater opportunities for hauls both ways in the city. Since the linear programming model only covers about 72% of the total inflows in Jingmen in 1987 (no MPP grain flows were modelled), it stands to reason that the savings would be much greater if the other 28% of inflows were included.

A major problem in reducing dead-hauls is that most work units bring in supplies with their own vehicles. No extra charge is made to customers when there is a dead-haul and likewise there is no reduction if there is a backhaul. Economic rates could be conceived which reflect the opportunity of a backhaul being present and this might result in rural economic units making greater use of the Grain Bureau's trucks. Unless the current rate charged by the JTC also covers the cost of empty hauls, it would appear that it would be worthwhile to subsidize the cost of transporting goods that are demanded at the supply points so that at least some of the cost of empty hauls could be recovered. Bricks for house construction are the most common goods being carried in this area of China but the production of bricks occurs in many localities and are therefore easily acquired locally. Many other types of goods are considered contaminants, including chemical fertilizer, but fertilizer can be taken to the countryside without contamination. For whatever reason, the percentage of freight which is grain and oil has become very high in the last three years (table 28, column 11) and this may indicate greater intolerance for other cargoes.

Average Hauling Distance

Average hauling distance is one of the efficiency measures that JTC wanted to improve. However, they have no current measure of this indicator. This section provides a method for how this indicator might be measured in 1987. It will be up to JTC to determine if this measurement is accurate and use the data presented for other years of operation.

There are 52 trucks in the fleet. Each truck must travel an average of 57,078 kms. per year to reach the number for the total kms. travelled in the data. If we assume that each truck was in operation for only 258 days of the year[58] each truck must travel 221 kms. per working day on average. As will be shown, this is slightly more than two average round-way trips per ten hour work day. If 300 days is assumed, the truck must travel only 163 kms. per day.

The presumed average daily distance of 221 kms. seems slightly excessive since, from Jingmen city, the most northerly point is 57 kms. away and the most southerly point, Shashi, is 86 kms. away from Jingmen. The northern point represents the furthest any transfer station should have to go to collect the grain according to its market area as defined by the optimal network in chapter 4. While the flows that actually occurred in 1987 included a number of trips which

[58] 258 days is calculated as 90.3% of the possible working days as shown in column 13 in table 27. This 90.3% refers to the days people could work out of the total possible but is applied here to the number of days the truck could work.

were greater than 60 km.(e.g. to SSTS) these alone could not account for the long average distance travelled per trip.

If we divide the average tonnage carried per truck into the total tonnage carried (285,067) then we can calculate that there were would be 33,070 one-way trips for the truck fleet. Of these trips with goods, 14.64% of them are estimated to be hauls which carry goods both ways (4,841 full round-trips) and therefore we can estimate that there are 28,229 round-trips taken. Dividing half of the total kms. travelled by trucks by the number of trips taken yields an average one-way distance travelled of 52.6 kms. Two trips of this sort would result in 210 kms. travelled, which is 11 kms. less than the average daily distance trucks travelled in 1987.

Using the same analysis as above but assuming an average 6.8 tonnes carried (i.e. a truck without a wagon) per trip yields an average one-way haul distance of 41.5 kms. The author was under the impression that the trucks rarely left the Jingmen area but since this one way distance also exceeds what may be considered an acceptable average for the area given the size of the area, we must assume that the trucks are often travelling outside the area. If we do not assume this, then the trucks are often travelling with small loads or the data is not accurate. If 25 kms. was the average one-way distance (a reasonable guess), the average load would be just 4.1 tonnes each trip but JTC reported that trucks almost always load and unload a full truck at each stop.

Shayang's flour and oil processing factory has a fleet of six trucks which carry 70,000 tonnes of goods a year.[59] They are expected to travel only 120 kms. a day and it was estimated that of the ten hours worked, six were spent waiting. While this would represent an average speed of only thirty kms. an hour, 120 km travelled daily is probably closer to reality.

It is probable that an increase in hauling distance can lower total costs since loading and unloading takes a great deal of time but without some method for measuring this objective it cannot be known if this objective is being met. A method for measuring the average hauling distance has been shown but the determination of the trend for this indicator is left for further research.

Efficiency of Input Usage

The performance indicators which can be derived from the data presented to the author are quite useful. Fuel used per tkm. (column 12, table 27) has been generally decreasing over time and is much lower than in the early 1980s. Fuel used per tonne of truck carrying capacity was at its lowest in the intervening years of 1983 and 1984. These two years, plus 1982, were the only years in which the company was able to stay below its quota for fuel consumption. The percentage of

[59]Fan Wei Xie, Interview by author, translated by Zhang Xing Bo, Shayang TS, Jingmen, 10 November 1988.

man-days worked out of the total possible (generally considered to be 25 days per month) is an indicator of labour performance (column 13) since labour also gets paid when they don't show up for work. From 1982 to 1987, this indicator has increased from approximately 80% to 90%. This increase is a considerable accomplishment. The total tkms. travelled per tonne of truck carrying capacity shows that the fleet improved from 1984 to 1986, but 1987 saw a fairly large reduction in this indicator (column 14). This reduction was largely due to the fact that the quantity carried in 1987 was 5% less than in 1985 and almost 7% less than in 1986. Why there was less transported by JTC in 1987 when production has been increasing is a mystery.

Firm conclusions on the basis of these five indicators of efficiency of input usage are difficult to make since there are indications of increasing and decreasing efficiency. The company seems to be doing fairly well however.

Summary

The analyses indicated that the average tonnage carried per truck is 8.62 tonnes. Using this average, empty hauls cost JTC an estimated 2,238,490 ¥ in 1987. For the grain flows in the linear program model the cost was 1,835,823 ¥ in 1987. If the system had been run in an optimal manner, the cost would have been 368,929 ¥ less for the flows modelled (a reduction of 280,113 kms. of empty hauls). This saving, added to the saving that could have been accrued to full trucks running under the optimal scenario discussed in chapter 4, means that the Grain Bureau could have saved an estimated 981,078 ¥ in 1987 by simply re-routing its grain flows. The percentage of distance travelled empty has been increasing since 1984 and re-routing grain flows cannot change this. Incentives, which could take various forms, must be instilled before there will be a change in the trend. JTC is not currently accomplishing its objective of decreasing empty hauls.

Another JTC objective which has not been accomplished is to keep below the allowed quota for fuel consumption. This objective could perhaps be accomplished if the shipments were re-routed since the distance travelled is reduced considerably.

The efficiency of input usage appears to be increasing since the quantity of fuel and truck capacity used to transport one tonne for a kilometre appears to be decreasing although the trend is not unequivocal. The use of larger, faster trucks appears to be making the difference although wagons are increasingly being overloaded and this may have consequences for future road repairs. Wagons are currently overloaded by 25% and this may be an indication that JTC is getting close to its maximum carrying capacity. The hypothesis that they are close to maximum carrying capacity is further supported by the fact that the percentage of goods carried which were either grain or oil (its main priority) has been much higher at about 98% in recent years. This high percentage might indicate that there is a lack of capacity to carry other goods. The estimated 221 kms. per day which must be travelled by each truck is also supporting evidence for this hypothesis since this usage would represent what the author considers to be near the maximum possible. The estimate of 221 kms. assumed trucks worked much fewer days than seems possible but the repair of foreign trucks may be difficult as factories in Jingmen were having a terrible time replacing imported parts.

The above included estimates for the cost of empty hauls and therefore closes out the discussion of objective 2(i) and of hypothesis 2. Hypothesis 2 stated that the cost of mismanaging grain flows was large. While large is certainly a relative term, the estimated savings of nearly one million Yuan which could have been captured in 1987 is a significant amount and can be considered large. If the cost of running empty remained at about 60% of the cost of mismanaging full loads (as was the case in 1987), the cumulative four year extra cost by 1990, assuming a 59% increase in costs, would be 5.1 million Yuan (1.7 million Canadian Dollars), _ceteris paribus_.

THE NEW MONOPOLY MARKET STRUCTURE

Since 1955, when the purchase and sale of grain was monopolized, China has had a system of rationing grain. In February 1959, China's State Council divided commodities into three categories. Category 1 included thirty-eight commodities, including grain, thought to be vital to national interests. The marketing of these commodities was apparently tightly controlled because "All quotas concerning the purchasing, marketing, allocation, export, import and storage of these goods were to be set by the State Council."[60] A brief rendition of how these delivery/procurement quotas are communicated through the planning hierarchy can be found in a report by the FAO.[61] While grain remains in category 1 today, many small movements of grain outside state control were allowed in recent years, and individuals could store grain in hopes of better returns later or elsewhere. The state monopoly over the buying and selling of rural products, including grain, was ended in 1985.[62] In 1988 the government announced that grain could no longer be bought, sold, or transported outside the state system without prior permission. It appears that this policy existed in Jingmen in 1987. The policy applies to wheat and non-glutinous rice but not to grains such as potatoes. Permission to market these grains has to be acquired from the local Grain Bureau which itself is under the control of the Ministry of Commerce. The new policy only affects market price purchases (and the old category of above-

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[60]China Handbook Editorial Committee, China Handbook Series: Economy (Beijing: Foreign Languages Press, 1984), 312.

[61]FAO, China: Agriculture in transition, FAO Economic and Social Development Paper 18, Rome, 1981, 8-9.

[62]China Reconstructs, June, 1988.

quota sales) since it is this grain which had been marketed outside of the state system in the past. The policy seemed to be fairly strictly enforced and thus the government has re-established its monopoly in the grain market.

Various people in the government's grain bureau felt there would be little change in their operations because of the new policy.[63] The Grain Bureau itself, however, has lost its selling authority at the Grain Management Station level. Whereas they could once sell the MPP grain where they liked (as could farmers), they must now sell all of this grain to the newly formed Grain and Oil Commerce Company which is usually called the Market Price Grain Company by the local population. One GMS reported that this policy has resulted in decreased profits for them.[64] The effect on farm income has likely been similar although officials in the Grain Bureau disagree with this view. It appears the higher level Grain Bureau organs have found a new source of revenue by designating the Grain and Oil Commerce Company as the monopoly buying agency and thus reducing or at least controlling the profits of GMSs. At least one GMS in Jiangling had previously

[63]Many interviewees were asked if their operations have or would change with the new policy and the response was uniformly negative. This is definitely an example of "toting the government line" as this policy change is indeed very controversial in China. A lecture at Hubei Agricultural University given by the author was terminated when this question was asked by students.

[64]Long Xue Sheng, Interview by author, translated by Zhang Xing Bo, Jinan Grain Management Station, Jiangling County, Hubei, 24 March 1989.

sent grain by truck to Guangdong Province (bordering Hong Kong) where the market price for rice is much higher.Given this national policy of increased centralization, it was considered inappropriate to attempt to assess whether development could occur through the greater privatization of transportation and marketing of grain. This assessment was an original objective of the author's.

The 1988 policy was said to be required because of the low production due to natural disasters in 1988 (i.e. a form of price control). Some others saw it as an action designed to reduce the number of farmers leaving the land, thus relieving pressure on the cities as well as increasing the amount of land cultivated and reducing the number of grain merchants. The "speculative" middleman and the "illegal profits" that they have been accumulating was another reason given by the government for taking hold of the commercial grain system. Grain speculation is generally said to occur when a person or group manages to accumulate a large amount of government price grain and attempts to sell it at market price. A China Daily[65] article quips that there is not a good market for grain at higher prices (i.e. grain sold on the free market) because people now have enough ration coupons in their possession. The market most likely does exist because there are currently many people in the cities (rural migrants) who do not have grain coupons and therefore cannot buy any grain

[65] China Daily, May 5, 1988.

legally. Whatever the reasons for the return to a completely monopolized grain system (in theory) after a three year respite, this was undoubtedly the most important policy change of the year.

Grain bureaus across the country also had their budgets fixed in 1988. A China Daily article reported that the budget for grain storage and transportation would be fixed for the next two or three years. Jingmen Grain Bureau said its budget was recently reduced and that they knew of the recent budgetary restraint. This policy, if carried out, will put serious limitations on the grain bureau's ability to perform under the current conditions of increasing production, operating costs, and perhaps commercial grain which they must now market themselves due to the new policy.

It was also reported that, according to the State Planning Commission, China would monopolize the sale of farm production materials.[66] The prices of important means of production (e.g. chemical fertilizer) were also placed under the "unified control of the State Administration of Commodity Prices".[67]

The conclusions from this and the following two sections are directed towards the investigation of the third hypothesis: that management and institutional constraints limit the extent to which the system can be run in a least

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[66] China Daily, 4 February 1988.

[67] China Daily, 20 January 1988.

cost fashion. These sections cannot provide quantitative support unlike the investigations of rate policy in Chapter 4. This section has made a number of postulations for what might be the effect of the return to a monopolized grain marketing system but the effect can only be determined with time. Given the planning advantages inherent in a monopoly, the marketing system should be able to be run in a more cost efficient manner but the effect that the monopoly might have on production might negate these gains. With the prices of inputs and outputs held at fixed levels, the grain farmer's income will now be essentially determined by the state and this loss of a self determined income incentive may reduce the farmers enthusiasm to produce. This enthusiasm is already at a low level according to the results of a survey of 3,200 rural households.[68] Asked about the purpose of growing cereal crops, 40.5% replied they did it just to feed themselves, 29% said they did it to earn their income, 18% said they crop to fulfil their state contract, and 12% replied the purpose was to feed pigs and poultry. The article reports that with the current price regime, "farmers have no alternative but to shift to other occupations." Thirty percent of the farmers replied they used their income to build new houses but it is an open question of how many of these farmers would rather be spending their time freely marketing and transporting their

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[68]China Daily citing Farmers Daily, 27 September 1988.

grain, if they could. Such survey results are indeed worrisome to those who would like to see the grain economy invigorated.

THE GRAIN PAYMENT SYSTEM

The payment system for grain is somewhat complex. This section provides an overview of how the system of payments is accomplished according to the new system implemented in 1987. It shows how the GPP and MPP purchasing channels are related to system participants and how the payment system may be influencing the operation of the marketing system. The implementation of this system was likely done in expectation of the 1988 policy change discussed in the above section.

The reason for dividing grain into GPP and MPP purchasing channels has to do with the intended final consumer. GPP grain is destined for consumers in the cities and the state processing facilities before that. The MPP grain is generally for the purpose of making up the shortfall in the GPP grain in the cities and for use in factories that are outside the state system. Almost all grain sent outside the province is MPP grain as each province is supposed to be self-sufficient and must therefore pay the higher price associated with the MPP grain for its imports (Beijing is an exception). It is not clear if these types of grain are physically separated but according to the author's observations, and logically, this is unlikely. The previous quota system included three categories. The currently termed MPP grain was previously broken down into "above-quota purchases" and what may be called "negotiated price" or "market price" grain. The previously named above-quota grain was solely for the use of making up GPP grain shortfalls in the cities while the market price grain was that sold on the open markets.

On delivery of the grain to a collection station, the farmer will receive money from the collection station if and only if he does not owe any money to his village. If he owes money the village head will receive the money and deduct what is owed before paying the farmer. This payment system presupposes that the Agricultural Bank of China has the money to loan the GMSs, which was not the case for late harvested (November) rice in 1988. When a truck comes to transfer the grain to a processing factory, the driver must be paid by the collection station for his services before driving away if his company is under the responsibility system. If the driver is not under this system, the payment will go to the company directly through the banking system.

The GPP grain purchase is the basis for the amount of money transferred to the GMSs via the Financial and Fiscal Bureau (FFB). The GMS will receive the state quoted price multiplied by the GPP grain quota it has been assigned. The GMSs will be charged interest on this money by the FFB. The TS will pay the GMS the same price for the grain as the GMS paid the farmer (eg. .44 ¥ per kilogram for paddy or the equivalent of .64 ¥ per kilogram for processed rice in Jiangling). Any other value added to the GPP grain is not paid for by the TS or anyone further down the consumption chain. The MPP grain is used as a means for repaying the GMSs for the losses incurred in GPP grain transactions. The GMS thus incurs a loss equal to the present cost of borrowing money until such time as they sell their MP grain and repay the interest. The money used to buy the MPP grain comes on loan from the Agricultural Bank. Each GMS has a quota for the delivery of MPP grain although the farmers do not. The GMSs must compete to a small extent to get the farmer's MPP grain and perhaps the collection stations below the GMS level compete as well. The amount of MPP grain delivered to a GMS is crucial to the profitability of a GMS as only this grain has a profit margin attached to it (see paragraph below). It is clear that there is a direct benefit for a GMS if it can procure a large amount of MPP grain and have its grain shipped out as soon as possible to reduce interest payments. This opportunity perhaps leads to some conflict in the system and the use of "friends" to ensure prompt arrival of trucks and to convince TSs to take their grain as early as possible. This phenomenon may be one of the reasons that the system is currently not run in accordance with least cost routings as identified in chapter 4. Since the closest TS may not be able to take delivery when the GMS is ready to deliver, the GMS may convince the Grain Bureau to deliver to a farther TS and this might even make sense if the storage losses for grain (e.g. stored outside) were high at the GMS. The cost of storage is suppose to be covered by the state and thus one would think that amount of time grain is in storage at the GMS should not influence the arrival of transport. It is not so simple as the following example illustrates. Shayang Oil factory decided to build its own storage and a certain area's grain was stored here. This was done to ensure a smooth supply of input since deliveries were unreliable. The factory soon found it could not afford the storage costs and wanted the Grain Bureau to help pay the cost of storage. The Grain Bureau said it couldn't and when the author asked if the certain area's storage allowance had been reduced, the answer was of course no. The author asked if this was because it was difficult to reduce a station's allowance (budget). The answer was yes. This example shows that there is at least some relationship between storage costs, i.e. when the grain is purchased, and station prosperity.

The Grain and Oil Commerce Company (henceforth simply the Company) calculates the cost of storage, transportation, bank interest, salaries etc., adds a profit rate, and then negotiates with the GMS on the amount which should be paid to the GMS for the costs incurred in handling both the GPP and MPP grain. This amount is credited to the GMS's account at the Agricultural Bank. While the Company is a monopoly buyer of MPP grain and GMSs have admitted that they make less money with this system as compared with before 1987, the two GMS directors interviewed replied that the negotiations with the

Company were fair and not too difficult. This reply may indicate that the GMSs have accepted their fate of having the state determine their costs, profits and salaries or perhaps they have a good relationship with the Company. Since the stations' director's negotiation skills and relationships essentially determine the prosperity of the station, the system is again open to corrupt practices.

The GMSs are given price ceilings for both GPP and MPP grain, based on quality and variety, which is the maximum amount the state will pay them as included in the costs calculated by the Company. The GMS can offer a higher price for the MPP grain but if it is greater than the price the Company has set, the difference still comes out of their profit in the final tally for payment from the Company. Jingmen once increased its MPP grain price but when Jiangling realized it was losing MPP grain to Jingmen and complained, the Provincial Grain Bureau forced Jingmen to lower its price again. While some officials believe farmers can still sell their grain privately to factories (but not middlemen) and therefore still feel they are in competition with the factories and other outlets, this selling seems to be against the law according to the new regulations. It appears more the case that farmers must accept the price offered to them by the GMSs or use it themselves. Only time will tell if this policy and the prices it encompasses can be flexible enough to promote MPP grain production, but we have already seen that the commercial grain collected in 1987 was 14.6% less than the .59 mt. the Grain Bureau expected to collect in 1987. The large amount kept on the farm in 1987 may be an indication that farmers knew about the impending policy change or were already influenced by the monopoly powers of the Grain and Oil Commerce Company and so decided to store more and/or feed more to animals.

Some families have one parent who is classified as agricultural and therefore has some land to farm while the other parent is urban and has grain ration coupons. Such families have, in the past, been able to save up their monthly grain ration coupons because they had their own grain production to consume. With the advent of a new policy, which went hand-in-hand with the other policies in 1988, these families are no longer able to use their coupons in the following months and their saved ones from the past months are now useless. Now they often use all their coupons to purchase grain at the government grain sale store rather than eating their own grain so purchases of government subsidized grain have likely increased. This new pattern of purchasing also means there will be less processing done at the local level and more in the state system at larger processing facilities. This policy change, enacted in 1988, stopped profit taking by these individuals and the merchants they often sold to. Profits were large when buying at .3 ¥ per kilogram at the state store and then selling it in some place like <u>Guangzhou</u>

(Canton) for 4 ¥ per kilogram. GMSs themselves were previously involved in this interprovincial trading. If this family lived in Jiangling, they would get approximately 1.4 ¥ per kilogram for their paddy rice (2 ¥ per kilogram processed) at the MPP grain price and could purchase processed rice for .6-.65 ¥ per kilogram at the state store. The amount of money that can be earned this way is likely less than the profit taken by speculators prior to 1988 but it is quite likely that a much larger amount of grain will have to flow through the commercial grain system and this is going to cost the government money which it was not spending before. There will be greater amounts transported to the processing facilities and back again to the consumer and more processing to be done at the larger factories. Presumably, the larger processing facilities will be able to process the grain at a lower per unit cost and there will thus be some savings here but it is unlikely that these savings will be greater than the increased costs of transport. In the light of this evidence and the likelihood of more commercial grain to be handled because of the forced exit of grain traders, the government should perhaps reevaluate its intended reduction of the Grain Bureau's budget for the transportation and storage of grain, especially if it does not want to change the current grain flow network to a new one.

Summarizing, there are seven impacts from the purchasing system which are envisioned: (1) The possibility of greater misuse of power, (2) farmers will keep more commercial grain on the farm for feed and in storage, (3) purchases of government subsidized grain in rural areas will increase, (4) less processing will be done at the local level and thus more in the state system at larger processing facilities, (5) state grain transport costs will increase, (6) the Grain Bureau will have difficulty remaining within its reduced budget, (7) this difficulty will result in cost cutting which may limit the Grain Bureau's ability to run the system in an efficient manner. Impacts 6 and 7 can likely be avoided if the Grain Bureau would manage the grain flows as outlined in chapter 4.

GRAIN HANDLING RESPONSIBILITY SYSTEM

The visit to Shayang was made most interesting by the explanation of the responsibility system it practices in conjunction with other components of the storage and transportation system. This section describes this system and presents suggested solutions for some of the problems the author identified in the grain handling responsibility system.

After receiving the state plan the station further refines the collection, transportation and distribution plan according to its own circumstances. The buyers, sellers and transporters are assembled and a contract with specific responsibilities is set up. The typical contract states that the driver of a truck must have an information card which states the quality of the grain and type, the number of bags, and whether the bags are new, old, or have a hole (3 classes). Both the seller (usually a purchase station) and the driver sign the card and the driver thus becomes responsible. The goods are re-inspected on delivery and the card is matched against the goods delivered.

When the TS takes bags out of store to load a boat, each bag's characteristics must be agreed upon before the person transporting the bag(s) accepts the bag. The visual characteristics (such as grade of the bag, quality of the seal and wetness) having been met, the transporter accepts a token (a bamboo stick) for each bag which is then transferred to the boat transporter and then again to a person who is collecting the sticks presumably to return to the TS. This procedure was not observed at Shayang but was at Jiangling's Shashi TS. Labourers taking bags off a wagon and putting them on a conveyor belt, a distance of about three meters, made no inspection of bags although another person was inspecting them (and allowed a bad one through by mistake). Perhaps the confusion of having so many people in the small area contributed to the inspector missing the bad bag of grain. Three people distributing, collecting and storing the sticks in this small area made it somewhat difficult for the labourers to load the mechanical conveyor belt which takes the grain to the boat and it was suggested that they have greater flexibility in the use of the system for cases as observed at Jiangling's Shashi TS.

The boat must meet certain specifications as set out by the station since the station, even during boat transport, is responsible for the grain moisture, quality class, casing and overall weight. This is a major problem in the system. Only if the boat sinks is the boat company responsible for the grain it carries. The boat's hold must have a cover, be without holes in the floor, and have no suspicious smells. A boat the author inspected in Shashi seemed to have holes in the floor although there could have been another layer of planking below the one observed. Since there are some arguments about the grain characteristics on delivery the procedure for closing the ships holds was discussed and it was suggested that the ships holds be locked in such a way as to prevent tampering with the shipment enroute. With this system there could be no question of who was responsible for a shipment, it was suggested. After some lengthy discussion which was at times tense, it was admitted that there was absolutely no way to make the boat company responsible for anything that happened to the locks or to the shipment. If this is the case, it might also make the stevedores care less about the condition of the boat (for example, whether it has holes or not) since an indifferent attitude might arise towards quality assurance if their efforts are always stymied by careless or dishonest boat operators. It is suggested that something be done immediately to correct this lack of a responsibility system in the shipping industry.

The boat transportation company in turn requires all boats of less than 400 tonnes to be loaded in one day and those under 1000 tonnes to be loaded within two days. The data in table 3 (see page 62) show that this feature may be influencing the size of ships used. Both the shipments to Nantong and Shanghai from SYTS are multiples of 400 and Hao Xue TS also had a shipment to Shanghai which was a multiple of 400. Given the distance involved and the prospect of a lower per unit cost of transport if larger ships are used, this observation should be further investigated to see if this policy is indeed influencing the size of ships used. The boat will arrive before the scheduled loading day as per the monthly transportation plan given to it by the station. Since transport by a state boat company is cheaper, their boats are used when possible.

The issue of how to determine who and how much must be compensated was discussed briefly. The responsibility system previously described can generally identify who must be paid but the amount to be paid has been difficult to determine in the past. There is a state boat management agency, which is closely related to the Yangtze Shipping Company, which can unilaterally decide the above questions for barge shipments. In the case of disagreement between buyer and seller on the characteristics of the shipment, an expert from the selling TS will be sent to the delivery point to re-examine the grain and negotiate with the buyer. This person will be sent within 7 days of receiving the telegram from the buyer.[69] The fact that this boat management agency has such arbitration powers may explain why the shipping companies cannot be made responsible for losses. However, such an agency would surely have the effect of reducing the responses time below 7 days. Again, if there was a better responsibility system which applied to state barge companies, the number of times an enterprise would have to be in negotiation would likely decrease.

An accident enroute by truck can also be envisioned. While the transportation company and/or the driver is responsible, most of the responsibility is delegated to the driver. The consequences for the driver can be quite serious not least of which is the fine he will have to pay (which will be determined by his ability to pay and the severity of the accident). Truck drivers, on the other hand, receive wages in excess of most people (approximately 200-1,500 ¥ per month with 500 ¥ being about average) although they often work longer hours. According to a survey of 67 households in Jiangling, the annual income per grain producer was 1,661 ¥ while that for a worker in transportation was 3,202 ¥.[70]

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[69] Gan Xuhui and Xiong Guisheng, Director and Party Secretary respectively, Shashi TS of Jiangling County, Shashi, Hubei. 29 March, 1989.

[70] Niu Ruofeng, "China's Grain Production Toward 2000", <u>China's Rural Development Miracle - With International Comparisons</u>, John W. Longworth, Editor, University of Queensland Press, 1989, Pages 196-207.

Perhaps because of this accident risk and the long working hours these wages are acceptable but there are many who consider this situation unjust. Apparently, a major reason for the high wages of drivers is that their three year contracts used fixed prices for fuel costs but the rates they could charge for goods increased with the cost of this input. The state criterion for the first 20 kms. was .2 ¥ per tkm. five years ago, higher than the current prevailing criterion, so the rate increases must be those for non-state goods only. This type of contract will obviously change in the future and officials admitted that they were not far-sighted enough when the contracts were implemented. This is partially due to the new experience of inflation.

It is by no means easy to get a licence to drive in China and it is easy to limit the number of people who can get a licence just by refusing them access to a vehicle. Drivers are in general the most arrogant of the working class in China and enjoy a lot of power. In 1988 the government passed a regulation that stipulated only one person can be allowed to drive a particular car. Thus it seems that the drivers of China will retain their extraordinary amount of power and will be able to continue to demand high wages and, perhaps, avoid large settlements in cases of accident. At work units in China, it is not uncommon for drivers to simply refuse to drive. There is definitely a lack of competition which is needed to increase service quality and labour productivity.

It was also mentioned that the rule of thumb is, if there is a disagreement over the amount which should be dispersed, payments or services are simply withheld until the matter is resolved.

In summary, the suggested solutions for problems in the responsibility system for grain handling are: (1) that they have greater flexibility in the use of the system of transferring responsibility (bamboo sticks) so as not to congest barge loading areas, (2) that a responsibility system be formulated for the shipping companies, so that the ships holds can be locked in such a way as to prevent tampering with the shipment enroute and so that responsibility for the shipment can be determined, thus reducing negotiation effort and losses, (3) there should be further investigations to determine if the policy toward demurrage allowances is influencing the size of ships used for shipments, as now seems the case, (4) greater research efforts should go into devising driver contracts, and (5) greater competition for driving positions should be introduced so that service quality and labour efficiency can be enhanced.

GOVERNMENT ESTABLISHED MARKETING COSTS

All participants in the system have state goals for marketing costs which are their responsibility to accomplish. Some of these goals will be discussed in this section in terms of their possible economic impacts. Inspection of the allowances also provides some indication of where the greatest marketing costs are occurring and thus may indicate where costs can be reduced.

Most grain comes into transfer stations by truck except perhaps some very local production which is transported by the ubiquitous walking tractor. The Grain Bureau's transportation company is allowed, under state criterion, to charge the station .198 yuan per tonne-kilometre (tkm.) for the first twenty kms. and ten percent is added for distances over 20 kms. It is because of this ceiling price they are forced to adhere to that 33% of transportation companies in China are losing money, according to Jingmen Transportation Company. In 1989 this criterion had been lifted in Jiangling to .25 ¥ per tkm. after five years at a rate of .2 ¥ per tkm. It appears from this example that state criteria are not very flexible in the medium term and have not been able to adjust to changing market conditions.

The Grain Bureau reported that all costs are below the state criteria and it appears that the government feels that the criteria represent the maximum a task should cost. It is not clear if there is any financial incentive for performing the task at a cost less than the criterion but there are economic implications for a system of charges where it is known that the cost will be paid. Work slowdowns may occur, and costs may be inflated to reach the criterion so as to forestall budget cuts and/or allow embezzlement of funds. On the other hand, if the criteria represent the true cost or lower than the true cost, the criteria will give enterprises an incentive to lower costs since criticisms will ensue if state targets are repeatedly unachieved.

A number of state criteria were given on the maximum amount of money which can be attributed to different handling tasks according to whether the unloading is done in the city (where labour is more expensive) or in the rural areas. The former is referred to as a "class one port" while the rural port is "class two." These cost criteria are illustrated in table 29. One can judge for themselves if these costs are in line with labour costs, which are about .5 ¥ per man-hour. Jingmen claimed they could load a boxcar for only .85 ¥, .13 ¥ below the state criterion of .98 ¥. This shows that they are at least concerned about reducing costs. The author was told it takes 12.5 man-hours to load a boxcar (about 10 tonnes). The state allowance would therefore be .0784 ¥ per man-hour, which is an impossibly low wage. I was told all state allowances are met everywhere in Jingmen but it appears from the above labour cost that the state criteria, which are mostly based on the cost of labour, are not in line with the current wage structure in China. It is difficult to understand

TABLE 29

MAXIMUM COST OF HANDLING TASKS BY STATE CRITERION
AT CLASS ONE AND CLASS TWO PORTS
(Yuan Per Tonne)

1. load or unload a truck (includes cleaning stacking, covering and bundling) <50 meters		.98	(.91)
2. Move grain from one WH to another <30 meters		.70	
3. Move grain from one WH to another greater than 30 m. but less than 300 m. add:		.28 per meter	
4. Empty the bag		.28	(.21)
5. Processing:	of rice (grade no. 2)	9.00	
	of wheat	27.00	
6. Fill bag and seal it		.77	
7. Transport back to the WH (as in no. 1)		.98	(.91)
8. Stack bags from a floor position:	6 bags high	.28	(.21)
	: 6-12 layers	.42	
9. Load train from less than 30 meters distance		.98	(.91)
10. Load boat from less than 50 meters distance		1.96	(1.68)

Source: Gu Cheng Jian, Interview by author, translated by Zhang Xing Bo, Jingmen Grain Bureau, Jingmen, Hubei, P.R.C., 1 November 1988.

Note: Class one costs are followed by class two (in parentheses) only if class two is different from class one.

Note: WH is "warehouse".

how these state criteria could be accomplished if labour costs are about .5 ¥ per man-hour.

All TSs are class 1 ports. Since both GMSs and all other purchasing stations are class two ports, it would seem likely that the GMS has some advantages in handling grain more inexpensively but in any case would likely be different. The author wonders whether there should perhaps be four classes of ports: one for the smaller purchasing stations and one more for large city ports. While labour costs may not be different between the GMS and the smaller stations, it is likely different between small and large cities.

The scenario of one tonne of rice being delivered to JTS from twenty kms. away would result in 17.93 ¥ of value added and 50% of the value would be processing and 22% of it would be truck transport. The cost of processing, while being somewhat low,[71] is at least realistic. The author is more interested in the cost of filling and sealing bags (.77 ¥ per tonne) since this relates to the savings which might be made from moving to a bulk handling system. Bags are often emptied into warehouses in the countryside to enable a greater amount to be stored inside. This means that the grain must be put into a bag at least twice. It also costs 1.31 ¥ per tonne to cover and uncover an outdoor warehouse. Jingmen has about half

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[71]See FAO, Rice Marketing, FAO Marketing Guide no. 6, Rome, 1972, Page 64, for costs of processing in the 1960s in some developing countries. The actual cost in Taiwan was reported to be below $3.50 U.S.

its storage outside (.27 mt.) which also tends to be in bulk form. Some of the savings which might be made from moving to a bulk handling system can therefore be estimated. The total cost that could be saved from not having to bag grain a second time would be 423,500 ¥ for Jingmen's .55 mt. of storage capacity. This money would cover the cost of building 19,430 tonnes of indoor storage.[72] The covering cost could be reduced by 353,700 ¥ if the .27 mt. of out door storage could be stored inside. JTS is currently set up to receive bulk shipments and thus it is suggested that the Grain Bureau make some further studies to determine if this facility can be used as a trial for bulk handling.

There are also grain losses that should be included in handling costs. The Grain Bureau considers six types of losses: transferring from bulk to bag, drying, loss of soil and dust when turning over the bag, loading/unloading, rats, and natural breathing of the grain. It is obvious that not all these would be considered losses in the way others might classify losses. Breathing of grain would seem to mean the same thing as drying. According to state criteria as explained below, the loss rate for grain that has been in storage for less than half a year is a maximum .65% and a minimum .3% depending on the length of the collection and distribution hauls and on the mode used for distribution. These can be

[72]Costs of building various forms of storage on a per tonne storage capacity basis were given to the author. The cost here is 40 ¥ per tonne, the lowest construction cost.

determined from the data described below. Using the state set price of .60 ¥ per kilogram for rice, this is equivalent to 3.90 ¥ and 1.8 ¥ per tonne for the maximum and minimum respectively. Including the cost of losses would bring the total cost to about 22.55 ¥ per tonne. The loss rate is .1% for the first half year and increase by .05% for every half year more that the grain is in storage to a maximum of .3%. The criteria are especially interesting for losses in transport. Allowances do not consider the type of vehicle used. Road transport is .1% for less than 20 kms. and .25% thereafter. The railways are allowed .1% for the first 50 km., .25% from 50-1000 kms. and .3% thereafter. Boats are allowed .1% no matter what distance because of the belief that the grain does not lose its moisture content using this form of transportation and thus losses will be lower. One person stated that the loss in water transport is perhaps .5% but that 2.5% of the grain is delivered at a lower quality because of exposure to water.[73]

It is clear that such aggregated classifications could bias economic haul distances since, for example, the difference in allowances for road transport might result in deliveries to TSs which are further than 20 kms. away to take advantage of the greater allowance although there may be a closer TS which could be delivered to. The .15% difference in

[73]Professor Ju, Wuhan Grain Industry Institute, Wuhan, 9 January 1989.

the allowance would allow a station delivering 30,000 tonnes a year to save 2.7 million Yuan worth of grain at the price of .6 ¥ per kilogram. Similarly, rail shipments may focus on distances just slightly greater than 1000 kms. The criteria likely represent a very low loss rate although they claim Jingmen does better than the criteria.

Given the cursory assessment of the possible economic impacts of the state cost criteria, the following conclusions are postulated: (1) state criteria are not very flexible in the medium term and have not been able to adjust to changing market conditions and thus are unable to reflect actual costs, (2) there are possible problems which are inherent in the system when it is known that the marketing costs will be paid, (3) there should perhaps be four classes of ports: one for the smaller purchasing stations and one more for large city ports, so that the marketing costs can more adequately reflect local conditions, (4) Given the cost of bagging grain and storing grain outside, the Grain Bureau should make further investigations to determine if conversion to a bulk handling system might allow funds to be released for warehouse construction, and (5) aggregated classifications of transport loss allowances could bias economic haul distances.

CHAPTER 6

SUMMARY AND CONCLUSIONS

SUMMARY

China has recently discovered that reform in agriculture has not given enough attention to the post-production process. Moving grain from surplus to deficit points has become a problem with the increased surpluses that have occurred in some areas. This study attempted to analyze the economics of grain transportation in China by investigating the Grain Bureau management system in a small area of China, Jingmen City (a former county). Jingmen City is an important grain surplus area in China. The study focuses on the economics of grain flow management as it occurred in 1987, and projected for 1990. In addition, some institutional constraints to efficient transportation and marketing are identified and discussed.

The grain flow network was primarily analyzed using a linear programming transportation-transsshipment model. This model was used to determine the optimal grain flow network for 1987 under various alternative assumptions and to determine the network in 1990 given the estimated surplus available and estimated demands in that year. The existence of an overburdened railway system has led to the need for examining alternative routes such as roads and rivers to carry goods. Towards this objective, the model was rerun with the addition of a road route which was expected to result in grain being re-routed through a water route rather than a railway route. The output of the model is also used to estimate the cost of empty truck hauls through an analysis of the trucking company run by the Grain Bureau, and to determine the effect on system flows of a dual rate structure for barge shipments.

CONCLUSIONS

Several conclusions can be drawn from analyses of the various results. The more important are listed below.

(1) the quantity of surplus grain that will have to be transported in 1990 will increase by 59% over 1987 given current estimated trends in population, demography, grain yields and cultivated grain area;

(2) the current networking of flows is not an optimal one in terms of a least cost criterion;

(3) the rescheduling of collections and distributions could have saved the Grain Bureau, not including costs for empty hauls, 612,149 ¥ in 1987 (a 16.2% reduction in system costs), and would save them 3.2 million Yuan (in 1987 Yuan) by the end of 1990, _ceteris paribus_;

(4) Pressure can be taken off the railway system, and the viability of the Shashi transfer station can be ensured, if a 10 km. long road is made available in southwest Jingmen;

(5) the dual rate structure for barge shipments is not biasing flows away from the most economic routes;

(6) the possible cost saving for empty hauls in 1987 was 368,929 ¥ (a 20.1% reduction in cost for the flows modelled in the linear programming model) and thus the possible cost savings by 1990, assuming a 59% increase in costs for full and empty hauls, would be 5.1 million Yuan (1.7 million Canadian Dollars), ceteris paribus, or a 17.5% reduction in system cost;

(7) rigidities in the system of management, and policies affecting the marketing and transportation system, are inhibiting the efficient operation of the system.

Analysis of the current and optimal networks show that the majority of additional costs arise because of the use of SSTS and JTS to transfer grain to Wuhan. The author can only speculate why this is the case. It may be because the number of barges available on the Han-Shui River is not sufficient for greater flows from SYTS and the lack of barges may be due to the more attractive back-haul opportunities which exist on the Yangtze River. The depth of the river should not be a too great of a problem since rice harvests occur during or after the summer rains. Storage capacity, although currently for long term use, is not a constraint. It does not appear that there are any major physical barriers to greater throughput at this station and therefore the author suggests that SYTS be allotted a greater share in the government plan.

STUDY LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The first limitation of this study is that the use of a linear programming model results in only a "picture" of a single year. The model is static and assumes that all other sectors of the economy remain constant during the period of study. Consequently, it is very difficult to forecast using this type of model. If predictions are to be made using the model, then they must also assume that the general economic conditions present in 1987 continue to prevail. While this continuation is unlikely in the milieu of China's reform experiments, the results of this study remain valuable.

The greatest limitation of this study is that a number of difficulties in securing accurate data resulted in the imposition of certain assumptions. These assumptions sometimes detract from reality but the estimates are believed to be realistic, assuming that the data used has not been falsified nor translated incorrectly. In particular, the study does not take into account grain moved through the MPP grain channel.

The inclusion of this grain in future models is necessary and it should be relatively easy to include now that the government has complete control over these movements. It was also assumed that all deliveries to the transfer stations were of processed rice and that the quantity entering the transfer station was therefore the same as the quantity leaving. Forecasted savings presuppose that the pattern of flows would continue through to 1990. The study does not consider the effect of the new railway which will run between Jingmen City and Jiangling County in the near future. It seemed odd to the author that this railway parallels the new highway between these points, thus duplicating services.

Another limitation is that it cannot be determined if there is a true desire to attack the problems outlined herein. Chinese society is very complex and decisions require a great deal of input from a substantial number of personalities. The author has now realized that any study of a Chinese system requires complex analysis of the people themselves. The lack of a human behavior analysis is a limitation of this thesis.

There are a number of areas for further research which can make use of the linear programming model, but it is suggested that if changes to the system are to be contemplated, then a more complete model should be built which includes both the MPP grain and the cost of handling grain at the transfer stations (assuming standardized data collection exists at the transfer stations). A revised model would be more appropriate for guiding policy and management decisions. This study utilizes rates which are apparently not based on the real cost of transport. Cost data exist at Jingmen Transportation Company and it would be useful to rerun the model with these costs. An analysis using real costs would show the extent of subsidization caused by use of the state criterion rates. One official estimated that grain sent to northwest China carried a transport subsidy of two Yuan per kilogram. Dynamic programming is also an option for further research but the author feels that the current accounting practices and data collection techniques should be refined and standardized before such complicated mathematical programming is carried out.

The fluctuations in the proportion of agricultural and urban population is of interest if planners wish to estimate future supplies of commercial grain. The wide fluctuations in this proportion and the reason(s) for it should be investigated. Anecdotal evidence suggests that Jinan Township in Jiangling had a population increase from approximately 30,000 to 50,000 from 1986 to 1988 because certain officials were allowing friends from the more distant rural areas to migrate to this township, which is next to the prefecture capital. This phenomenon was severely hampering the township's ability to meet the state quota for grain delivery since they had to provide grain for these people. Such migration patterns need to be investigated.

The author attempted to bring a systems approach to this research but many aspects of the system have been left out due to lack of space. It is hoped that the reader now has at least a cursory knowledge of how the grain transportation system works in China.

The research found herein has many uses, each with different degrees of value. From a personal standpoint, the author has learned a great deal about China, Chinese people, information gathering in China and conducting development projects. To me, this research has been of immense significance. To China, and particularly the people of Jingmen, this research, while representing a birth in the area, still needs to be groomed before it can exhibit its real value. To researchers and those interested in China, it provides the basis for provoking greater thought on an area of study which has been relatively untouched by either foreigners or Chinese. The thesis is proof that foreigners and Chinese can work together in sensitive domains to produce meaningful results. If the data is correct and there is the political will to implement the suggestions, there is a lot of money that can be released for other projects. Unfortunately, there is no room in the academic exercise of a thesis to relate emotional accounts or experiences of a more general nature. These are not in the thesis and will remain with the author.

APPENDIX 1

NAMES OF PLACES CORRESPONDING TO NUMBER DESIGNATES IN THE LINEAR PROGRAMMING MODEL

STATION NUMBER	NAME
1	Xian Ju
2	Yan Chi
3	Li Xi
4	Shi Qiao Yi
5	Zi Ling
6	Yan Dun
7	Tuan Lin
8	unavailable
9	Cao Chang
10	Wu Li
11	Shi Li Pu
12	Shi Qiao
13	Zeng Ji
14	Cai Miao
15	Ma Cheng
16	Shen Ji
17	Yan Gou
18	Mao Li
19	Guan Dang
20	Ma Liang
21	Li Shi
22	Hou Gang
23	Si Fang Pu

APPENDIX 2

PEOPLE AND PLACES VISITED FOR DATA GATHERING PURPOSES (IN CHRONOLOGICAL ORDER)

*Gu Wenyi, Wuhan Grain Bureau, Wuhan, Hubei Province, P.R. of China. Position: Manager of the Storage and Transportation Division. 25 October, 1988.

*Shashi Transfer Station of Jingmen Grain Bureau, Shashi City, Hubei Province. 30 October, 1988.

*Gu Chingjian, Vice-Director of the Storage and Transportation Department of Jingmen Grain Bureau, Jingmen City, Hubei Province. 1 November, 1988.

*Huang Puyuan, Director, Jingmen Transfer Station, Jingmen. 2 November, 1988.

*Guang Dacheng and Liu Daoshun, Directors, Jingmen High Density Feed Factory. 3 November, 1988.

*Hu Zhengguo, Director, Shenji Grain Management Station. 4 November, 1988.

*Liu Jiayu, Director, Ma Cheng Grain Purchasing Station. Ma Cheng Township, Jingmen. 4 November, 1988.

*Shayang Grain Processing Factory (no specific representative), 5 November 1988.

*Li Dehuai and Li Weizhou, Factory Director and GMS Director respectively, Hou Gang Rice Milling Factory. 7 November, 1988.

*Liu Guangxi and Ju Ren, Wu Li GMS Directors. 8 November, 1988.

*Du Zhuolong, Director, Jingmen Grain Bureau's Transportation Company. 9 November, 1988.

*Fan Weixue, Secretary and Director, Shayang Transfer Station, Shayang, Jingmen. 10 November, 1988.

*Professor Ju, Wuhan Grain Industry Institute, Wuhan. 9 January 1989.

*Yu Changzhou, Vice Director, Jiangling County Grain Bureau, Jiangling County, Jingzhou Prefecture, Hubei. 23 March, 1989.

*Li Weizhou and Long Xuesheng, Director and Vice Director, Jinan GMS, Jinan Township, Jingzhou County, Hubei. 24 March, 1989.

*Liu Zuxing, Vice Director, Guan Yingdang GMS, Guan Yingdang, Jingzhou County, Hubei. 25 March, 1989.

*Lu Ruitao and Li Huanghe, Director and Vice Director, Hao Xue Transfer Station, Hao Xue, Jingzhou County, Hubei. 27 March, 1989.

*Hou Shijun, Ba Lingshan GMS, Jingzhou County, Hubei. 28 March, 1989.

*Gan Xuhui and Xiong Guisheng, Director and Party Secretary respectively, Shashi TS, Shashi, Hubei. 29 March, 1989.

*Zheng Changbing and Shi Changbing, Director and dispatcher respectively, Jingzhou Grain Bureau Transportation Company. 30 March, 1989.

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