The impact of transportation rates on the location of western flour mills

by William Allen Nelson

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

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The purpose of this study was to analyze the transportation sector of the United States wheat flour economy, highlighting Montana. A linear programming transportation model was used to explore the impact of changing transportation rates for wheat and flour on milling location and regional wheat demand. The impact of higher wheat export demand, and growing western population was also reviewed.

The study incorporates the three major wheat classifications, winter, spring, and durum. An interative process was utilized to incorporate the effect of size economies present in the milling process.

The research supports three principal conclusions. First, differential rates for wheat and flour transportation influence the regional orientation of flour milling. Secondly, western population growth does not appear to shift the orientation of milling, and lastly, growth in the export demand for wheat increases milling activity at interior milling locations.

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A thesis submitted in partial fulfillment
of the requirements for the degree

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ABSTRACT

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Chapter 1

INTRODUCTION AND OBJECTIVES

The purpose of this thesis is to analyze the transportation sector of the Western United States wheat-flour economy, highlighting Montana. The principal analytical tool of this study, the transportation model of linear programming will be used to analyze the flow of grain and milled products. Studying the wheat-flour transportation sector is important for two reasons.

First, transportation has become increasingly important in milling location decisions. Instability in world energy markets can have large impacts on the costs of transportation services. Highly variable transportation rates alter producer prices and shift the location of milling plants. Simultaneously, increased uncertainty is introduced into the agricultural and milling processes. Research that contributes to the evolving theory of "production under uncertainty" benefits both the miller and the producer as well as the public at large. This thesis reviews transportation response to short-run instability.

The second reason that the study performed in this thesis is important is that the results are useful for policy purposes. Transportation rates are a controversial subject. Confrontations between producers, transportation firms, and government are common, and it appears they will continue in the future.

The objectives of the thesis are:

A) To describe the western United States wheat-flour economy in a linear programming transportation model that incorporates the three major wheat classifications (winter, spring, durum).

B) To analyze the sensitivity of regional flour milling location and regional wheat demand to wheat and flour transportation costs.

C) To analyze the impact of increased wheat export demand, domestic consumption, and milling capacity on milling location and regional wheat demand.

The following section outlines the Montana wheat-flour economy and provides a brief history of the U.S. milling industry.

Background

Montana's climate, soils, and topography render an environment ideal for the production of high quality hard wheat. The flat and rolling lands of the north central and eastern portions of the State are well suited for modern mechanized wheat production. These lands, consisting of well drained loams and clays lie at relatively high elevations. Average annual moisture measures twelve to eighteen inches and during the growing season, days are warm and arid, and nights are cool. These attributes are the foundation of Montana's potential as a wheat producer.

Montana wheat statistics date back to 1873 when the State's farmers harvested 220,000 bushels of wheat from 11,000 acres. Production has grown steadily. Before the turn of the century, in 1891, the harvest exceeded one million bushels. The Montana harvest first topped the 100 million bushel mark in 1953, in subsequent years this mark has been eclipsed 13 times. The 1975 and 1976 harvests notched back to back production records with harvests of 155 and 167 million bushels [21].

Production of all types of wheat in Montana averaged over 122 million bushels during the 1970's, consistently ranking the State among the top five of the nation's wheat producing states. At the present time winter wheat accounts for roughly fifty-nine percent of the Montana crop, spring and durum account for thirty-six percent and five percent respectively. Wheat is grown throughout the State, however the northeast corner of the State and the northcentral region outlined by a triangle connecting Great Falls, Havre, and Shelby account for about seventy percent of a typical Montana wheat harvest [21].

Extensive storage and transportation systems have helped Montana realize its potential as a wheat producing area. Farm to market roads, railroads, on farm and commercial elevators are examples of the physical apparatus supporting production. In addition to these, organizations such as USDA, Cooperative Extension Service, and State Universities provide a network of services ranging from crop insurance and information dissemination to basic research.

The principal intermediary of the wheat-flour economy is the milling industry. Milling operations in Montana are centered in Billings and Great Falls. A Peavey Company mill is located in Billings; General Mills and Con Agra Corporations house operations in Great Falls. The combined capacity of in state mills totals 14,000 hundredweight of flour daily. Given this capacity, the annual wheat requirements of Montana millers may reach eleven million bushels. Table 1.1 provides a summary of the three Montana milling operations.

The eleven Western states of interest in this study[1] have a pooled daily capacity of 157,200 hundredweight [20]. The top milling states are California and Utah. Idaho, Nevada, and Wyoming have no major milling operations. Table 1.2 lists milling capacity by states.

History

Traditionally, industries display one of three location orientations with respect to their markets and resources; (a) resource-oriented, (b) market-oriented, (c) intermediate-point-oriented. The wheat-flour economy provides an illustration of these orientations. Wheat production is resource-oriented because land is a relatively

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[1] The states included in the study are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Table 1.1. Flour Milling in Montana

	Peavey Billings*	General Mills Great Falls*	Con Agra Great Falls*
Milling Capacity	5,000 cwt/day	3,800 cwt/day	5,200 cwt/day
Wheat Storage	310,000 bu.	1,500,000 bu.	1,000,000 bu.
Products	Baker Flour Family Flour Whole Wheat Flour	Baker Flour Family Flour Durum Flour	Baker Flour
Marketing	50% In State 50% Out of State	50% In State 50% Out of State	30% In State 70% Out of State

*Thesis survey of western mills.

Table 1.2. Western U.S. Flour Milling

	Number of Mills[1]	Total Milling Capacity*[2]
1) Arizona	1	1,000
2) California	9	46,950
3) Colorado	3	17,200
4) Idaho	0	--
5) Montana	3	14,000
6) Nevada	0	--
7) New Mexico	2	650
8) Oregon	3	19,700
9) Utah	10	31,420
10) Washington	4	27,250
11) Wyoming	0	--

*cwt flour per day.

[1]Milling and Baking News.

[2]Thesis survey of western mills.

immobile resource. The perishable nature of baked goods necessitate the baking industry's market-orientation. Milling has typically been intermediate-oriented.

The proclivity for milling to shift closer to either a market or resource orientation is a function of the everchanging equation of population changes, transportation advantage, and lower power costs. The position of the location equation impacts farming decisions and income. The brief history section which follows, provides an insight into the location equation.

Flour milling in the young American Colonies for the most part was a cottage industry. Steadily growing population, an influx of capital, and pilfered European technology stimulated the growth of specialized industries. Flour milling was among the first activities to be removed from the household.

Milling centers were clustered around large population centers that afforded water transportation for incoming wheat and outgoing flour. Early milling centers included New York, Philadelphia, and Baltimore. Later, Richmond and Rochester also became important milling centers. Eighteenth century mills were small. In 1750 the largest flour mills ground 100,000 bushels of grain annually, this translates to a daily flour production of 1,000 pounds.

In 1790 Oliver Evans introduced screw conveyors and bucket elevators that moved grain and flour horizontally and vertically without human labor. Evans then combined his innovations with sifters and bolters in the first continuous, uninterrupted flour milling process.

The new process reduced labor requirements and total costs, however cheap water power became more important in the milling location equation. Mills that converted to the continuous process found that optimal mill output was twenty to forty percent greater than under the previous process.

The six decades spanning 1800 to 1860 were a period of vast changes in the United States. The area of the present continental U.S. was consolidated; railroad, canal, and all weather highway construction boomed; population grew from slightly more than five million in 1800, to the 1860 count of 31,443,321 [7]. The productivity of innovations in the plow, reaper, and thrasher were also demonstrated during this period. Even with all the changes of this period the wheat-flour economy, for the most part, remained unchanged. Mills were small, located near a source of water power and close to communities where their flour could be sold. The new urban centers of Chicago and St. Louis emerged as flour milling centers. The development of these cities as milling centers did not reflect a fundamental change in the wheat-flour economy but rather a growing population in the midwest.

The combined effect of inventions in agricultural production and flour manufacturing after 1860 changed the location of both wheat production and flour milling. Harvest time was an important constraint on western wheat production in the 1800's; the invention of the "Marsh Harvester" and John F. Appleby's "twine binder" more than doubled the speed of harvesting. Inventions in flour manufacture were LaCroix's "middlings purifier" and the substitution of rollers for stones in grinding. These changes allowed high quality flour to be economically milled from the hard spring wheats grown in the Dakota, Minnesota, and Montana Prairies.

In 1860, more than half of the U.S. wheat crop was still grown east of the Mississippi River. As a result of the innovations in agriculture and manufacturing, western wheat production more than doubled in the following decade, while production in the Middle Atlantic states increased only 15%. This trend continued, and by 1939 five western states: Kansas, North Dakota, Oklahoma, Montana, and Washington raised half the U.S. wheat [7]. Flour mills in 1939 were no longer strictly bound to water power; milling capacity had increased five fold and large mills were located close to production areas and shipped flour to several communities.

The orientation of the flour milling industry began to shift from a resource orientation toward a market orientation in the early 1950's. The introduction of large hopper cars and unit trains for transporting wheat led to increased competition between trucks, barges, and railroads. This competition resulted in greater reductions in the transportation rates for wheat than for flour. The differential rates contributed to the flour milling industries movement toward a market orientation throughout the nineteen-fifties, sixties, and early seventies.

The most profound change in the wheat-flour economy is the increasing scale of milling operations. In 1870 more than twenty-seven thousand mills serviced the demands of thirty million Americans. Today 70 firms operate 200 flour mills serving more than two hundred fifteen million consumers [7,20].

Transportation

Transportation regulation is a variable that is often overlooked when considering the milling location equation. Transportation regulation impacts the wheat-flour economy because it affects transportation rates and the availability of transportation services.

Agricultural groups in the midwest and western U.S. had long regarded the railroads longhaul-shorthaul and rebate pricing practices as unfair. Discontent among farmers led to the formation of several agricultural action groups, the most notable being the "Granger movement." The Granger organizations in Illinois, Minnesota, Iowa and Wisconsin waged fierce battles with the railroads from 1869 to 1875.

The activities of the Grange moved many state legislatures to limit railroad practices perceived as unfair. In 1869 Illinois passed an act to limit railroads to "just, reasonable and uniform rates." The Illinois constitution passed in 1870 ordered the legislature to "pass laws to correct abuses and to prevent unjust discrimination and extortion in the rates of freight and passenger tariffs."

Several other midwest states enacted legislation to regulate railroads and grain elevators in the 1870's and 80's. Railroads and elevator companies vigorously opposed the new legislation in a series of court battles. For the most part the courts struck down attempts by individual states to regulate railroads and grain elevators.

The Federal Government took up the regulation issue in 1872 when President Grant appointed a committee to study the issue. The Interstate Commerce Act was the federal government's first attempt at regulation; the act was passed in 1887. The second major act, the Sherman Antitrust Act was passed in 1890. The Interstate Commerce Act was ineffective; by 1905 the Commission responsible for carrying out the legislative mandate had only one ruling upheld out of sixteen appealed to the U.S. Supreme Court. Passage of the Hepburn Act of 1906 enhanced the Interstate Commerce Commission's ability to identify and prosecute violators.

The United States Congress continued to pursue the regulatory cause into the twentieth century. By 1950 all forms of transportation enterprise were regulated.

Procedure

The thesis will proceed in four parts. First, the literature review covers major works in the linear programming-transportation model area, and reviews recent applications of these models. Second, chapter three develops the model and data used in the thesis. Third, chapter four presents results. Finally, chapter five presents the conclusions and discusses the implications of the study.

Chapter 2

REVIEW OF THE LITERATURE

Chapter 2 discusses the algorithm used in the thesis, and cites previous authors who have done work under the rubric of "transportation linear programming." The chapter is divided into three sections. Section I is a review of the linear programming algorithm. Section II traces the early application of LP to agricultural transportation problems. Section III discusses recent work in the transshipment rubric, and some of the problems encountered.

Linear Programming

Linear programming is strictly a mathematical technique. Like other forms of mathematics, linear programming has no economic content. The linear programming process however, can be used to find the economic implications in information we already have, or are willing to draw from the body of economic theory.

The transportation model, a subset of linear programming, in its simplest form specifies a commodity, surplus and deficit points, unit costs for transferring the commodity, and a market clearing equilibrium. The need for a programming solution to transportation problems arises from the inherant nature of these problems. Standard calculus (marginal) techniques breakdown because of the need to specify precise levels for some variables, and less restrictive minimum or maximum levels for other variables. This breakdown of marginal techniques can be illustrated by a simple example (figure 2.1) presented by William Baumol [3]. Marginal analysis finds the point of maximum profits by locating the point at which marginal profit equals zero (output $\overline{OQ_m}$ in the figure). It is clear that when the output constraint (labeled C in the figure) is imposed, the first-order conditions of marginal analysis cannot be met. That is, at the constrained optimum point ($\overline{OQ_i}$ in the figure), the marginal criterion, marginal profit equals the slope of the total profit curve equals zero, is invalid.

Linear programming provides a mathematical method for determining the optimal solution for systems that cannot be solved with calculus. The linear programming algorithm uses an iterative procedure, which is a systematic trial-and-error process, that compares various routes in a way that guarantees that each trial will yield values closer than the preceeding one to the correct answer.

Early Transportation Work

The linear programming problem was first formulated by the Russian mathematician L. V. Kantorovich. The work of George Dantzig resulted in the first successful computational technique, the simplex method. The first effective transportation problem solution procedure was also developed by Dantzig [5]. Dorfman, Samuelson, and Solow described the process by which a transportation problem could be transformed

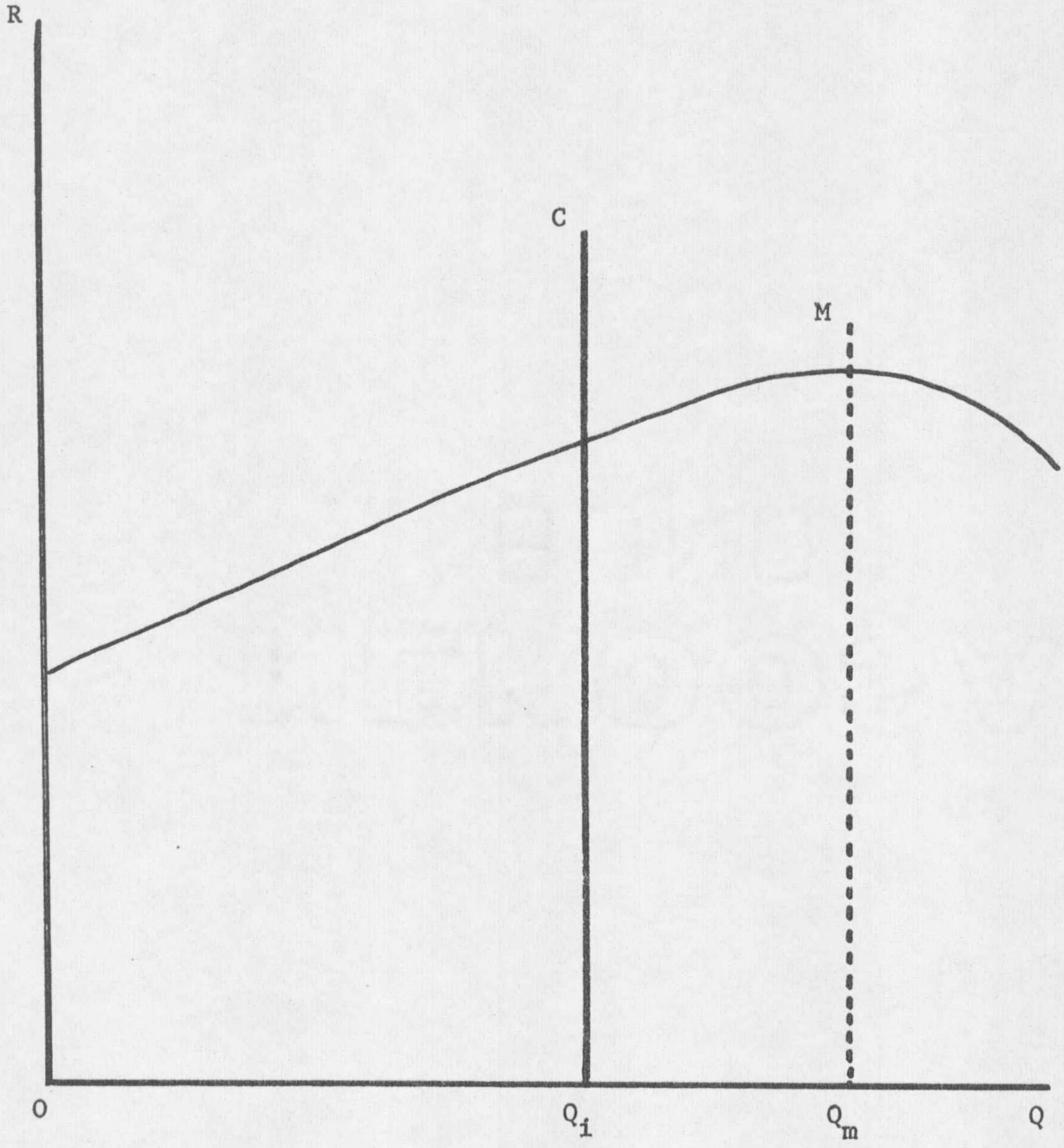


Figure 2.1. The Breakdown of Calculus (Marginal) Techniques in Constrained Problems.

into a general linear programming problem [6]. The combination of improved computational capabilities and the transformation to a general linear programming technique have produced a functional problem solving tool.

Orden [24] developed the transshipment model from an original transportation model set down by Koopmans in 1947 [16]. The transshipment formulation of the transportation problem provided a more efficient, easily managed algorithm suitable for small problems. Research by Stollstiemer [26] led to his development of a model for optimal plant numbers and locations. Practical applications for the Stollstiemer model were limited. The model did not permit simultaneous consideration of assembly, processing, and distribution costs. Also, only a single raw material could be considered in the optimal solution.

Judge, Havlicek, and Rizek [10] formulated a multiregion, multiproduct, and multiplant problem in a general linear programming framework. The Judge, et al. model was considered an improvement because it could handle additional constraints on regional processing centers simultaneously.

King and Logan [11] introduced a model to determine the optimum location, number and size or processing plants for the California cattle slaughtering industry. The transshipment algorithm presented by King and Long for the first time incorporated an iterative process to analyze the impact of ecnomies of size.

Hurt and Tramel also presented a transportation problem in the form of a general linear programming system. The Hurt and Tramel system was capable of optimizing problems with several levels of processing, more than one plant level, and multiple final products. The Hurt and Tramol algorithm provided a sufficiently general form, suitable for application to a wide range of problems both in and out of agriculture.

Recent Research

Recent work in grain transportation has reviewed the impact on grain flows of transportation deregulation, branch line abandonment, and grain transportation by unit train. The base model for most recent work was developed by Ladd and Lifferth [17]. The Ladd and Lifferth transshipment model is an extention of the Stollsteimer model, the model utilizes a heuristic procedure to estimate the optimal grain distribution system. Ladd and Lifferth used their model to determine the optimal number, size, and location of grain storage and handling facilities for a 6½ county area of Iowa. A similar study, focused on the Boissevain region of Canada, was performed by Tyrchniewicz and Tosterud [27]. The Tyrchniewicz and Tosterud model was a one-period analysis and dealt with only one grain, the principal advantages of the Ladd and Lifferth model were its multiple time periods and simultaneous treatment of several grains.

Many studies have been based on the Ladd and Lifferth model. Baumel, et al. [2] used the model to evaluate grain distribution in Iowa under multiple-car rate structures. Baumel also used a modified version of the model to evaluate the economic effects of branch rail line abandonment on the Iowa grain industry. Anderson et al., [1] used the same transshipment model to optimize grain distribution under an alternative multiple-car rate structure in Nebraska.

Wright [33] used a transshipment model developed by Leath and Martin [18] to analyze the national wheat-flour economy. Wright's research focused on the optimal location of milling in the United States. The principal limitation of the Wright study is its treatment of wheat as homogeneous commodity.

Several previous grain transportation studies have focused on Montana. The first of three major studies was undertaken by Copeland and Cramer [4]. Copeland and Cramer used a transshipment model to estimate the optimal number, size, and location of grain elevators in Montana. Results of the study indicated fewer, but larger elevators would minimize transportation, storage, and handling costs.

A 1975 study by Koo and Cramer [15] used a mathematical programming model to analyze the movement patterns of Montana grain under alternative truck-barge and rail rate structures. Koo and Cramer also analyzed shipment patterns of U.S. wheat under alternative export demand situations and under alternative transportation rate structures [14].

Koo and Cox [13] projected future quantities of Montana grain production and surplus grain that would require transportation services. The 1978 study did not incorporate detailed transportation modeling, but utilized projections based on previous trends to estimate future demand and supply.

Summary

This literature review has pursued three topics. First, a historical background and development of linear programming was presented. The second topic was a documentation of the development of the present transportation linear programming algorithm. The final section presented recent research involving transportation in Montana and at the national level.

The remainder of this thesis develops the data and model used in the study and presents results, implications and limitations. The works of other authors, outlined in this literature review, provide the basis and justification for the model.

Chapter 3

MODEL AND DATA DESCRIPTION

Chapter 3 is divided into four sections. The first section presents a discussion of the linear programming transportation model used in the thesis. A small sample model is presented, and the large model used to obtain the final results is described. The computer package that is utilized is also mentioned. Section two describes the geographical regions that define areas of production, milling, consumption and export. The third section details sources, assumptions and processes used in collecting and deriving the data used in the thesis. The final section describes the various models used to meet the objectives of the thesis.

The Model

The principal objective of the thesis is the analysis of the interaction between transportation rates for wheat and flour and the location of the flour milling industry. The formulation of a linear programming system is required to analyze the potential impact of changes in wheat and flour transportation costs on milling location. The system also requires that wheat production levels, milling capacity, milling cost, export demand, and consumption demand be specified.

The model used is an extension of the Stollstremer [26] linear programming transportation algorithm. The model's objective row contains transportation costs related to the movement of grain and flour, and flour milling costs. Inequality constraints are specified for wheat supply regions, milling regions, export centers, and consumption areas. The wheat supply and milling region constraints specify maximum available supplies of wheat, and flour milling capacities. Wheat is separated by winter, spring, and durum classifications. This separation of wheat types is maintained throughout the system for both wheat and flour. The export and consumption constraints require minimum levels of wheat and flour that must be shipped to consumption, and export demand centers. Additional "transfer" equality constraints are used to insure that grain and flour move through the model in a logical manner. The transfer constraints are necessary to prevent the system from minimizing costs by shipping negative quantities of wheat and flour, or creating additional supplies at an intermediate milling location. Table 3.1 shows the model in generalized tableau form.

Table 3.2 shows a small sample problem with three wheat supply areas, two milling centers, two export centers, and two final consumption points. The sample model has two wheat types, winter and spring. The movement of wheat and flour through the small sample

Table 3.1. General Tableau Form

Objective Row	Production to Milling Transportation Rates	Production to Export Transportation Rates	Milling Costs	Milling to Consumption Transportation Rates	Right Hand Side Values = 0
Producing Regions	Production to Milling Counter	Production to Export Counter			Production Levels
Milling			Mill Capacity Counter		Milling Capacity Levels
Export		Export Quantity Counter			Export Demand Levels
Consumption				Consumption Quantity Counter	Consumption Demand Levels
Milling Transfer	Production to Milling Transfer		Production to Milling Transfer		0
Consumption Transfer			Milling to Consumption Transfer	Milling to Consumption Transfer	0

Table 3.2. Sample Model

	P^{1*}_1	P^1_2	P^2_1	P^2_2	P^3_1	P^3_2	P^4_1	P^4_2	P^5_1	P^5_2	E^{1*}_1	E^1_2	E^2_1	E^2_2	E^3_1	E^3_2	E^4_1	E^4_2	E^5_1	E^5_2	L^{1*}_1	L^1_2	L^2_1	L^2_2	$D^{1\#}_1$	D^1_2	D^2_1	D^2_2	D^3_1	D^3_2	D^4_1	D^4_2	Right Hand Side
Objective Row	2	3	2	3	4	5	4	5	7	1	4	3	4	3	5	2	5	2	4	2	1	2	1	3	6	3	6	3	5	2	5	2	=0
Winter Wheat Supply #1	1	1									1	1																					$\le$ 100
Spring Wheat Supply #2			1	1									1	1																			$\le$ 100
Winter Wheat Supply #3					1	1									1	1																	$\le$ 100
Spring Wheat Supply #4							1	1									1	1															$\le$ 100
Winter Wheat Supply #5									1	1									1	1													$\le$ 100
Mill Capacity #1																					1	1											$\le$ 200
Mill Capacity #2																							1	1									$\le$ 200
Winter Wheat Export #1											1				1				1														$\ge$ 30
Spring Wheat Export #2													1				1																$\ge$ 30
Winter Wheat Export #3												1				1				1													$\ge$ 30
Winter Wheat Export #4														1				1															$\ge$ 30
Winter Flour Consumption #1																									1				1				$\ge$ 40
Spring Flour Consumption #2																											1				1		$\ge$ 40
Winter Flour Consumption #3																										1				1			$\ge$ 40
Spring Flour Consumption #4																												1				1	$\ge$ 40
Milling Transfers	1				1				1												1												= 0
Milling Transfers		1				1				1													1										= 0
Milling Transfers				1					1													1											= 0
Milling Transfers																								1									= 0
Consumption Transfers																					1				1	1							= 0
Consumption Transfers																						1					1	1					= 0
Consumption Transfers																							1						1	1			= 0
Consumption Transfers																								1							1	1	= 0

#Mill; to Consumption $i = D^1_j$

*Production i to Milling j - P^i_j

Production i to Export j - E^i_j

*Mill Location i, Product j L^i_j

system (Table 3.2) is identical to the large system used in the thesis with the exception of an additional wheat classification, durum wheat.

The large model has one-thousand-four-hundred-sixty-three activities (columns), and one-hundred-ninty-eight constraints (rows). The objective row contains one-thousand-four-hundred-twenty-one transportation costs and fourty-two milling costs. Forty-nine wheat production areas are used; twenty-two winter, seventeen spring and ten durum. Western mills are grouped into 14 milling centers, and export ports are grouped into three areas; pacific, gulf, and lakes. Each export center has a separate constraint specified for each of the three wheat classifications used in the thesis; winter, spring, and durum. The final forty-two inequality constraints specify consumption of winter, spring, and durum flour products for each of the fourteen consumption areas. Eighty-four additional "transfer" constraints are also used in the large model.

The computer package "Modular In-Core Nonlinear Optimization System" (MINOS) [22] was used to calculate the optimal solution for the various specifications of the large model. The primary advantages of the MINOS algorithm are its large problem capabilities and an easily operated restart procedure.

Regional Demarcation

The first section of this chapter briefly introduced the concept of regional demarcation when production, export, milling, and consumption regions were mentioned. The division of the study area into subregions allows examination of the spatial interaction between transportation rates, other exogenous variables, and the wheat-flour economy.

The degree, or size, that an area is broken down to depends on several factors. First, the objective of the study to a large extent determines the number and size of subregions. A second consideration is the availability of relevant data. The computational feasibility of the problem is a third significant factor in determining the number and size of subregions.

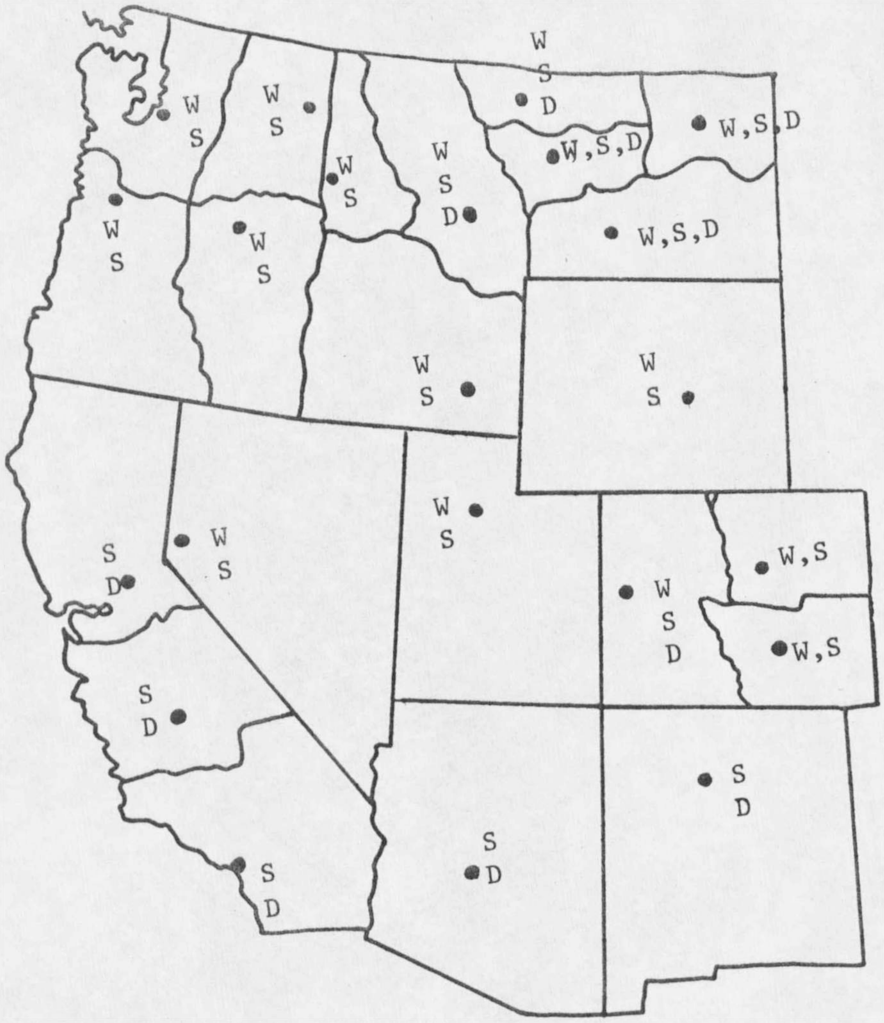
In general, the theoretical process used in determining the level of regional demarcation is similar to a general linear programming problem. The size dictated by the goals and objectives of the study can be viewed as the objective function of the problem. The limiting constraints are the availability of data and the computational feasibility of the various options. Obviously, as the number of regions increases, the precision of the study is enhanced. Simultaneously the computational difficulty increases and data becomes more difficult to acquire. The principal constraint limiting regional demarcation in this thesis is the computational feasibility. The following paragraphs describe the regional demarcation used in the thesis.

Twenty-two wheat supply areas were identified. The study area was first divided into eleven regions, one for each state in the study area. Those states with large quantities of wheat production were then further divided to include from two to five subregions. Figure 3.1 displays the final regions and the assembly point for each region.

The transportation costs from all supply sources with-in any region to milling and export centers outside that region are assumed to be equal to those from the region's assembly point. This assumption is obviously invalid for a region like Utah where Salt Lake City is assumed to be the originating point for all of Utah's wheat production.

The objective of regional demarcation then is not one of eliminating all error, but rather minimizing error. The process described earlier, in which states with high production were divided into subregions attempts to minimize this error. Smaller subregions, like those in Montana, exhibit small differences between rates from the region's assigned assembly point and the actual originating point of production in the subregion. Because states with high production are divided into subregions, an inverse relationship exists between error in transportation costs and the quantity of wheat.

The addition of subregions in high production states minimizes



W - winter wheat
S - spring wheat
D - durum wheat

Figure 3.1 Production Regions.

error in actual transportation rates. The assignment of assembly points is also designed to minimize error.

Thirty-five flour mills are located in the eleven state study area. These mills are assigned to one of fourteen milling centers. Figure 3.2 shows the final milling demarcation.

With the exception of Utah, all mills included in a milling region are within thirty miles of the designated milling center. The Salt Lake City milling center represents mills up to two hundred miles away. The distant mills were included in the Salt Lake City region because of their small milling capacities. Eighty percent of the Salt Lake City milling region's capacity is within 20 miles of Salt Lake City.

Areas of consumption are developed in the same manner as were the production regions. Each state is designated as a consumption region, subregions are then designated in states with large populations in geographically distinct locations. Figure 3.3 shows the fourteen consumption regions used in the thesis.

The process used establishes two consumption regions in Washington, California, and Nevada, the other eight states can be adequately represented by a single location.

The final regional designations are for export facilities. Export ports are grouped into one of three general geographic areas:

Figure 3.2. Milling Centers

Figure 3.3. Consumption Regions

Great Lakes, Gulf of Mexico, and Pacific. No specific port is specified within the export region as the export center. Wheat, instead, is allowed to flow from the production region to the nearest port within the three export regions.

A final note on demarcation should be added. The eleven state study area is subject to injections and leakages of both flour and wheat to and from other areas of the U.S. and Canada. Fortunately, the amount of interaction between the study area, and other surrounding areas is minimal.

Significant quantities of wheat flow into the area from North and South Dakota. These shipments are primarily to Pacific Northwest ports. Other inflows of flour and wheat occur in Colorado, these shipments originate from the midwestern wheat states.

Leakages, outflows, are from Montana to Great Lakes export ports and from Colorado to Gulf ports and to flour mills in Kansas and Oklahoma. Data about interstate wheat flows was accumulated by Leath, et al. [19].

The Data

The following section describes the sources, assumptions, and processes used in collecting and deriving the data used in the thesis. The section procedes with a discussion of wheat supply, flour milling capacity, wheat exports, flour consumption, and finally transportation costs.

The analysis requires estimates of the quantities of wheat available at different geographical locations. The majority of wheat production is fixed because of climatic and geological conditions. Abnormal climatic conditions may substantially affect the geographical distribution of production from a single crop, but such incidents tend to cancel one another over longer periods.

Livestock and Crop Reporting Service [29] county estimates for winter, spring, and durum wheat production are used to derive production levels for the twenty-two production regions. Mean production levels for the six year period, 1974-1979, are calculated for each region. The mean production levels are used in the base model, these production levels are listed in Table 3.3.

Data about the flour milling industry come from two sources. First, a survey of the western United States mills was conducted in conjunction with this thesis. A second source of flour milling information is Milling and Baking News [20], a milling trade publication. The milling centers and their annual milling capacities are listed in Table 3.4.

As mentioned earlier, export ports are divided into three regions; Pacific, Gulf, and Great Lakes. Total wheat movement through each export region, by wheat type, was taken from U.S.D.A. export

Table 3.3. Regional Wheat Production

Production Region	Wheat Type	Bushels
1. Arizona	Winter	5,152,089
2.	Durum	9,129,911
3. Northern California	Winter	15,217,851
4.	Durum	1,175,219
5. Central California	Winter	20,380,426
6.	Durum	1,573,906
7. Southern California	Winter	14,286,502
8.	Durum	1,103,294
9. North East Colorado	Winter	45,006,396
10.	Spring	220,280
11. South East Colorado	Winter	9,707,134
12.	Spring	54,530
13. Western Colorado	Winter	4,393,419
14.	Spring	1,553,001
15. Northern Idaho	Winter	16,999,496
16.	Spring	1,742,231
17. Southern Idaho	Winter	20,241,318
18.	Spring	25,988,624
19. North East Montana	Winter	8,606,205
20.	Spring	27,165,893
21.	Durum	5,341,003
22. Southern Montana	Winter	12,315,271
23.	Spring	2,706,319
24.	Durum	182,448
25. North Central Montana	Winter	45,581,239
26.	Spring	16,640,183
27.	Durum	1,404,868
28. Central Montana	Winter	12,069,346
29.	Spring	2,502,181
30.	Durum	147,187
31. Western Montana	Winter	3,648,232
32.	Spring	1,099,801
33.	Durum	50,820
34. Nevada	Winter	861,000
35.	Spring	708,000
36. New Mexico	Winter	8,083,204
37.	Durum	249,996
38. Western Oregon	Winter	24,103,971
39.	Spring	2,095,997
40. Central and East Oregon	Winter	28,867,132
41.	Spring	2,510,186
42. Utah	Winter	5,368,505
43.	Spring	1,252,495
44. Eastern Washington	Winter	67,431,060
45.	Spring	7,492,340
46. Central and Southern Washington	Winter	47,399,940
47.	Spring	5,266,160
48. Wyoming	Winter	6,774,799
49.	Spring	568,201
		542,419,609

Table 3.4. Base Model Milling Capacities

	Milling Center	Capacity
1.	Arizona	452,034
2.	S.E. California	361,627
3.	S. California	14,261,673
4.	N. California	6,599,697
5.	W. Colorado	452,034
6.	E. Colorado	7,322,951
7.	S. Montana	2,260,170
8.	N. Montana	3,804,770
9.	New Mexico	293,822
10.	E. Oregon	2,802,612
11.	W. Oregon	6,102,458
12.	Utah	14,428,925
13.	W. Washington	6,893,518
14.	E. Washington	5,424,408

statistics [30]. The percentage of each export region's total shipments attributable to the eleven state study area was estimated. Estimates of export share were based on a national study of wheat movements by Leath, et al. [19].

The export demand levels used in the final model are derived by calculating the mean exports (1978-1980) for each export region, less the percentage of wheat not originating within the boundaries of the study area. The export demand estimates are listed in Table 3.5.

Domestic flour consumption is another component of the model. Patterns of per capita flour consumption are relatively stable over time [31]. Consequently, population is used to estimate the geographical distribution of flour consumption. The 1980 Census of Population and Housing [28] county population counts are summed to determine the consumption regions populations. Regional population is multiplied by per capita annual flour consumption (116 pounds [23]) to determine total wheat demand.

The final consumption demand levels used in the model separate the demand for products milled from winter, spring, and durum wheats. Most flours are actually milled from a combination of wheat types; however, in the aggregate no significant distortion is created by assuming flour is milled from a single wheat type. The percentage of flour demand attributed to each wheat type was assumed to be equal to the rate at which winter, spring, and durum wheats are used as inputs in the total wheat milling process. Table 3.6 shows the final consumption demand levels.

Several problems are encountered in the transportation rate area. First, large transportation models specify thousands of potential routes through which commodities may flow. Collecting and interpreting these rates is exceedingly difficult. Truck and barge rates tend not to be publicly available. Railroad rates, at best, are difficult to acquire. Frequent rate changes also compound the collection problem.

As a response to the cumbersome rate collection problem many transportation studies estimate transportation charges with cost or rate functions. A second problem is encountered here, large geographic area may exhibit highly variable degrees of competitiveness, and factors exogenous to the model may change costs in some areas.

The third, and most pervasive problem, affects studies dealing with the intermediate and long run. Simply put, the future is uncertain, precise projections of future transportation rates in most, if not all, instances will be inaccurate. The system used to establish transportation costs for the thesis attempts to minimize the forementioned problems.

The process for determining transportation costs was as follows.

Table 3.5. Base Model Export Demand

	Winter Wheat*	Spring Wheat*	Durum Wheat*
Great Lakes	51,000	205,200	267,600
Gulf	799,800	62,400	11,400
Pacific	154,349,400	41,541,600	4,734,000

*Hundredweights of wheat per year.

Table 3.6. Base Model Consumption Demand

		Winter	Spring	Durum
1.	Arizona	2,466,316	565,377	122,608
2.	S. California	12,174,295	2,790,828	605,219
3.	N. California	9,292,910	2,130,301	461,977
4.	Colorado	2,620,150	600,642	130,255
5.	Idaho	855,865	196,198	42,547
6.	Montana	713,522	163,567	35,471
7.	N. Nevada	273,686	62,740	13,606
8.	S. Nevada	451,168	103,425	22,429
9.	New Mexico	1,179,061	270,287	58,615
10.	Oregon	2,387,805	547,379	118,705
11.	Utah	1,325,150	303,776	65,877
12.	W. Washington	3,011,547	690,365	149,713
13.	E. Washington	737,480	168,372	36,513
14.	Wyoming	427,027	97,891	21,229

First, it was assumed that unit car rail transportation will become more dominant. Twenty-six car unit train rail road rates were used when available. If unit train rates were unavailable, converted single car rates were utilized. The single car rate was converted to a unit car rate by reducing the rate twenty percent.

Railroad rates, single and multiple car, were not available for some routes. Rates on these routes were estimated with a multiple car railroad rate function developed by Won Koo [15].

Rate = (1.164 X mileage) - (0.00035 X mileage^2) + regional factor. A sample of known rates was also estimated as a check on the reliability of the rate estimation function. Comparison of actual and estimated rates indicated that the function was yielding satisfactory estimates. The railroad mileages used in the function are from the Rand McNally Railroad Atlas of the United States [8].

Transportation by truck was used for routes, or portions of routes, without railroad service. Again, work by Koo [15] provided the basis for rate estimation. The truck cost function developed by Koo in 1979, was updated to reflect increased costs. The updated function for computing wheat transportation costs per trip is:

(1.320 X distance) + 11.34.

The iterative process used to analyze the economies of size in flour milling utilize three separate milling costs estimated by

Neirnberger et al. [23]. Neirnberger estimated costs ranging from $1.55 per hundredweight of flour for mills with less than 3,000 hundredweight. Capacity to $1.09 for mills with daily capacities over 7,000 hundredweight per day. Costs per hundredweight were estimated to be $1.25 for medium sized mills with 5,000 hundredweight capacity.

Base Model Adjustments

The model described throughout this chapter is the basic, or base, model. In order to meet the objectives of the study it was necessary to adjust the levels of several base model variables. Adjustments to the model can be grouped in six categories:

1. Higher flour transportation costs.
2. Higher wheat transportation costs.
3. Increased wheat export demand.
4. Increased domestic flour consumption.
5. Increased flour milling capacity.
6. Adjusted flour milling costs.

Twenty-two separate models are generated by adjusting one, or more, of the basic models seven variables.

Four adjusted models are created by increasing flour transportation rates alternatively by ten, twenty, forty, and one hundred percent. With the exception of higher flour transportation costs, these models are identical to the base model. Two other models utilize forty and one hundred percent higher flour rates combined with fifteen percent higher flour milling capacity, and unconstrained milling.

An additional six models are generated with higher wheat transportation costs. The higher wheat transportation cost models are constructed in the same manner as were the higher flour cost models.

Export demand for wheat is increased by ten and twenty percent in the two models used to analyze the impact of higher export demand. Two models have the base model levels for milling replaced with fifteen percent higher milling capacities and unconstrained milling. Size economies are analyzed in one model by adjusting milling costs.

The domestic consumption of flour is also adjusted. One model contains fifteen percent higher flour demand, another scales consumption by the region's percentage population growth during the period 1969 to 1979. The population growth percentages used for each region are listed in the Appendix.

Three models were developed to review scenarios of potential future activity in the wheat-flour economy. These models have adjusted levels for milling, exports, and consumption.

Summary

Chapter three presented the thesis model, explained the regional demarcation process and the data. The models used to obtain the final results were also mentioned.

Chapter four will present the results of the study, and the final chapter, five, will present the conclusions and discuss the implications of the thesis.

Chapter 4

EMPIRICAL RESULTS

In this fourth chapter the empirical results are presented. However, before introducing the results, a clarifying statement should be made. The thesis, and the models used, do not specify the optimal number of flour milling plants, or their optimal location and size. The thesis takes the existing market structure as given and then determines the optimal, least cost, flow of wheat and flour within the existing system. Results that indicate increased milling at particular milling centers do not necessarily guarantee new mills will, or even should be, built at that milling location.

Results generated by the base model are described by reviewing wheat production, wheat movements, flour milling, and flour movements as separate components.

The base model objective function is minimized at a cost of 284,152,646 dollars. The minimized objective function value reflects the costs of wheat transportation, exclusive of assembly costs, to both milling and export destinations. Milling costs and flour transportation costs to final market areas are also included. The cost of distributing flour within a consumption region is not included in the model.

Wheat production and slack, or storage are listed in Table 4.1.

Table 4.1 Wheat Demand - Base Model (flour cwt equivalents 1 cwt = 2.283 bu).

			Activity	Slack
1)	Arizona	(W)		
2)		(D)	1,851,988	1,851,988
3)	N. California	(W)		
4)		(D)		
5)	C. California	(W)		
6)		(D)		
7)	S. California	(W)		
8)		(D)		
9)	NE. Colorado	(W)	15,616,569	15,575,166
10)		(S)		
11)	SE. Colorado	(W)	5,824,280	5,824,280
12)		(S)		
13)	W. Colorado	(W)	2,636,051	2,636,051
14)		(S)		
15)	N. Idaho	(W)		
16)		(S)		
17)	S. Idaho	(W)	4,223,639	4,265,042
18)		(S)		
19)	NE. Montana	(W)	4,612,723	4,612,723
20)		(S)	7,109,982	6,960,986
21)		(D)	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,862,253
23)		(S)		
24)		(D)		
25)	NC. Montana	(W)		
26)		(S)		
27)		(D)	265,417	265,417
28)	C. Montana	(W)	4,528,056	4,528,056
29)		(S)		
30)		(D)		
31)	W. Montana	(W)		
32)		(S)		
33)		(D)		
34)	Nevada	(W)		
35)		(S)		
36)	New Mexico	(W)	2,850,122	2,850,122
37)		(D)	37,968	37,968
38)	W. Oregon	(W)		
39)		(S)		
40)	CE. Oregon	(W)		
41)		(S)		
42)	Utah	(W)		
43)		(S)		
44)	E. Washington	(W)		
45)		(S)		
46)	CS. Washington	(W)		
47)		(S)		
48)	Wyoming	(W)	3,564,880	3,564,880
49)		(S)	129,525	278,521

The majority of unused capacity is located in northeast Colorado, and northeast and southern Montana.

The interstate movements of wheat to milling and export are shown in Figures 4.1 and 4.2. The majority of the wheat used in the milling process is grown and milled in the same state. The most notable exceptions are the roughly 23 million bushels shipped from Idaho to Utah and Oregon mills and the one million bushels of durum wheat shipped from Montana to Washington and Utah mills.

The movement of wheat to export is a much larger activity. Washington leads all states in deliveries with over 120 million bushels moved to the Pacific ports. Montana and Oregon follow Washington with 80 million and 58 million bushels respectively. Wheat in Wyoming, Colorado and New Mexico move to the Gulf ports, northeastern Montana ships wheat to the Great Lakes ports.

Excess flour milling capacities are exhibited by half of the fourteen milling centers (southeastern California, eastern Colorado, northern Montana, New Mexico, western Oregon, western and eastern Oregon). Milling ranges from a high in Utah of 14 million cwts. of wheat annually to the low, in New Mexico, of 58 thousand cwts. Table 4.2 lists base model milling activity.

The transportation of flour is more complicated than are wheat movements to either export or milling. The quantities of flour shipped

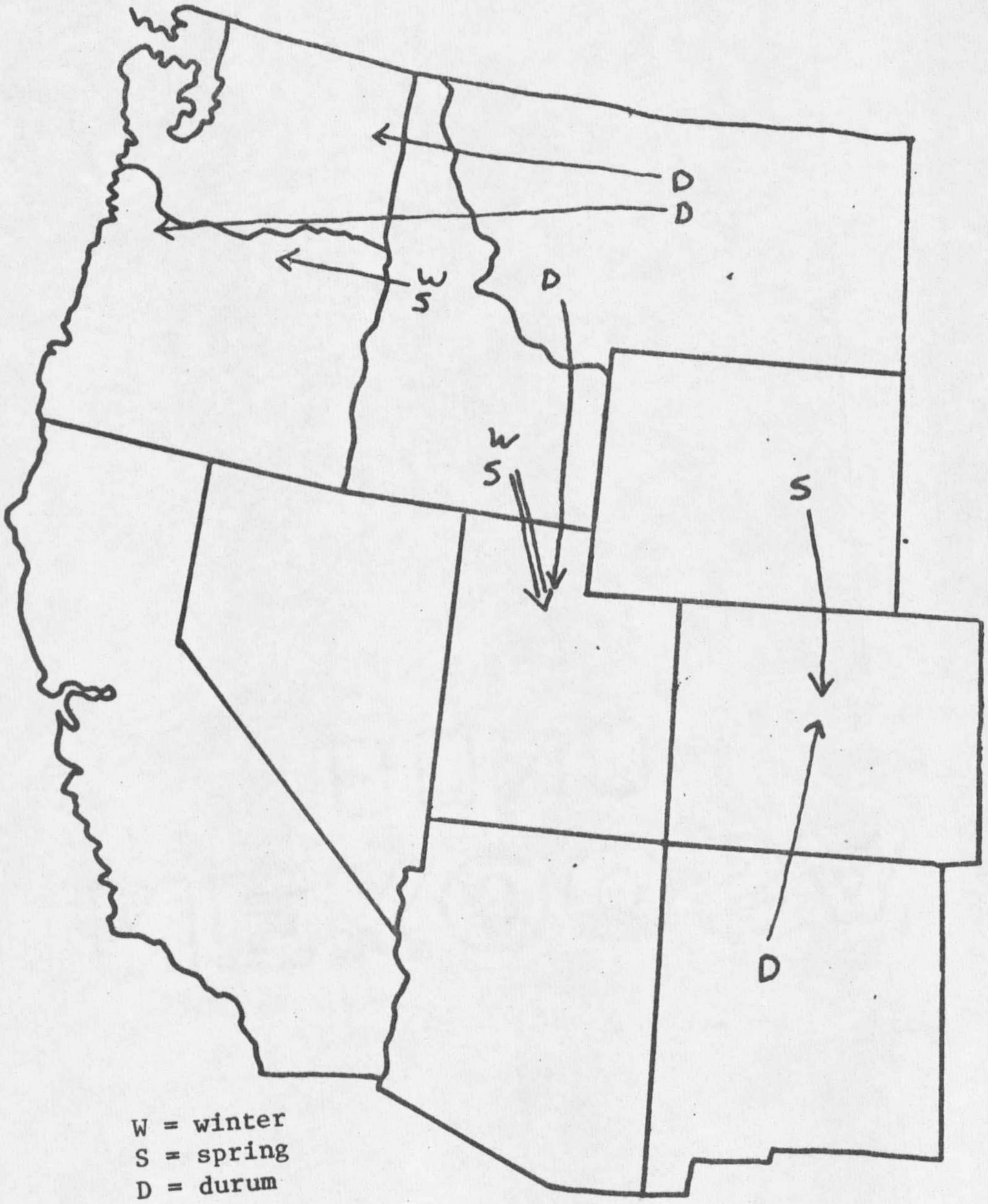


Figure 4.1. Wheat Production in Flour Milling.

Figure 4.2. Wheat Production to Export

Table 4-2. Increasing Flour Transportation Costs (cwt's milled)

		Base Model	20% Higher Flour Rates	40% Higher Flour Rates	40% Higher Flour Rates*	100% Higher Flour Rates*
1)	Arizona	452,034	452,034	452,034	3,204,573	3,193,173
2)	SE. California	361,627	361,627	361,627	15,592,771	15,592,771
3)	S. California	6,799,246	11,952,553	14,261,673	0	0
4)	N. California	6,599,697	6,599,697	6,599,697	11,898,794	11,898,794
5)	W. Colorado	452,034	452,034	452,034	3,351,047	3,351,047
6)	E. Colorado	7,222,933	6,771,765	6,771,765	1,449,348	1,449,348
7)	S. Montana	2,260,170	2,155,314	2,155,314	546,147	546,147
8)	N. Montana	1,966,217	935,019	935,019	912,590	912,590
9)	New Mexico	58,615	58,615	58,615	8,343	19,743
10)	E. Oregon	2,802,612	42,547	42,547	42,547	42,547
11)	W. Oregon	293,824	3,053,889	3,053,889	3,053,889	3,053,889
12)	Utah	14,428,925	10,862,840	8,553,720	3,637,885	3,637,885
13)	W. Washington	939,365	939,365	939,365	939,365	939,365
14)	E. Washington	3,851,625	3,851,625	3,851,625	3,851,625	3,851,625

*Unconstrained milling.

interstate are minimal with four exceptions. Utah mills ship over 12 million hundredweight of milled product to California, Idaho and Nevada. The eastern Colorado mills in Denver ship four and one-half million hundredweight to southern Nevada, Arizona, and New Mexico. Flour mills in Montana ship a total of 3,500,000 hundredweights to five locations: southern California, Idaho, southern Nevada, Wyoming, and Colorado. Figure 4.3 displays the flow of flour in the base model solution.

The principal objective of the study, analysis of the impact of changing relative transportation rates for wheat and flour on flour milling location, is pursued by changing transportation rates used in the base model. Four models are utilized to explore the effect of higher flour transportation costs. The first model increases flour transportation costs twenty percent. The twenty percent figure was chosen because it roughly equals the differential between single car and unit-train rail rates.[a/] This distinction assumes that possible future increases in unit-train wheat transportation will not be extended to flour transportation. A second model increases the base model transportation rates by forty percent. The forty percent level is an extension of potential future savings from economies captured by utilizing unit trains for transporting wheat. Two models were run using the forty percent higher flour rates. One features base model

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[a/] Computed from a selected sample set of rail rates.

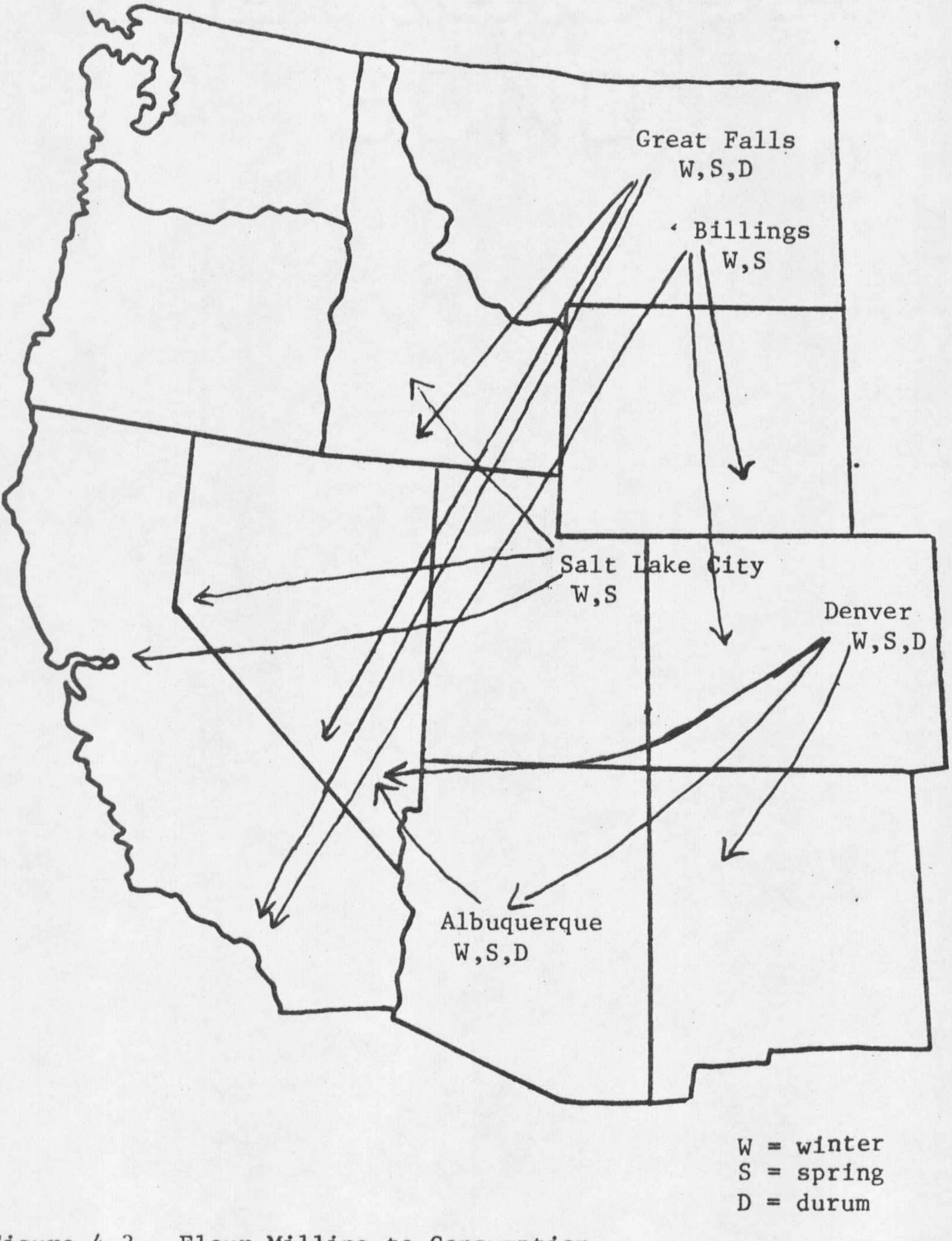

Figure 4.3. Flour Milling to Consumption

milling capacities, a second does not constrain the quantities of grain milled at the regional milling centers. The third set of transportation rates increases flour transportation one hundred percent, and leaves flour milling capacity unconstrained.

The results of increasing transportation costs for flour are listed in Table 4.2. The milling locations most sensitive to increasing flour transportation rates are Utah, eastern Oregon and northern Montana. Southern California and western Oregon show significant increases in milling under the twenty percent higher flour rate scenario. In general, the results are as expected, larger urban areas increase milling activity, rural wheat production locations demonstrate lower levels of milling.

The most notable changes occur at the southern California milling center. Smaller changes in transportation rates, twenty to forty percent, lead to higher levels of milling, however, when constraints on regional milling capacity are lifted, no flour is milled at the southern California (Los Angeles) milling center.

The effect of higher flour transportation rates on regional wheat demand is for the most part limited to very small changes. Northeast Colorado experiences higher demand for winter wheat, while demand falls for western Colorado winter wheat. Other changes in wheat demand are small, a complete listing of regional wheat demand under the various rate levels is located in the appendix.

The sensitivity of milling location to higher wheat transportation costs was analyzed in the same fashion as were higher flour transportation rates. Three levels of higher wheat transportation rates were used: twenty, forty, and one hundred percent. Again, the forty percent higher rate models utilized both constrained and unconstrained milling capacity, the one hundred percent model was also unconstrained at milling centers.

Results generated by the higher wheat transportation cost models indicate a movement of milling from the low-wheat production urban areas to more rural wheat production areas. Arizona, southeast California, eastern Colorado, southern and northern Montana display significant increases in milling while Washington and northern and southern California mills production falls. Table 4.3 shows the results from the higher wheat transportation cost models for milling location. The impact on regional wheat demand is again small, these results are listed in the appendix.

Three other components of the western wheat-flour economy were analyzed, higher milling capacity, increased flour consumption, and higher export demand.

Two special models were created to review the impact of increased regional milling capacity. The first model increases regional milling capacities fifteen percent over those used in the base model, a second, again identical to the base model, features unconstrained

Table 4.3. Increasing Wheat Transportation Costs

(cwt's milled)

	Base Model	20% Higher Wheat Rates	40% Higher Wheat Rates	40% higher Wheat Rates*	100% Higher Wheat Rates*
1) Arizona	452,034	452,034	452,034	2,669,968	4,375,707
2) SE. California	361,627	361,627	361,627	12,779,514	4,587,222
3) S. California	6,799,246	4,860,675	4,818,660	0	0
4) N. California	6,599,697	6,599,697	6,599,697	475,583	0
5) W. Colorado	452,034	452,034	452,034	3,351,047	730,897
6) E. Colorado	7,222,933	7,322,951	7,322,951	10,652,782	13,272,932
7) S. Montana	2,260,170	2,260,170	2,260,170	2,160,287	9,122,423
8) N. Montana	1,966,217	3,804,770	3,804,770	5,505,472	8,704,614
9) New Mexico	58,615	58,615	100,630	0	0
10) E. Oregon	2,802,612	2,802,612	2,463,018	42,547	42,547
11) W. Oregon	293,824	118,705	0	0	0
12) Utah	14,428,925	14,428,925	14,428,925	7,000,099	7,622,090
13) W. Washington	939,365	36,513	0	0	0
14) E. Washington	3,851,625	4,929,596	5,424,408	3,851,625	30,492

*Unconstrained milling.

regional milling activity.

The distribution of flour milling after adjusting milling capacities is shown in Table 4.4. The less restrictive constraints on milling reduce the objective function costs to $218,004,914 for the fifteen percent model and $271,812,211 with the unconstrained milling model. Reductions in the base model objective function attributed to the relaxed milling constraint are small, $600,000 with fifteen percent higher milling and $13,000,000 when milling capacity is unconstrained.

Increasing regional milling capacity results in significantly decreased milling at the southern California milling center, milling increases in northern California, eastern Colorado, and southern Montana. The impact on the Utah milling center is mixed, fifteen percent higher capacities leads to an increase of more than two million hundredweights, alternatively milling activity falls ten million hundredweights when milling in unconstrained.

Increasing and unconstrained milling boosts the quantity of wheat demanded in Montana and northeast Colorado. The quantity demanded falls in western Colorado and southern Idaho. The complete listing of regional wheat demands is in the appendix.

The prospect of future growth in western population, given constant per capita consumption, led to three models which analyze increased consumption of flour products. The first model increases

Table 4.4. Higher Milling Capacities

Milling Cap. =	cwts milled		
	Base Model	15% Higher Milling Capacity	Unconstrained Milling Capacity
1) Arizona	452,034	519,839	3,212,916
2) SE. California	361,627	415,871	14,832,122
3) S. California	6,799,246	3,983,493	0
4) N. California	6,599,697	7,589,651	11,583,560
5) W. Colorado	452,034	519,839	3,351,047
6) E. Colorado	7,222,933	7,155,128	1,449,348
7) S. Montana	2,260,170	2,599,196	546,147
8) N. Montana	1,966,217	1,166,602	912,590
9) New Mexico	58,615	58,615	0
10) E. Oregon	2,802,612	2,977,731	2,977,731
11) W. Oregon	293,824	118,705	118,705
12) Utah	14,428,925	16,593,264	4,713,768
13) W. Washington	939,365	36,513	939,365
14) E. Washington	3,851,625	4,754,477	3,851,625

demand in all consumption regions by twenty percent. A second model scales the consumption regions demand by a percentage equal to the rate of growth in population exhibited by the region during the period 1969 through 1979. The final model uses the trend growth approach in addition to fifteen percent higher regional flour milling.

Results obtained from runs involving higher consumption levels indicate growth in milling, greater than the percentage growth in consumption, at three locations. Milling activity doubles at the southern California and northern Montana milling centers, milling triples at the western Oregon center. Easing the milling capacity constraints shifts milling out of southern California and western Oregon and increases milling in northern Montana and Utah. Table 4.5 lists the complete milling location results, the effect in regional wheat demand is located in the appendix.

The final variable analyzed in the thesis is export demand. Two additional models were created in which the base model export levels were increased by ten and twenty percent. A third model was created by increasing regional milling capacity by fifteen percent in tandem with twenty percent higher export levels.

Higher export demand has a limited impact on the location of milling prior to the easing of the milling capacity constraints. Two million hundredweight of flour milling activity is transferred from the southern California center to northern Montana. Small increases also

Table 4.5. Increased Consumption

Consumption Level = Milling =	Base Model	20% Higher Consumption	cwts milled Trend Consumption	Trend Consumption*
1) Arizona	452,034	452,034	452,034	519,839
2) SE. California	361,627	361,627	361,627	415,871
3) S. California	6,799,246	12,745,764	14,261,673	9,604,600
4) N. California	6,599,697	6,599,697	6,599,697	7,589,651
5) W. Colorado	452,034	452,034	452,034	519,839
6) E. Colorado	7,222,933	7,322,951	7,322,951	8,421,394
7) S. Montana	2,260,170	2,260,170	2,260,170	2,599,196
8) N. Montana	1,966,217	3,804,770	3,804,770	4,375,486
9) New Mexico	58,615	293,822	293,822	233,302
10) E. Oregon	2,802,612	2,802,612	2,802,612	3,223,004
11) W. Oregon	293,824	913,003	1,704,682	649,551
12) Utah	14,428,925	14,428,925	14,428,925	16,593,264
13) W. Washington	939,365	1,127,238	1,127,238	1,127,238
14) E. Washington	3,851,625	4,621,950	4,621,950	4,621,950

*15% higher milling capacities.

occur at the eastern Colorado and eastern Washington milling centers.

After the milling capacity constraint is eased a large scale shift occurs, in general, milling shifts from those centers closest to export ports to those most distant. The results from increased export demand are contained in Table 4.6.

The impact of higher export demand on regional wheat demand is as expected. Montana, Colorado, and New Mexico production regions experience sharp increases in demand, while demand remains relatively constant at other locations. The regional wheat demand results are in the appendix.

As a final addition to the thesis three models were developed combining several adjusted variables. These models attempt to combine variables in a way that may reflect future changes in transportation rates, export demand, consumption demand, and milling capacity.

The first model, Projection Model 1, utilized equal rates for flour and wheat transportation, export demand increases ten percent, milling capacity fifteen percent and regional consumption increases twenty percent. Percentage changes refer to increases over levels used in the base model.

Projection Model 2 adjusts the consumption demand levels used in the first projection model. Model 2 contains regional consumption levels increased over base model levels by the percentage growth rate of the region's population during the 1970's. The final

Table 4.6. Increased Export Demand (cwt's milled)

		Base Model	10% Higher Exports	20% Higher Exports	20% Higher Exports*
1)	Arizona	452,034	452,034	452,034	519,839
2)	SE. California	361,627	361,627	361,627	415,871
3)	S. California	6,799,246	4,860,675	4,860,675	189,348
4)	N. California	6,599,697	6,599,697	6,599,697	7,589,651
5)	W. Colorado	452,034	452,034	452,034	519,839
6)	E. Colorado	7,222,933	7,322,951	7,322,951	8,421,394
7)	S. Montana	2,260,170	2,260,170	2,260,170	2,599,196
8)	N. Montana	1,966,217	3,804,770	3,804,770	4,375,486
9)	New Mexico	58,615	58,615	58,615	58,615
10)	E. Oregon	2,802,612	2,802,612	2,802,612	2,977,731
11)	W. Oregon	293,824	293,824	293,824	118,705
12)	Utah	14,428,925	14,428,925	14,428,925	16,593,264
13)	W. Washington	939,365	36,513	770,993	258,360
14)	E. Washington	3,851,625	4,754,477	4,019,997	3,851,625

*15% higher milling capacities.

projection model, number three, has ten percent higher export demand, fifteen percent higher milling capacities and trend growth in flour consumption. Transportation rates for flour are increased by twenty percent in Model Three.

The results obtained from the three projection models are listed in Table 4.7. Regional milling capacity remains relatively constant with two notable exceptions, southern California and eastern Oregon. Milling in southern California increases significantly in all three models, under the assumptions of Model Three milling activity more than doubles. Milling in eastern Oregon increases slightly in Models One and Two and then drops to near zero in Model Three.

The appendix contains a listing of regional wheat demand in the three projection models.

Summary

Chapter 4 has presented the results of the models developed in the study. The final chapter, Chapter 5, will discuss the limitations and implications of the study and present the conclusions.

Table 4-7. Future Scenarios (cwts milled)

		Base	Projection Model 1	Projection Model 2	Projection Model 3
1)	Arizona	452,034	519,839	519,839	519,839
2)	SE. California	361,627	415,871	415,871	415,871
3)	S. California	6,799,246	7,616,916	9,604,600	15,227,590
4)	N. California	6,599,697	7,589,651	7,589,651	7,589,651
5)	W. Colorado	452,034	519,839	519,839	519,839
6)	E. Colorado	7,222,933	8,421,394	8,421,394	8,421,394
7)	S. Montana	2,260,170	2,599,196	2,599,196	2,599,196
8)	N. Montana	1,966,217	4,375,486	4,375,486	1,098,220
9)	New Mexico	58,615	70,338	233,302	337,895
10)	E. Oregon	2,802,612	3,223,004	3,223,004	55,194
11)	W. Oregon	293,824	492,611	3,817,361	649,551
12)	Utah	14,428,925	16,593,264	16,593,264	14,142,947
13)	W. Washington	939,365	245,862	925,192	1,127,238
14)	E. Washington	3,851,625	5,503,326	4,823,996	4,621,950

Chapter 5

IMPLICATIONS AND CONCLUSIONS

In this final chapter, three topics are covered. First, the objectives of the thesis and the methodology used to meet these objectives is presented. Second, the limitations of the study are discussed. Finally, the implications and conclusions drawn from the study are presented.

The thesis objectives were:

A) To describe the western United States wheat-flour economy in a linear programming transportation model that incorporates the three major wheat classifications (winter, spring, durum).

B) To analyze the sensitivity of regional flour milling location and regional wheat demand to wheat and flour transportation costs.

C) To analyze the impact of increased wheat export demand, domestic consumption, and milling capacity on milling location and regional wheat demand.

Objective A was met by establishing regions of production, export, milling, and consumption for the western United States study area. Data was collected and derived from a number of sources. The incorporation of the three basic wheat types was maintained throughout the system.

The solution algorithm utilized was a general linear programming system with additional "transfer" constraints. The algorithm did not have integer capabilities, therefore economies of size were incorporated by utilizing an iterative process.

The second objective (B) required the creation of eight additional models. These models contained three levels of transportation costs, and in some instances adjusted flour milling capacities. The adjusted models analyzed the impact of potential future changes in actual transportation rates.

The final objective, C, was met by generating models with adjusted levels for export demand, domestic consumption, and milling capacity. Three additional models were created to analyze the interaction of the variables when all of the model's variables were adjusted.

Limitations

Evaluation of the results obtained in this thesis and their implications for different sectors of the wheat-flour economy should be considered in light of the study's limitations. The limitations of the study can be grouped into two areas, problem definition and computational feasibility.

The basic model does not deal with two characteristics of the wheat flour economy. First, milling wheat produces joint products, flour and millfeed. The model used in this study considers only flour. Millfeed, a bulky low value product, represents 25 percent of milling output measured by volume. Given that the geographical location of the feed industry is not the same as population, a large degree of error may be present.

Second, transportation routes and systems have finite capacities, no constraints were placed on the various routes of this study. Transportation problems encountered in Colorado and Montana are well publicized, the extent to which the absence of transportation constraint would reorient milling or production is uncertain.

Finally, the model used in this study does not accurately reflect the costs of milling flour. The process of regional demarcation groups several individual flour mills into a single milling center. Assigning precise milling costs to a center with several sizes of milling operations is not possible. The milling cost assignments were determined by the mean size of the mills within the regional milling center.

Implications

This section will proceed with a discussion of the overall results of the various models. A second section reviews flour milling activity in Montana.

Transportation rates for wheat that are below the rates for flour lead to a shift in the location of milling toward major population centers. The location of milling with few exceptions does not shift dramatically even when large changes in relative transportation rates are imposed. Also, wheat production is stable even under extreme changes in transportation rates.

Increasing transportation charges for wheat result in a shift in milling to rural wheat production areas. Milling location appears very sensitive to increasing wheat transportation rates, vastly different milling patterns appear with forty percent higher wheat rates. These changes occur only after milling capacity constraints are lifted.

Increasing consumption levels tend to boost regional milling proportionately. The pattern of flour milling remains stable even when subjected to an average growth in consumption near thirty percent.

The most surprising results are taken from those models examining the impact of higher export levels. The shift of milling from costal areas to interior mills is substantial. Ten percent of total western milling moves from coastal areas to the interior, when export levels are boosted by twenty percent.

Milling in Montana remains relatively stable in most of the analysis. Milling at the northern Montana center ranges from 912,590 hundredweight to 8,704,614 hundredweight. The southern Montana center mills from 546,147 hundredweight to 9,122,423 hundredweight. The variability of milling appears large, however it should be noted that the models in which the high and low levels occur contain very extreme assumptions.

Increasing flour transportation costs reduce milling by 50 percent at the northern mills. The southern Montana mill is not vulnerable to changes in flour transportation rates until regional milling capacity is increased. Once milling capacities are adjusted milling decreases fourfold.

Higher rates for transporting wheat do not increase milling in southern Montana until the wheat rate is double the flour rate. This result is attributable to the absence of slack capacity at the southern Montana mill. In northern Montana milling increases steadily as wheat transportation rates are adjusted upward.

Expanding regional milling capacity initially increases the quantity of wheat milled in southern Montana, northern Montana production falls 35 percent. When the quantity of flour that each center can produce is unconstrained, milling at both Montana milling centers falls to less than one million hundredweight.

Higher flour consumption doubles milling in northern Montana, utilizing all of the region's previously idle capacity. Southern Montana had no slack excess capacity, so the quantity of wheat does not increase until the milling capacity constraints are eased. Both Montana mills utilize all their available capacity when trend consumption growth and fifteen percent higher milling capacity are analyzed.

Ten percent higher export demand results in an increase in milling at the northern Montana center. The increase which roughly doubles milling activity again utilizes all of northern Montana's capacity. When regional milling capacity is boosted and twenty percent higher exports are imposed, milling in northern Montana is again at the limits of the region's assigned capacity. The results in southern Montana are similar. Because no slack production is available in southern Montana, the quantity of wheat milled does not increase until capacity constraints are increased.

The actual level of milling that takes place in Montana will depend on the interaction of several variables. Those variables typically assumed to be most important and described above, have very different impacts on the milling process. The three projection models described earlier attempt to explore the interaction of the various variables.

The results indicate milling in Montana will remain relatively stable. Milling activity exhibits strong growth in projection models one and two, both Montana milling centers utilize all of their available capacity. In projection model three a differential transportation rate structure is introduced and milling levels are reduced. Milling at the southern Montana center is ten percent higher than base model levels, northern Montana milling drops to a level just over half of the original base model.

The regional demand for wheat is stable throughout the analysis. The value of production as represented by the dual solution of the models naturally increases when export demand and consumption increase. Increasing flour and wheat transportation rates did not affect regions, or different wheat types within a region uniformly.

The marginal value of Montana production is higher in all three of the projection models. The amount the objective function would be reduced by adding an additional hundredweight of wheat to each Montana production region, marginal value, is listed in Table 5.1.

Conclusions

The results of the analysis support three main conclusions:

(1) The structure of transportation rates between wheat and flour influences the regional orientation of the flour milling industry, and therefore the pattern of wheat and flour shipments.

(2) Growth in western population does not dramatically alter the pattern of flour milling in the western United States.

(3) Large increases in export demand for wheat will increase the importance of milling at interior milling centers.

The location of flour milling in the western United States will

Table 5.1. Dual Solution Values (cents/hundredweight)

		Base Model	20% Higher Flour	20% Higher Wheat	Projection 3
		-(Transportation Rates) -			
NE.MT	(W)	0	0	0	.04
	(S)	0	0	0	0
	(D)	0	0	0	0
S.MT	(W)	0	0	0	0
	(S)	.15	.08	.18	0
	(D)	.15	.08	.18	.37
NC.MT	(W)	0	.02	0	.21
	(S)	.17	.17	.20	.17
	(D)	0	0	0	0
C.MT	(W)	0	0	0	.14
	(S)	.10	.10	.18	.10
	(D)	.13	.06	.16	.13
W.MT	(W)	.17	.19	.20	.38
	(S)	.34	.34	.40	.34
	(D)	.32	.31	.27	.33

W - Winter
S - Spring
D - Durum

probably remain relatively constant. The potential differential in flour and wheat transportation rates created by the expanded use of wheat unit trains will shift milling toward larger urban centers. Simultaneously, a continuation of export demand growth would have a nearly opposite and equal impact. Population growth boosts milling at all centers; however, recently growth has been highest in the less densely populated Rocky Mountain area. The combined affect of higher exports and growing consumption balance, in net, the tendency for milling to shift toward urban centers.

Regionally, Utah and southern California are the most vulnerable to moderate shifts in the model's basic variables. Southeast California and eastern Washington exhibit the most persistent growth tendencies.

Milling in Montana will probably remain constant, the demand for Montana wheat, while changing only slightly, is higher under the future scenarios assumed to be most likely.

APPENDIX

Appendix Table A.1. Wheat Demand - Higher Flour Transportation Costs (flour cwt equivalents, 1 cwt = 2.283).

			Base Model Slack	20% Higher Flour Rates Slack	40% Higher Flour Rates Slack	40% Higher Flour Rates Slack*	100% Higher Flour Rates Slack*
1)	Arizona	(W)					
2)		(D)	1,851,988	1,851,988	1,851,988	1,779,287	1,779,287
3)	N. California	(W)					
4)		(D)					
5)	C. California	(W)					
6)		(D)					
7)	S. California	(W)					
8)		(D)					
9)	NE. Colorado	(W)	15,616,569	16,067,737	16,067,737	20,824,777	20,824,777
10)		(S)					
11)	SE. Colorado	(W)	5,824,280	5,824,280	5,824,280	5,824,280	5,824,280
12)		(S)					
13)	W. Colorado	(W)	2,636,051	2,636,051	2,636,051	15,901	15,901
14)		(S)					
15)	N. Idaho	(W)					
16)		(S)					
17)	S. Idaho	(W)	4,223,639	3,672,588	3,672,588	1,535,698	1,535,698
18)		(S)					
19)	NE. Montana	(W)	4,612,723	4,612,723	4,612,723	4,612,723	4,612,723
20)		(S)	7,109,982	7,105,009	7,105,009	7,239,507	7,239,507
21)		(D)	2,204,602	2,204,602	2,204,602	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,962,136	6,962,136	6,962,136	6,962,136
23)		(S)					
24)		(D)				22,363	22,363
25)	NC. Montana	(W)					
26)		(S)					
27)		(D)	265,417	270,390	270,390	300,882	300,882
28)	C. Montana	(W)	4,528,056	4,528,056	4,528,056	4,528,056	4,528,056
29)		(S)					
30)		(D)				52,841	52,841
31)	W. Montana	(W)					
32)		(S)					
33)		(D)					
34)	Nevada	(W)					
35)		(S)					
36)	New Mexico	(W)	2,850,122	2,850,122	2,850,122	2,850,122	2,850,122
37)		(D)	37,968	32,995	32,995	0	0
38)	W. Oregon	(W)					
39)		(S)					
40)	CE. Oregon	(W)					
41)		(S)					
42)	Utah	(W)					
43)		(S)					
44)	E. Washington	(W)					
45)		(S)					
46)	CS. Washington	(W)					
47)		(S)					
48)	Wyoming	(W)	3,564,880	3,564,880	3,564,880	3,564,880	3,564,880
49)		(S)	129,525	134,498	134,498	0	0

*Unconstrained milling.

Appendix Table A.2. Wheat Demand - Higher Wheat Transportation Costs (flour cwt equivalents, 1cwt = 2.283 bu).

			Base Model Slack	20% Higher Wheat Rates Slack	40% Higher Wheat Rates Slack	40% Higher Wheat Rates Slack	40% Higher Wheat Rates Slack
1)	Arizona	(W)					
2)		(D)	1,851,988	1,851,988	1,829,559	1,770,944	1,770,944
3)	N. California	(W)					
4)		(D)					
5)	C. California	(W)					
6)		(D)					
7)	S. California	(W)					
8)		(D)					
9)	NE. Colorado	(W)	15,616,569	15,516,551	15,325,540	11,847,101	9,226,951
10)		(S)					
11)	SE. Colorado	(W)	5,824,280	5,824,280	5,824,280	5,824,280	5,824,280
12)		(S)					
13)	W. Colorado	(W)	2,636,051	2,636,051	2,636,051	15,901	2,636,051
14)		(S)					
15)	N. Idaho	(W)					
16)		(S)					
17)	S. Idaho	(W)	4,223,639	3,851,218	4,000,214	12,144,791	12,144,791
18)		(S)					
19)	NE. Montana	(W)	4,612,723	4,612,723	4,612,723	4,612,723	4,612,723
20)		(S)	7,109,982	7,109,982	6,960,986	6,960,986	6,960,986
21)		(D)	2,204,602	2,204,602	2,204,602	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,862,253	6,862,253	6,962,136	0
23)		(S)					
24)		(D)					
25)	NC. Montana	(W)		1,938,571	2,003,015	1,490,868	11,464,551
26)		(S)					
27)		(D)	265,417	265,417	287,846	376,086	376,086
28)	C. Montana	(W)	4,528,056	3,061,924	3,039,495	1,405,771	0
29)		(S)					
30)		(D)					
31)	W. Montana	(W)					
32)		(S)					
33)		(D)					
34)	Nevada	(W)					
35)		(S)					
36)	New Mexico	(W)	2,850,122	2,850,122	2,850,122	2,850,122	2,850,122
37)		(D)	37,968	37,968	37,968	8,343	8,343
38)	W. Oregon	(W)					
39)		(S)					
40)	CE. Oregon	(W)					
41)		(S)					
42)	Utah	(W)					
43)		(S)					
44)	E. Washington	(W)					
45)		(S)					
46)	CS. Washington	(W)					
47)		(S)					
48)	Wyoming	(W)	3,564,880	3,564,880	3,564,880	3,564,880	3,564,880
49)		(S)	129,525	129,525	278,521	278,521	278,521

Appendix Table A-3. Wheat Demand - Increased Export Demand (flour cwt equivalents, 1 cwt = 2.283 bu).

			Base Model Slack	10% Higher Exports Slack	20% Higher Exports Slack	20% Higher Exports Slack*
1)	Arizona	(W)				
2)		(D)	1,851,988	1,392,194	905,188	905,188
3)	N. California	(W)				
4)		(D)				
5)	C. California	(W)				
6)		(D)				
7)	S. California	(W)				
8)		(D)				
9)	NE. Colorado	(W)	15,616,569	15,386,134	14,951,174	13,989,373
10)		(S)				
11)	SE. Colorado	(W)	5,824,280	5,824,280	4,864,520	5,824,280
12)		(S)				
13)	W. Colorado	(W)	2,636,051	2,636,051	0	0
14)		(S)			341,501	137,054
15)	N. Idaho	(W)				
16)		(S)				
17)	S. Idaho	(W)	4,223,639	0	0	0
18)		(S)				
19)	NE. Montana	(W)	4,612,723	173,392	0	0
20)		(S)	7,109,982	2,786,306	0	0
21)		(D)	2,204,602	2,204,602	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,843,674	0	0
23)		(S)			195,245	399,692
24)		(D)				
25)	NC. Montana	(W)				
26)		(S)				
27)		(D)	265,417	243,630	211,897	211,897
28)	C. Montana	(W)	4,528,056	0	0	0
29)		(S)				
30)		(D)				
31)	W. Montana	(W)				
32)		(S)				
33)		(D)				
34)	Nevada	(W)				
35)		(S)				
36)	New Mexico	(W)	2,850,122	2,770,142	0	0
37)		(D)	37,968	18,249	35,768	35,768
38)	W. Oregon	(W)				
39)		(S)				
40)	CE. Oregon	(W)				
41)		(S)				
42)	Utah	(W)				
43)		(S)				
44)	E. Washington	(W)				
45)		(S)				
46)	CS. Washington	(W)				
47)		(S)				
48)	Wyoming	(W)	3,564,880	3,564,880	3,562,839	3,564,880
49)		(S)	129,525	272,281	340,921	340,921

*Unconstrained milling.

Appendix Table A-4. Wheat Demand - Increased Consumption (flour cwt equivalents, 1 cwt = 2.283 bu.).

			Base Model Slack	20% Higher Consumption Slack	Trend Consumption Slack	Trend Consumption Slack*
1)	Arizona	(W)				
2)		(D)	1,851,988	1,584,392	1,533,195	1,569,081
3)	N. California	(W)				
4)		(D)				
5)	C. California	(W)				
6)		(D)				
7)	S. California	(W)				
8)		(D)				
9)	NE. Colorado	(W)	15,616,569	15,013,595	15,018,746	13,920,303
10)		(S)				
11)	SE. Colorado	(W)	5,824,280	5,824,280	5,824,280	5,824,280
12)		(S)				
13)	W. Colorado	(W)	2,636,051	2,636,051	2,249,346	2,636,051
14)		(S)		317,805	696,428	241,918
15)	N. Idaho	(W)				
16)		(S)	4,223,639	0		
17)	S. Idaho	(W)				
18)		(S)				
19)	NE. Montana	(W)	4,612,723	4,612,723	4,612,723	4,612,723
20)		(S)	7,109,982	4,842,553	3,344,407	4,504,826
21)		(D)	2,204,602	2,204,602	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,862,253	6,156,344	6,523,227
23)		(S)			705,909	0
24)		(D)				
25)	NC. Montana	(W)				
26)		(S)				
27)		(D)	265,417	202,538	168,291	132,405
28)	C. Montana	(W)	4,528,056	1,995,552	1,275,800	1,560,135
29)		(S)				
30)		(D)				
31)	W. Montana	(W)				
32)		(S)				
33)		(D)				
34)	Nevada	(W)				
35)		(S)				
36)	New Mexico	(W)	2,850,122	2,626,638	2,629,569	2,690,089
37)		(D)	37,968	0		
38)	W. Oregon	(W)				
39)		(S)				
40)	CE. Oregon	(W)				
41)		(S)				
42)	Utah	(W)				
43)		(S)				
44)	E Washington	(W)				
45)		(S)				
46)	CS. Washington	(W)				
47)		(S)				
48)	Wyoming	(W)	3,564,880	3,564,880	3,564,880	3,564,880
49)		(S)	129,525	340,921	340,921	340,921

*Unconstrained milling.

Appendix Table A.5. Wheat Demand - Size Economies (flour cwt equivalents, 1 cwt - 2.283 bu).

			Activity	Slack
1)	Arizona	(W)		
2)		(D)	1,851,988	1,851,988
3)	N. California	(W)		
4)		(D)		
5)	C. California	(W)		
6)		(D)		
7)	S. California	(W)		
8)		(D)		
9)	NE. Colorado	(W)	15,616,569	15,575,166
10)		(S)		
11)	SE. Colorado	(W)	5,824,280	5,824,280
12)		(S)		
13)	W. Colorado	(W)	2,636,051	2,636,051
14)		(S)		
15)	N. Idaho	(W)		
16)		(S)		
17)	S. Idaho	(W)	4,223,639	4,265,042
18)		(S)		
19)	NE. Montana	(W)	4,612,723	4,612,723
20)		(S)	7,109,982	6,960,986
21)		(D)	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	6,862,253
23)		(S)		
24)		(D)		
25)	NC. Montana	(W)		
26)		(S)		
27)		(D)	265,417	265,417
28)	C. Montana	(W)	4,528,056	4,528,056
29)		(S)		
30)		(D)		
31)	W. Montana	(W)		
32)		(S)		
33)		(D)		
34)	Nevada	(W)		
35)		(S)		
36)	New Mexico	(W)	2,850,122	2,850,122
37)		(D)	37,968	37,968
38)	W. Oregon	(W)		
39)		(S)		
40)	CE. Oregon	(W)		
41)		(S)		
42)	Utah	(W)		
43)		(S)		
44)	E. Washington	(W)		
45)		(S)		
46)	CS. Washington	(W)		
47)		(S)		
48)	Wyoming	(W)	3,564,880	3,564,880
49)		(S)	129,525	278,521

Appendix Table A-6. Future Scenarios (flour cwt equivalents, 1 cwt = 2.283 bu).

			Base Slack	Projection Model 1 Slack	Projection Model 2 Slack	Projection Model 2 Slack
1)	Arizona	(W)				
2)		(D)	1,851,988	1,137,907	1,095,681	1,083,141
3)	N. California	(W)				
4)		(D)				
5)	C. California	(W)				
6)		(D)				
7)	S. California	(W)				
8)		(D)				
9)	NE. Colorado	(W)	15,616,569	14,226,412	13,920,303	14,024,896
10)		(S)				
11)	SE. Colorado	(W)	5,824,280	5,824,280	5,824,280	5,824,280
12)		(S)				
13)	W. Colorado	(W)	2,636,051	2,636,051	2,392,096	2,636,051
14)		(S)			234,538	142,485
15)	N. Idaho	(W)				
16)		(S)				
17)	S. Idaho	(W)	4,223,639	0	0	0
18)		(S)				
19)	NE. Montana	(W)	4,612,723	0	0	0
20)		(S)	7,109,982	0	0	423,339
21)		(D)	2,204,602	2,204,602	2,204,602	2,204,602
22)	S. Montana	(W)	6,862,253	1,094,187	0	2,354,003
23)		(S)		1,238,271	1,161,559	
24)		(D)				
25)	NC. Montana	(W)				
26)		(S)				
27)		(D)	265,417	147,723	104,505	117,045
28)	C. Montana	(W)	4,528,056	0	0	0
29)		(S)				
30)		(D)				
31)	W. Montana	(W)				
32)		(S)				
33)		(D)				
34)	Nevada	(W)				
35)		(S)				
36)	New Mexico	(W)	2,850,122	2,770,142	2,610,109	0
37)		(D)	37,968	0	0	0
38)	W. Oregon	(W)				
39)		(S)				
40)	CE. Oregon	(W)				
41)		(S)				
42)	Utah	(W)				
43)		(S)				
44)	E. Washington	(W)				
45)		(S)				
46)	CS. Washington	(W)				
47)		(S)				
48)	Wyoming	(W)	3,564,880	3,564,880	3,564,880	3,564,880
49)		(S)	129,525	272,281	340,921	340,921

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