REGIONAL AND SECTORAL EFFECTS OF COMPETITION FOR WHEAT TRANSPORTATION

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Increased competition from barges and trucks for wheat traffic has caused rail charges for transporting wheat to decline relative to those for flour. Some flour milling centers now find themselves in an uneconomic location. The development and consequences of truck-barge-rail competition for wheat transportation is discussed in terms of the development of a differential between rates for wheat and flour. A spatial model that isolates the effects of these changes in rates for analysis is presented and the implications of the results are discussed as they pertain to various sectors and regions of the wheat-flour economy.

DEVELOPMENT AND CONSEQUENCES OF INTERMODAL COMPETITION

Until 1963, the railroads charged the same to haul wheat as they did to haul flour, even though wheat is easier to handle and less perishable than flour. In addition, railroads did not charge for costly transit stops. Transit stops enabled grain merchandisers and processors to store and/or mill wheat (or flour) at points between wheat producing areas and flour markets. The use of transit, also, committed the shipper to use rail transportation for the remaining portion of the total haul.

Mills at transshipment points in and near major wheat producing areas prospered with such a structure of rates. Not only could additional loading and unloading costs be avoided by milling at major grain storage and merchandising centers (transshipment points), but millfeed could also be disposed of locally, thus, avoiding the cost of transporting it to more distant markets where it was worth little, if any, more.

Rail rates increased rapidly after World War II in response to higher wages and operating costs. Meanwhile, highway and inland waterways were built and improved. Technological improvements in trucking and barging tended to keep pace with the higher operating costs of these two modes. Consequently, trucks and barges independently, and in combination, became competitive in hauling wheat to Gulf ports for export and to developing mills nearer to Southeastern population centers. By the late 1950's, established geographical flows of wheat and flour and the associated pattern of milling had been severely disrupted.

Railroads were tardy in recognizing the changes in the wheat-flour transport market, and made no adjustments in their century-old package of price and service factors until 1963 when the Southern Railroad[1] innovated with equipment modernization, abolishment of transit privileges for lowest available rates, and rates for wheat considerably below those for flour. It waged a long and hard-fought battle with opponents of its proposed innovations before the Interstate Commerce Commission, Federal District Courts and the Supreme Court before it obtained final approval to use the new rates with the new equipment. Similar rates and equipment have been adopted by many other railroads, in cases for traffic movements where there was little direct competition from trucks and barges. Indirect competition from trucks and barges, through the potential diversion of seemingly captive rail traffic to competing modes, has been lucidly recognized by railroad management, leading to somewhat general revisions of the price-service package offered to wheat and flour shippers.

Disadvantaged millers in the producing areas aided in the formation of a Twelve States Governors Conference on Transportation (since renamed the Mid-America Governors Transportation Committee). Its initial effort was directed at recreating a parity

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[1] Use of the name of a particular company in this report does not constitute endorsement of the company named or imply discrimination against other companies.

between rail rates for wheat and flour. Wheat rates could not be raised because truck and barge rates were controlling, and the railroads were opposed to reducing flour rates to as low a level as wheat rates. The railroads argued their costs of transporting flour really were greater than those for transporting wheat, and there was no competitive reason for reducing flour rates.

Freight rates for wheat may remain below those for flour. If they do and other factors do not offset this new structure of freight rates, the optimum location of the milling industry will exhibit more of a market orientation than it has in the past. The remainder of this paper deals with quantifying the expected reorientation of the industry and of consequent effects on different sectors and regions of the wheat-flour economy.

FORMULATION AND IMPLEMENTATION OF TRANSSHIPMENT MODEL

A model is formulated in the first part of this section that will be used to isolate the impact of lower transportation rates for wheat on the location of the milling industry and on the various sectors and regions of the wheat-flour economy. Its implementation is discussed in the second part of this section.

Formulation of Model

The basic transportation model developed by Koopmans [1] is formulated as a transshipment model to analyze the effects of the wheat-flour rate differential. The formulation is basically a refinement of the general multi-factor, multi-product transshipment model developed by Leath and Martin [2]. Flour milling centers serve as transshipment points between wheat shipments (from wheat supply areas) and flour shipments[2] (to major population centers). In addition, basic activities are included to represent wheat shipments from supply areas to U.S. ports for export. The formulation pictured on Figure 1 encompasses 4 wheat supply areas (1, 2, 3 and 4), 3 mill centers (5, 6 and 7), 2 ports (8 and 9), and 5 flour markets (10, 11, 12, 13 and 14).

Entries in each of the submatrices of the cost matrix are as follows:

Submatrix A: Zeros on main diagonal, ∞ elsewhere.

Submatrix B: Wheat transport costs from supply points to ports.

Submatrix C: Zeros on main diagonal, ∞ elsewhere.

Submatrix D: Wheat transport costs from supply points to mill centers.

Submatrix E: Zeros on main diagonal, ∞ elsewhere.

Submatrix F: Flour transport costs from mill centers to population centers.

Entries in the row and column bordering the cost matrix indicate the formulation fulfills the basic supply equal demand requirement of the transportation model. Letting

WS = wheat supply
MC = milling capacity
EX = wheat exports
FL = flour requirements

produces a row sum (WS + WS + MC) that equals the column sum (WS + MC + EX + FL), cancelling a WS and MC from both the row and column sum leaves supply (WS) equal to demand (EX + FL).

Two situations are constructed and solved to isolate the impact lower transportation rates for wheat may be expected to have on the location of the milling industry and the various sectors and regions of the wheat-flour economy.

Situation I depicts the rate equalization concept, Situation II uniformly lowers rates for moving wheat. Rates for transporting flour and the spatial distribution of wheat supplies, flour requirements and wheat exports are other sectors of the wheat-flour economy that remain unchanged when isolating the effect of the wheat rate differential.

The equalization concept is depicted in Situation I by summing appropriate entries in Submatrices D and F. For example, if rates for shipping wheat from producing area 1 to mill centers 5, 6, and 7 (Submatrix D) were 25, 50, and 75 cents, respectively, then the rates for shipping flour from mills 5, 6, and 7 to market 14 (Submatrix F) would be, respectively, 75, 50, and 25 cents. Mills at all centers on a specific traffic lane are faced with the same total transportation costs, i.e., \$1. To portray the differential concept in Situation II, all entries in Submatrices D and B (lower rates also apply on shipments of wheat for export) are lowered 20 percent.

Total transportation costs facing mill centers 5, 6, and 7 are now, respectively, 95 cents (20 + 75); 90

[2] Throughout this analysis, flour refers to the joint products of milling, flour and millfeed. Additional modification of the model would be required if millfeed requirements were to have a different spatial distribution than flour requirements.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	0			A				Wheat:	B						
2		0						Supply							
3			0					to							WS
4				0				Export							
1	0			C	Wheat:		D								
2		0			Supply										
3			0		to										WS
4				0	Milling										
5					0		E					Flour:		F	
6						0						Milling to			MC
7							0					Consumption			
	WS				MC			EX		FL					

FIGURE 1. TRANSSHIPMENT FORMULATION OF THE WHEAT-FLOUR ECONOMY

cents (40 + 50); and 85 cents (60 + 25). Consequently, mills nearest producing areas are disadvantaged relative to those near market areas.

A solution to the primal problem of this formulation will have entries in the submatrices that exhibit the following characteristics:

A(wheat for milling) + B(wheat for export) = WS
A(wheat for milling) + C(wheat for export) = WS
D(wheat for milling) + C(wheat for export) = WS
D(wheat for milling) + E(excess milling capacity) = MC
F(flour requirement) + E(excess milling capacity) = MC

Entries in Submatrices B, D and F of a primal solution describe the geographical shipment patterns of wheat and flour and the location of milling associated with them.

A solution to the dual problem of this formulation is a set of locational price differentials. Basing the set on one supply point, mill center or market, produces, when multiplied by the corresponding quantities, the value of wheat in producing areas and the value of wheat and flour in market areas, the difference between producing and market area values equaling total transportation costs. Using the same base for Situations I and II, solutions provide a means for ascertaining the impact of the lower rate for wheat for the consequent shift in location of milling on the various sectors and regions of the wheat-flour economy. Selection of a different basing point can produce a different distribution of impacts.

Implementation of Model

Five types of information are required to implement the model discussed in the earlier part of this section.[3] Each type of data and the procedures used to obtain them are briefly discussed.

Wheat Supplies. Ten year average (1951-60) estimates of wheat production[4] for 71 producing areas were obtained by aggregating wheat acreage and yield data for 144 producing areas contained in a data bank that is maintained by the Center for Agricultural and Economic Development, Iowa State University, Ames, Iowa [8].

Wheat Exports. Ten U.S. ports were selected to represent foreign disappearance of U.S. wheat. A two-year average (1966-67) of wheat exports was obtained from Grain Market News, U. S. Department of Agriculture publications [4 and 6] and assigned to the 10 ports, and then proportionately adjusted to satisfy the basic supply equal demand constraint of the formulation. Use of U.S. ports reflects the idea that the relationships between domestic transportation rates for wheat and flour and the location of the domestic milling industry are little affected by ocean freight rates.

Flour Consumption. Population data were used to estimate the geographical distribution of flour consumption, since per capita flour consumption is relatively stable among areas. The data for 57 regions were aggregated from the 501 State Economic Areas reported in the 1960 Census of Population [7].

Transportation Rates. Rail mileages [3] were used to estimate transportation rates used in this analysis. The new rail rates for wheat as well as the barge and truck rates that caused their adoption (discussed in the first section of paper) are based primarily on distance. The monetary transformation used in Situation I is a cent for each 10 miles. In Situation II wheat rates are reduced 20 percent, the flour rates remaining unchanged. Use of alternate levels of distance based rates in this formulation would yield the same least cost location of the milling industry but not the same valuation of wheat and flour in producing and market areas. Relative but not absolute differences between areas would be maintained.

Selection of Base Price. A solution to the dual system acquires economic meaning when values of the dual variable are interpreted as prices. Values for all the dual variables represent the geographical price differentials associated with the solution. Because there is one more equation than unknown in the system, one dual variable can be assigned an arbituary value. Such an assignment translates the price differentials into a set of prices that when multiplied by the quantity associated with each determines the value of wheat in producing areas and of wheat and flour in market areas. In one solution, the difference in the value of wheat or flour between any 2 areas is not affected by the location or the price chosen for the base, because values in both areas are dependent on

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[3] Conceptually, another type of data is required, that is a spatial distribution of milling capacity. To isolate the impact of the rate differential, however, assume milling occurs at least cost locations in each situation. Consequently, in both situations, capacity at each mill center is specified to be in excess of wheat supplies so that milling can and will occur at least cost locations. Mill centers included in the analysis are: Buffalo, New York City, Lancaster, Detroit, Fostoria, Evansville, Chicago, Minneapolis, Winona, Grand Forks, Davenport, St. Louis, Omaha, Kansas City, Wichita, Enid, Dallas, District of Columbia, Charlotte, Chattanooga, Jacksonville, Denver, Ogden, Spokane, Seattle, Portland, San Francisco, and Los Angeles.

[4] Includes hard, soft and white wheat, but excludes durum.

the difference between the values of the dual variables for the areas which remain unchanged.

The price of wheat is determined by a variety of forces. In recent years, international markets have been a dominant influence. World demand for U.S. wheat is reflected by wheat prices at U.S. ports. In 1966 and 1967, Houston exported more wheat than any other port [4 and 6]. The 1966-67 average price at Houston was $2.01 per bushel [5]. Consequently, the values of wheat and flour in each Situation are determined by a set of price differentials based on a wheat price of $2.01 per bushel at Houston for export.

RESULTS OF ANALYSIS

The results of this analysis are presented in two parts. The first part presents the changes in the location of the milling industry that might be expected by changing from an "equalization" to a "differential" structure of transportation rates. The second part presents the changes in the value of wheat in producing areas and the value of wheat and flour in market areas associated with the change in structure of transportation rates.

Location of Milling

The expected location of the industry (Situation II) is not compared with its Situation I location but rather with its current location for the following reason: The equalization structure of rates portrayed in Situation I results, as expected, in a locational pattern of the industry that is not unique, that is to say, mill centers in and between particular production and market areas each faced with the same transportation costs can and do share in the relevant milling.[5]

The West North Central Region with two-fifths of the nations milling capacity has more than 2½ times as much as any other region (Table 1). The North Atlantic, East North Central and Pacific Regions each account for an additional 10 to 15 percent. Remaining capacity is evenly distributed among the other 4 regions. The existing spatial distribution of capacity conforms quite well to the location(s) produced by a structure of transportation rates based on the equalization concept - - Situation I (results not shown in Table 1).

The least cost location of the industry is changed considerably when it is oriented towards the new structure of transportation rates (i.e., Situation II where rates for wheat are decreased while those for flour are not). The West North Central Region mills only one-fifth of the nations flour - half of its share of existing capacity. Producing area mill locations faced with high cost flour transportation are now uneconomic except to fulfill local flour requirements.

In four regions (North Atlantic, South Atlantic, East North Central, and Pacific), the region's share of milling exceeds its share of capacity (plus sign in column 5, Table 1). Little incentive for new mills exists in 2 of the regions (East North Central and Pacific), however, because capacity available exceeds that required (plus sign in column 6, Table 1).

The 30 million hundredweight (wheat) deficit (annual) in the North and South Atlantic Regions represents about 20 mills, each producing 4,000 hundredweight of flour per day.

Even though this indicates a substantial shift in the optimum location of the industry over the longer run, do not expect the new mills to be put into operation in the near future. The analysis itself does not contain any information concerning whether a relocation will take place nor if it does how fast it will occur.

The first deterrent to an immediate relocation is, of course, the locationally disadvantaged existing milling capacity. This is particularly true when a single firm is involved. A firm with a producing area mill that currently ships to the North or South Atlantic Regions needs to find a new outlet for that output if it builds a new mill in the eastern market area.

Additional deterrents to a complete and immediate relocation corresponding to the Situation II solution are factors not considered by the analysis. An important factor not analyzed is the disposition of millfeed. The analysis, as conducted, assumes the location of millfeed markets coincides with those for flour. This may not be true, particularly in coastal population centers. Incorporation of this factor would favor intermediate locations, thus, avoiding backhauling millfeed but still utilizing more of the relatively cheap wheat transportation and, consequently,

[5] Four interregional examples of this phenomenon in Situation I are: (1) Mills in the East North Central (Detroit, Fostoria, Chicago, Minneapolis, Winona and Davenport) and North Atlantic (New York, Buffalo, and Lancaster) Regions share the North Atlantic (Boston, New York, Syracuse, Buffalo, Philadelphia, and Pittsburgh) market for flour. (2) Mills in the West North Central Region (Omaha, Kansas City, and St. Louis) share the South Atlantic market (Columbia, Atlanta, Jacksonville, Orlando and Miami) with mills in 3 other regions (East North Central-Evansville, East South Central-Chattanooga, and South Atlantic-Jacksonville). (3) West North Central (Wichita) and West South Central (Enid and Dallas) mills share in 2 regions (East South Central-New Orleans and West South Central-Dallas, Houston, and San Antonio). (4) Mountain (Ogden) and Pacific (San Francisco and Los Angeles) mills share Pacific markets (San Francisco and Los Angeles) for flour.

TABLE 1. CURRENT AND EXPECTED LOCATION OF MILLING CAPACITY

	Location of Milling				Difference between Column 4 and Column 2	Excess Capacity Column 3 minus Column 1
	Existing Capacity[a] (000 cwt)	Percent	Situation II (000 cwt)	Percent		
	(1)	(2)	(3)	(4)	(5)	(6)
North Atlantic	41,818	12.7	60,731	22.3	+ 9.6	-18,913
South Atlantic	17,490	5.3	29,265	10.8	+ 5.5	-11,775
East North Central	51,771	15.8	46,182	17.0	+ 1.2	+ 5,589
West North Central	128,934	39.2	65,119	23.9	-15.3	+63,815
East South Central	14,229	4.3	9,127	3.3	- 1.0	+ 5,102
West South Central	24,961	7.6	19,387	7.1	- .5	+ 5,574
Mountain	15,096	4.6	9,922	3.7	- .9	+ 5,174
Pacific	34,471	10.5	32,441	11.9	+ 1.4	+ 2,030
United States	328,770	100.0	272,174	100.0	0	+56,596

[a] Capacity given in thousand hundredweights of wheat, mill operating 24 hours per day, 260 days per year with 73 percent flour yield.

SOURCE: "Statistical Summary," *The Northwestern Miller*, Volume 274, Number 9, pp. 9-71, Sept. 1967.

decreasing total transportation costs.

Impact on Various Sectors

The economic impact on different sectors of the wheat-flour economy is presented on an aggregate basis before being spatially disaggregated. In both parts of this section, comparisons are made between Situation I and Situation II solutions. The nonuniqueness in location of milling in Situation I does not affect the set of price differentials, hence, neither does it affect the valuation of wheat or flour.

Aggregate Impact. Seventy-six million dollars less is paid to transport wheat and flour in Situation II than in Situation I, the 20 percent reduction in wheat rates producing a 17.3 percent reduction in total transportation costs (Table 2). A full 20 percent reduction is not achieved because some flour transportation is still required and its rates are unchanged.

Theoretically, the producing and consuming sectors share the benefits of the decreased expenditures for transportation. Using export wheat at Houston as a basis for comparing the two solutions indicates five-sixths ($63 million) of the $76 million saving in expenditures for transportation will increase the value of wheat in producing areas 3.7 percent. The remaining one-sixth ($13 million) reduces the value of wheat at ports by seven-tenths of one percent ($9 million) and the value of flour in market areas by half of one percent ($4 million).

Spatial Distribution of Impact. The individual producing areas or market areas do not share equally, either absolutely or proportionately, in the benefits that accrue to the two sectors in the aggregate.

In two regions, in this analysis, the value of wheat in producing areas actually decreased, 5 and 8 cents per bushel, respectively, in the North and South Atlantic Regions (Table 3). The decreases result from decreases in market prices in the 2 regions that are determined by prices in producing areas that the regions draw from plus transportation costs from the relevant surplus producing regions. In each case, the decrease in transportation costs exceeds the increase in wheat price in the producing area, thus, lowering the market price in both of the deficit regions (North and South Atlantic).

The price increase in surplus producing areas (8, 7 and 10 cents per bushel, respectively, in the West North Central, West South Central and Mountain Regions) results directly from the decrease in transportation rates (being determined in this analysis by export market prices to which the regions ship, less transportation costs of shipping to them) that are lower in Situation II than in Situation I.

In three market areas (North and South Atlantic and Pacific) the value of flour decreases; in 2 more (East and West South Central) it remains unchanged, while it increases in the remaining 3 regions (East and West North Central and Mountain) (Table 4). The three increases result from the lower transportation charges being more than offset by the increased price of wheat in producing areas. Markets in the North and South Atlantic and Pacific Regions draw wheat and/or flour from distant surplus areas, thus, the absolute decrease in transportation rates is sufficient to offset increases in producing area wheat prices. In addition, the North and South Atlantic flour requirements are, in part, filled by lower priced local wheat.

Three (Atlantic, Gulf and Pacific) of the 4 coastal areas contribute to the $9 million decrease in the value of wheat at ports. An increase in the value of wheat at Great Lakes ports of $2 million is indicated, however, because the decreased transportation costs failed to offset the increase in the price (and value) of wheat in the West North Central Region, the main source of wheat exported is via the Great Lakes ports.

CONCLUSIONS

Generally, the foregoing analysis points out that the appearance and continued existence of a differential between transportation rates for wheat and flour will have a variety of long lasting ramifications for different sectors and regions of the wheat-flour economy. In particular, the analysis supports the following interrelated conclusions:

(1) Railroads will price services for transporting wheat below those for transporting flour, if technology permits, so they can compete with barges and trucks for wheat traffic.

(2) Transportation rates for wheat that are below the corresponding rates for flour will cause the economic location of the milling industry to shift towards major population centers (flour markets). A complete relocation will be conditioned by the limited opportunity for millfeed disposal in urban areas and delayed by the continued operation of existing capacity in nonoptimum locations. Mills may relocate in intermediate locations adjacent to population centers where they can capture most of the benefits of the lower wheat rates and yet avoid backhauling of millfeed.

(3) Savings in expenditures for transportation will, in a general equilibrium context, be shared by the producing and consuming sectors of the wheat-flour economy.

(4) Regional participation in the benefits accruing to the producing and consuming sectors will not be

TABLE 2. SECTORAL VALUATION, SITUATIONS I AND II

Sector	Situation I (million)	Situation II (million)	Change[a]	
			(Million)	Percent
Producing Area Value	$1,721	$1,784	+63	+ 3.7
Transportation Costs	438	362	-76	-17.3
Market Area Value	2,159	2,146	-13	- 0.6
Wheat	1,228	1,219	- 9	- 0.7
Flour	931	927	- 4	- 0.4

[a] The change in transportation cost equals the change in market area value minus the change in producing area value. As an example: -$76 = -$13 -(+63).

TABLE 3. PRODUCTION AREA VALUATION, BY REGION, SITUATIONS I AND II

Region	Quantity (million)	Situation I		Situation II		Change	
		Value (million)	Price (per bu.)	Value (million)	Price (per bu.)	Value (million)	Price (per bu.)
North Atlantic	28	$ 63	$2.23	$ 62	$2.18	$- 1	$ -.05
South Atlantic	19	42	2.24	41	2.16	- 1	-.08
East North Central	163	307	1.88	308	1.89	+ 1	+.01
West North Central	462	687	1.49	727	1.57	+40	+.08
East South Central	13	24	1.94	24	1.94	—	—
West South Central	110	183	1.66	190	1.73	+ 7	+.07
Mountain	153	217	1.42	234	1.52	+17	+.10
Pacific	106	198	1.86	198	1.86	—	—
United States	1,054	1,721	1.63	1,784	1.69	+63	+.06

TABLE 4. MARKET AREA VALUATION, BY REGION, SITUATIONS I AND II

Region	Situation I (000)	Situation II (000)	Change	
			(000)	Percent
		FLOUR		
North Atlantic	$260	$254	$–6	–2.3
South Atlantic	141	138	–3	–2.2
East North Central	161	163	+2	+1.2
West North Central	78	81	+3	+3.8
East South Central	68	68	—	—
West South Central	82	82	—	—
Mountain	28	30	+2	+7.1
Pacific	113	111	–2	–1.8
United States	931	927	–4	–0.4
		WHEAT		
Coastal Areas				
Atlantic	$164	$158	$–6	–3.7
Great Lakes	65	67	+2	+3.1
Gulf	651	648	–3	–0.5
Pacific	348	346	–2	–0.6
United States	$1,228	$1,219	$–9	–0.7

uniform. The impacts on producers and consumers in different regions quantified by using Houston as the basing point in this analysis are: Producers in surplus areas receive more for their wheat because of the lower transportation charges it incurs. Consumers in wheat surplus areas pay more for flour because it is made from higher priced wheat. Consumers in wheat deficit areas pay less for flour because of lower transportation costs involved in moving needed supplies from surplus areas. Producers in deficit areas receive less for their wheat because its value is based on the lower price in the market area resulting from the decreased cost of obtaining wheat from surplus areas. An alternate base for comparing the two solutions would, in most cases, produce different results. Analysis of alternate objectives or appearance of new dominating factors in wheat and/or flour price determination would indicate selection of a different base for use in computing regional and sectoral participation in benefits accruing from decreased expenditures for transportation.

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