THE UNIVERSITY OF MANITOBA

FREIGHT RATES AND THE CANADIAN WHEAT FLOUR ECONOMY

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF AGRICULTURAL ECONOMICS

WINNIPEG, MANITOBA

October 1981

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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Abstract

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Disruption of the transport price mechanism has the effect of masking underlying economic relationships and distorting the effective level and structure of freight rates. For industries dependent upon the transportation system, this may induce inefficient supply procurement and product distribution patterns in the short run and sub-optimal industrial location decisions in the long run. To a considerable extent the Canadian grain producing and processing sectors have been and continue to be affected by government's use of the transportation system as an instrument of national policy and, in particular, its intervention in the freight rate determination process.

This study examines effects which certain distortions in the freight rate structure may have had upon the Canadian flour milling industry and the wheat economy generally. Specifically, the impacts of federal government policies and programs affecting the grain freight rate structure upon the regional distribution of flour milling activity, upon the total cost of wheat and flour transportation and upon spatial price equilibrium in the Canadian

wheat economy are evaluated. The particular sources of distortion in the freight rate structure which are examined include the statutory "Crow's Nest Pass" and "At and East" rates, the subsidization of flour millers' in-transit stop-off fees and the operation of the St. Lawrence Seaway with a toll structure which, until recently, did not generate sufficient revenues to cover even its operating costs.

The implications of introducing cost oriented grain freight rates were simulated by means of a specialized transhipment varient of the linear programming transportation model. Optimal wheat grain and flour milling and shipment patterns within a twelve-region model of Canada were derived, first on the basis of the existing (1974) freight rate structure and then on the basis of cost oriented rates. In the short run, regional milling capacities were restricted to existing levels but, in the long run, these constraints were relaxed. The implications of making such changes in the freight rate structure were observed by comparing the solutions to the different versions of the model.

The results of this analysis provide some support for the hypothesis that freight rates have influenced the locational development of the Canadian flour milling industry. However, these results do not fully explain the current regional distribution of activity in this industry. Thus, while introducing cost oriented adjustments into the freight rate structure may enhance the comparative advantage of mills situated nearer to their raw wheat supplies, the results of this analysis suggest that this would not be likely to induce major changes in the industry's current pattern of location. A second conclusion of this analysis is that the introduction of cost oriented grain freight rates may result in marginally more efficient transportation patterns but that significant cost savings are not likely. Finally, this analysis demonstrates that introducing cost oriented grain freight rates would reduce the price of wheat in the Prairie provinces by from three to five percent.

ACKNOWLEDGEMENTS

I sincerely acknowledge my greatest appreciation to Dr. Ed Tyrchniewicz, my major advisor, whose guidance significantly enhanced the quality of both this thesis and my overall graduate program; to Drs. Colin Carter and Greg Mason for reviewing and critically evaluating the final draft of this thesis; to the Transportation Development Center of Transport Canada and to the University of Manitoba for financial support; to the faculty, staff and students of the Department of Agricultural Economics for providing a stimulating learning environment; and to Cathie, Mom and Dad for their continuing support and encouragement.

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CHAPTER I

> Transportation has always played a vital part in the Canadian grains industry. Canada's unique geography, the location of its major grain growing areas, and the sheer size of the country have, since the earliest days of agriculture on the prairies, made it incumbent upon Canada to have not only a good grain handling and transportation system, but the best system it could afford to meet its needs[1].

INTRODUCTION TO THE PROBLEM

The production and utilization of grain and grain products in Canada are distributed over vast geographic regions. The activities of handling, processing and storing which ensure that the grain reaches the proper place in the appropriate form at the correct time further serve to complicate the marketing function. Because of the complex interregional flows of grain and grain products which result, the grains industry has become heavily dependent upon the transportation system.

The prevailing level and structure of freight rates for these flows affect not only the pattern of grain shipments in the short run but also the location and profitability of grain handling and processing facilities in the long run. Freight rates for grain shipments in Canada are not based solely upon considerations of economic cost and

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[1]The Grain Handling and Transportation Commission, Grain and Rail In Western Canada, Volume I (Ottawa: Minister of Supply and Services Canada, 1977), p. 2.

efficiency, however. Government has long been involved in the regulation of transportation, determining and guiding the role which this factor has played in the country's development.

During the period when settlement of the Prairies ranked high on the list of national goals, for example, emphasis was placed upon the provision of abundant low-priced (as distinct from low-cost) transportation to and from the western region. The "Crow's Nest Pass" rail freight rates for grain[2] were introduced in 1899 at a level of approximately one-half cent per ton-mile. Despite increased railway costs since that time, these rates still apply at the original level. Similarly, government programs such as the "At and East" hold-down subsidy on export wheat and flour shipments to east coast ports distort the effective level and structure of existing grain freight rates. The result is that certain major portions of Canadian grain traffic are shipped at relatively low tariff levels while others are shipped at much higher levels.

It may be argued that low freight rates enhance Canadian farmers' ability to compete in the international grain markets. However, it should also be recognized that a freight rate structure which does not reflect economic costs may induce sub-optimal resource allocation patterns in industries served by the transportation system within

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[2]In 1925 these rates were incorporated into the Statutes of Canada (Chapter 52) and have since been more correctly known simply as "statutory grain freight rates."

Canada. For example, components of the grain marketing system which depend heavily upon transportation adjust their regional distributions in order to, among other things, minimize their required transportation expenditures. If freight rates are arbitrarily or politically determined, the location decisions of those industries will not reflect underlying economic relationships and inherent regional advantages. Rather, they will reflect the institutional framework supporting the rate structure. This will not likely be in the best interests of the industries affected, the producers of the grain or the people of Canada. It may result in non-optimal industrial location, inefficient use of existing grain transportation equipment and increased overall grain marketing costs. Thus, although artificially low freight rates for grain appear as a direct benefit to Prairie grain farmers, they may actually result in a net loss for the economy as a whole. Increasing these rates would not increase total costs but, instead, would only shift the burden of existing costs. In fact, it may lead to more efficient transportation flows and, consequently, lower total real costs.

Federal transportation policy, in general, and government regulation of freight rates, specifically, have been under review in recent years. As early as 1974, policy statements indicated the federal government's desire to have a national transportation policy based upon cost oriented freight rates and the removal of discriminatory aspects of the freight rate structure.[3] Later, major commissions of inquiry were established to study two important aspects of the grain handling and transportation system of Western Canada. The Commission on the Costs of Transporting Grain by Rail (the Snavely Commission) provided conclusive evidence that the revenues received by the railways for shipping grain do not cover even the variable costs incurred.[4] While recognizing this, the Grain Handling and Transportation Commission (the Hall Commission) nonetheless recommended that the level of grain freight rates facing Prairie farmers not be raised. It proposed, alternatively, that the government should continue and, in fact, expand its current subsidization of grain transportation through the railways.[5] However, other major studies which have been prepared for the government have been highly critical of the statutory grain rates, citing them as a principal cause of Canada's current grain transportation difficulties.[6]

Throughout discussions of the future of the statutory "Crow's Nest Pass" rates, the government has

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[3] Otto Lang, "Notes for an Address to the Canada Grains Council Semi-Annual Meeting and Seminar on Grain Handling and Transportation", (Edmonton: October 28, 1974).

[4] The Commission on the Cost of Transporting Grain by Rail, Report, Volume I (October, 1976).

[5] The Grain Handling and Transportation Commission, op. cit., pp. 336-337.

[6] See, for example, Booz-Allen & Hamilton Inc. and IBI Group, Grain Transportation and Handling in Western Canada (Ottawa: Department of Industry, Trade and Commerce, July, 1979).

emphasized that it will only negotiate a change in these historic rates when Prairie farmers are prepared to do so. By 1980, a number of broadly representative Western Canadian farm organizations have expressed their support for basic changes in grain freight rates.[7] With the Liberal Party forming a majority in the House of Commons and the next federal government election not expected until mid-1984, the Minister of Transport has implied that it would now be politically expedient to deal with this matter and that he has, in fact, already initiated the process of doing just that.[8] Thus, it would seem that a major revision of government transport policy and freight rate regulation may be imminent.

If grain freight rates remain unchanged the implications of their non-economic nature will also remain. If they are modified, however, incentives for major adjustments may arise in several components of the grain marketing system. One component which may be subject to such an effect is the Canadian flour milling industry (CFMI). It is one of the largest single outlets for the Canadian wheat crop, with

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[7] "Federations mold new freight rate policy", The Western Producer (Saskatoon), January 31, 1980, pp. 1-2.

[8] "Pepin consults his Crow timetable", The Western Producer (Saskatoon), October 30, 1980, p. 22.

about 15 percent of the wheat produced annually being milled in Canada.[9] However, the major markets for Canadian-milled flour are located at great distances from the primary source of the raw wheat supplies. Therefore, the CFMI is heavily dependent upon the transportation system and would be especially sensitive to fluctuations in grain freight rates.

Unfortunately, the CFMI has been experiencing considerable difficulty competing in the world flour markets. Canadian wheat flour exports dropped from their peak of more than 1.5 million tonnes in 1946-47 to less than 370,000 tonnes in 1973-74 and 1974-75. They have recovered modestly in more recent years, to more than 550,000 tonnes in 1977-78,[10] but the industry continues to operate at less than 85 percent of its total capacity despite reductions in the number of mills operating.[11] Any change in the level and/or structure of grain freight rates may influence the profitability of existing flour mills. In fact, there is concern that increased transportation costs would "virtually

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[9] Canada Grains Council, Canadian Grains Industry Statistical Handbook 78 (Winnipeg: 1978), Tables 3 and 21.

[10] Canadian Wheat Board, Annual Report (Winnipeg: various years).

[11] Statistics Canada, Grain Trade of Canada (Ottawa: Catalogue Number 22-201, annual).

guarantee the speedy demise of Canada's already eroded export flour trade."[12]

It has been suggested that regulated grain freight rates may have been a factor in determining the CFMI's current regional distribution.[13] The relationship between the cost of shipping wheat versus flour exerts considerable influence over the determination of the most profitable location for flour mills. Since the flour milling process reduces the weight of product to be shipped by some 27.5 percent,[14] there would seem to be some advantage in locating near the principal source of raw wheat supplies, the Prairies. This is especially true since the current rail freight rates for both wheat and flour are equal on a simple weight basis (even though flour may be implicitly more costly for the railways to carry since it requires greater and more careful handling). However, an increased proportion of the flour

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[12] Canadian National Millers Association, Elimination of the Subsidy on the Movement of Flour and Grain for Export Through Eastern Ports: A Submission by the Canadian National Millers Association to the Minister of Transport (Ottawa: February 16, 1976), p. 1.

[13] Carol D. Nachtigall, George F. Skinner and Edward W. Tyrchniewicz, "Crowsnest Pass Grain Rates: Time for a Change?", Proceedings 1975, Proceedings of the sixteenth annual meeting of the Canadian Transportation Research Forum and the Transportation Research Forum (Oxford, Indianna: Richard B. Cross Company, 1975), pp. 274-275.

[14] T.G. Johnson, "Transportation Related Distortions in the Canadian Flour Milling Industry", in The Grain Handling and Transportation Commission, Grain and Rail in Western Canada, Volume II (Ottawa: Minister of Supply and Services Canada, 1977), p. 389.

milling activity in Canada has taken place in the more highly industrialized central region of the country in recent years. While this shift may, in part, have been due to changing merchandising practices or changing characteristics of the demand for Canadian flour, artificially low regulated freight rates for wheat and flour would appear to have at least de-emphasized the comparative transportation advantage of flour mills located in Western Canada. For the Prairies, a region currently and actively seeking industrialization, this has been viewed as a serious problem.

Scope and Objectives

This study examines the effect which the prevailing freight structure may have upon the Canadian wheat flour economy. Given 1974 levels of supply, demand and freight rates, normative wheat grain and flour milling and distribution patterns within a system of seven domestic regions and five export positions are considered. The impact upon these patterns of adopting a "cost oriented" freight rate structure is analyzed both in the short term and in the longer run period when regional milling capacities might be expanded in response to transportation cost incentives.

The primary objective of this research is to clarify the nature of the relationship between the transportation system and the wheat flour economy. Observations drawn from the analysis provide evidence concerning the influence which the freight rate structure may have had on the past development of the CFMI and suggest some of the implications of future change. Specifically, this study attempts to demonstrate the impact of adopting cost oriented grain freight rates upon:

i) the regional distribution of Canadian flour milling activity;

ii) the real cost of wheat and flour transportation in Canada, and

iii) spatial price equilibrium in the Canadian wheat economy.

Approach

Grain shipment patterns and flour mill locations in Canada are determined by the aggregate effect of a number of interrelated factors, including characteristics of the demand for wheat and flour, the historical pattern of the industry's development and differences in processing and transportation costs between alternative locations. The singular influence of the freight rate structure is obscured by the existence of other factors. In order to isolate the effect of freight rates, therefore, a method of analysis is required which treats the transportation factor as a variable and which, at the same time, accepts the other factors as specified. While this abstraction of certain factors out of the analysis precludes achieving accurate predictive results, it allows the determination of normative solutions based solely upon considerations of freight rates. Thus, the impacts of several alternative freight rate levels and/or structures may be evaluated and compared.

Certain linear programming techniques offer such a method of analysis. The general "transportation" model determines least-cost routings between a number of spatially separated centres of production and consumption for a single commodity.[15] The "transhipment" model incorporates the possibility of indirect shipments between origins and destinations.[16] That is, routings through intermediate transhipment or processing locations are feasible. Further modifications of this technique have resulted in a sophisticated model capable of simulating complex distribution systems. In particular, given regional supplies, demands and processing capacities, it can determine minimum cost transportation flows simultaneously for a number of primary commodities and processed products.

The general approach of this study is to develop a framework within which the linear programming transhipment model may be applied in order to determine optimal wheat grain and flour milling and shipment patterns in Canada. Within this framework, three distinct modifications of the

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[15] F.L. Hitchcock, "The Distribution of a Product from Several Sources to Numerous Localities", _Journal of Mathematical Physics_, Vol. 20, 1941, pp. 224-230.

[16] Alex Orden, "The Transhipment Problem", _Management Science_, Vol. 2, 1956, pp. 276-285.

model are solved. Model I is based upon current freight rates and existing regional flour milling capacities. The solution to this model consists of grain shipment patterns and regional flour milling activities which would minimize transportation user expenditures given existing conditions. This solution provides a basis against which the solutions to subsequent models are compared.

Model II differs from Model I in that the least-cost shipment patterns which are determined are based upon cost oriented freight rates. Differences between the solutions to Models I and II simulate the short run effects of adjusting grain freight rates in this way. That is, they indicate where incentives may arise for changed wheat grain and flour milling and shipment patterns, if a cost oriented freight rate structure were introduced. Conversely, the results of Model II demonstrate the short run economic distortions inherent in the present rate structure.

Model III is also based upon cost oriented freight rates but the constraints limiting regional flour milling activities to existing capacities are relaxed. Regional flour milling is allowed, in this model, to seek out levels which would minimize total transportation user expenditures. Comparison of this solution to that of Model I demonstrates the incentives for long run relocation of the CFMI which would be associated with a change to cost oriented rates.

Comparison of the total direct transportation user cost of the shipment patterns derived in Models II and III with those for Model I (now priced at cost oriented rate levels) estimates the actual dollar-cost to the grain marketing system of maintaining the current freight rate structure (ie. the direct transportation cost of maintaining inefficient grain shipment patterns). In addition, this analytical approach estimates the impact of changing freight rates upon spatial price equilibrium in the Canadian wheat economy. Analysis of the "dual" solutions to the above models provides measures of the changed value of wheat in the various regions which would result from changing the level of freight rates.

Organization

The presentation of this thesis is arranged so as to assist the reader to develop, first, an understanding of some of the problems related to wheat grain and flour transportation in Canada and, second, an appreciation for the procedures applied in the research. Chapter II discusses the Canadian flour milling industry and the existing grain freight rate structure. Some related spatial analyses are also reviewed. Chapter III develops the conceptual framework of the study, including descriptions of the general theoretical models upon which it is based. The analytical procedures, data requirements and specific format of the empirical model developed and applied in this study are outlined in Chapter IV. Chapter V presents the empirical results and observations of this analysis while Chapter VI summarizes their implications and the conclusions to be drawn from them. The study's limitations and some suggestions for further research are also presented in this final chapter. A description of the linear programming transportation model, including several of its extensions, and a comparison of the optimal shipment patterns derived in this analysis with actual grain and grain product shipment patterns in 1974 are contained in the appendices.

CHAPTER II

BACKGROUND

The problem of a freight rate structure which is not based solely upon considerations of cost and efficiency and the effects which it may have had upon wheat grain and flour shipment patterns and the regional distribution of the flour milling industry within Canada is vastly complex. This chapter presents background information which will help to place the problem in its proper perspective. First, an overview of the Canadian flour milling industry is presented. Its present dimensions and some of the reasons for its historical pattern of development are discussed. Next, the determining characteristics of the freight rate structure for wheat grain and flour are summarized. Finally, several analyses which have been completed and which are of particular interest to the present study are reviewed.

The Canadian Flour Milling Industry

> ...no greater possibility of industrial development lies in sight than the creation of an industry which would convert the whole of the great Canadian supply of wheat into its final and highest priced form before it is sold.[1]

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[1] W.W. Swanson and P.C. Armstrong, *Wheat* (Toronto: The MacMillan Company of Canada Limited, 1930), p. 238.

Written in 1930, these words provide an indication of the unbounded optimism which once characterized the Canadian flour milling industry (CFMI). At that time, the industry was in the midst of a period of rapid growth and transition. The older system of many tiny mills, each serving only their local community, was being replaced by a system of much more efficient and economical large modern mills (at least by that day's standard). Export markets for Canadian-milled flour were expanding quickly and the industry's future appeared bright.

Table 2.1 presents an overview of the CFMI as it existed in 1926. At that time, there were some 442 flour mills operating in Canada. It is interesting to note the divergence between average mill capacities in the various

Table 2.1:

The Number, Location and Capacity of Flour Mills in Canada, 1926

Region	Number of Mills		Average Daily Capacity per Mill
Maritimes	40		3.6 tonnes
Quebec	92	..........)	26.4 tonnes
Ontario	199	..........)	
Western Canada	111		29.2 tonnes
Canada	442		25.1 tonnes

SOURCE: Derived from W.W. Swanson and P.C. Armstrong, *Wheat* (Toronto: The MacMillan Company of Canada Limited, 1930), p. 238.

regions of the country. The greater average mill capacity in Western Canada is indicative of a tendency for the newer larger mills to locate there, near the primary source of wheat supplies. The much lower average capacity of mills in the Maritime region would seem to suggest that new mills were not locating there.

The great expectations which had developed for the future of the CFMI were never realized, however. Flour milling in Canada reached a peak following World War II and has since declined considerably (see Figure 2.1). Canada's position in the world flour markets has declined in both absolute and relative terms. Exports dropped from their peak of more than 1.5 million tonnes in 1946-47 to less than 370,000 tonnes in 1973-74 and 1974-75 before recovering modestly to about 580,000 tonnes in 1978-79.[2] Between the five year periods 1950-51 to 1954-55 and 1970-71 to 1974-75, our share of total world trade in flour dropped from 37.3 percent to only 11.4 percent.[3] Over the same time period Canadian domestic consumption increased somewhat due to continuing population growth, thus acting as a stabilizing influence. The future outlook for the CFMI "is not

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[2] Statistics Canada, Grain Trade of Canada (Ottawa: Catalogue Number 22-201, annual).

[3] J.S. Carmichael, "Canadian Wheat Flour Situation", Canadian Farm Economics, Volume 12, Number 1, February, 1977, p. 18.

Figure 2.1: <u>Total Production, Exports and Domestic Disappearance of Canadian Wheat Flour, 1930-31 to 1977-78</u>

SOURCE: Statistics Canada, Grain Trade of Canada (Ottawa: Catalogue Number 22-201, annual).

optimistic",[4] however, despite the slight improvements recorded since 1974-75.

A number of factors which have contributed to the current plight of the CFMI have been enumerated:[5]

i) the European trend towards flour milling self-sufficiency and, in some cases, the creation of excess capacity resulting in competing flour exports from those countries;

ii) the establishment of domestic flour milling industries in a number of less developed countries, particularly in South America, which were formerly customers of the CFMI;

iii) increased subsidies on flour exports by Canada's major competitors;

iv) the higher cost of ocean freight for flour than for wheat;

v) relative prices at Canadian export positions which favor bulk wheat sales over flour sales, and

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[4] Ibid., p. 19.

[5] David Tak-Wai Leung, "The Concept of Effective Subsidy and Its Application to the Flour Milling Industry" (unpublished Master's thesis, Department of Agricultural Economics, University of Manitoba, 1973), pp. 21-38.

vi) changed baking technology which allows the use of lower quality flour (as opposed to Canadian flour which is generally of a higher quality).

As total sales have declined, flour mills in Canada have been forced to reduce both their production and their numbers. Table 2.2 compares the number and location of flour mills operating in Canada in 1948, 1958, 1968 and 1978. Even with the reduction in the number of flour mills which are active, from 174 in 1948 to only 39 in 1978, the remaining mills still operate at less than 85 percent of their total capacity.[6] Furthermore, the excess capacity is not distributed evenly throughout the industry but is more severe in Western Canadian mills.[7] Prior to 1964-65, flour milling in Canada was divided more or less equally between the provinces east of and west of the Ontario-Manitoba boundary (see Figure 2.2). Western mills now only account for about 30 to 35 percent of total Canadian production, however, whereas eastern mills account for about 65 to 70 percent.

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[6] Statistics Canada, Grain Trade of Canada, op. cit.

[7] Om P. Tangri and E.W. Tychniewicz, "The Removal of the Crow's Nest Pass Rates on Grain and Grain Products Moving to Eastern Canada for Domestic Consumption: Implications for Industrial Development and Expansion in the Prairie Provinces, Especially Manitoba", a Position Paper prepared for the Manitoba Department of Industry and Commerce, August, 1971, p. 37.

Table 2.2:

The Number and Location of Flour Mills in Canada, 1948, 1958, 1968 and 1978

Location	1948*	1958†	1968‡	1978§
Nova Scotia	1	-	-	1
Quebec	5	4	5	4
Ontario	78	41	28	20
Manitoba	25	7	6	5
Saskatchewan	29	9	6	4
Alberta	31	10	9	5
British Columbia	5	2	4	-
Canada	174	73	58	39

Sources: *Dominion Bureau of Statistics, Flour Mills in Canada, 1948 (Ottawa: Catalogue Number 32-D-23, annual).

†Dominion Bureau of Statistics, Flour Mills and Feed Mills in Canada, 1958 (Ottawa: Catalogue Number 32-501, occasional).

‡Dominion Bureau of Statistics, Flour Mills and Feed Mills in Canada, 1968 (Ottawa: Catalogue Number 32-401, bienniel).

§Statistics Canada, Grain Milling Statistics, August 1978 (Ottawa: Catalogue Number 32-003, monthly).

Figure 2.2: Wheat Flour Milled in Eastern and Western Canada, 1930-31 to 1977-78

SOURCE: Statistics Canada, Grain Trade of Canada (Ottawa: Catalogue Number 22-201, annual).

Western Canadian flour mills have traditionally relied upon the export market for the bulk of their sales while Eastern Canadian mills have been oriented more towards supplying the domestic market.[8] Thus, the serious losses of export flour sales experienced in the past have been largely at the expense of Western Canadian mills.[9] Eastern Canadian mills, on the other hand, have benefited from the steady growth of the domestic market.

Freight Rates and Flow Patterns

Interregional flows of wheat grain and flour within Canada arise as a result of the need to satisfy diverse requirements out of available, but remote, supplies. To a large extent, the pattern which these flows assume constitutes an attempt on the part of the grain marketing system to economize required transportation expenditures. As such, freight rates exert a considerable influence over the development of these flow patterns. However, the freight rate structure for grain, in addition to being determined by purely economic factors, is also affected by a number of institutional constraints and regulations. The result of these non-economic considerations is a system of freight rates so complex that the factors governing any particular shipment of grain are often conditions specific only to that

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[8] Ibid.

[9] Leung, op. cit., pp. 31-35.

shipment. Nonetheless, an appreciation for at least the fundamental forces underlying these shipment patterns is a prerequisite to further study of the system. An attempt is therefore made to summarize and discuss the main features of the freight rate structure for wheat grain and flour within the confines of the following few pages.

All shipments of grain and certain grain products (including wheat flour) from any point on any railway line west of Thunder Bay to:

i) Thunder Bay and Armstrong, Ontario for export or domestic destinations;

ii) Vancouver and Prince Rupert, British Columbia for export, only, and

iii) Churchill, Manitoba for export, only,

are shipped at the statutory "Crow's Nest Pass" grain freight rates. However, these rates, fixed by Act of Parliament (Statutes of Canada, Chapter 52, 1925) at a level of approximately one-half cent per ton-mile, are below the level of costs incurred by the railways in providing the associated services. In fact, the Commission on the Costs of Transporting Grain by Rail (the Snavely Commission) found that in order for the railways to have recovered the variable costs, alone, associated with this traffic for calendar year 1974, the statutory rates would have had to have been increased by a factor of 2.61.[10] By 1977 this

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[10] The Commission on the Costs of Transporting Grain by Rail, Report, Volume I (October, 1976), p. 205.

ratio of variable costs to user revenues had increased to some 3.08[11] and by 1980-81 has undoubtedly increased further. The Commission emphasized that even rates at such levels as these would not assure "an ongoing, viable grain transportation system" but that, in addition, some contribution towards system constant costs would also have had to have been generated by this traffic.[12]

Shipments of grain and grain products between Prairie points and from Prairie points to British Columbia which are destined for domestic consumption are shipped at rates substantially higher than the statutory rates. In 1974 domestic rail rates from various Prairie points to Vancouver, for example, ranged from two and one-half to six times greater than the statutory rates for similar shipments which were destined for export.[13] Shipments of Prairie feed grains (including low grade wheat and millfeeds) to certain domestic markets outside of the three Prairie provinces,

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[11] Snavely, King and Associates, 1977 Costs and Revenues Incurred by the Railways in the Transportation of Grain under the Statutory Rates (Ottawa: Transport Canada TP1758, September, 1978), Schedule IV-3.

[12] The Commission on the Costs of Transporting Grain by Rail, op. cit., p. 64.

[13] Statistics Canada, Grain Trade of Canada, op. cit.

however, are subsidized under the federal government's Feed Freight Assistance program. This program, intended to "ensure the fair equalization of feed grain prices in various locations of Eastern Canada and British Columbia, ...establishes freight subsidies in such a manner that the net costs of transport after allowance for the subsidy are approximately equalized to all locations."[14]

Eastwards from Thunder Bay, shipments of grain (in bulk) may travel by rail, by lake vessel or by a combination of rail and lake vessel. Flour, on the other hand, is not so easily loaded onto lake vessels because it requires more careful handling since it is prone to contamination. Flour milled in the West, therefore, normally follows an all rail route to destinations east of Thunder Bay.

Freight rates for moving grain by water are characteristically economical. This is particularly true for movements on the St. Lawrence Seaway where, prior to 1978, tolls charged for the use of Seaway facilities were indirectly subsidized by the federal government. In 1976-77, for example, the fees levied by the St. Lawrence Seaway Authority only generated sufficient revenues to cover approximately 80 percent of the operation and maintenance

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[14] Food Prices Review Board, Feed Grains Policy in Canada (Ottawa: December, 1975), p. 42.

costs of the Seaway.[15] Moreover, this figure is irrespective of any consideration for the near-billion dollar capital committment of the Seaway. Reinforced by this subsidization, the water route east of Thunder Bay enjoys a strong advantage over the rail route, especially on shipments for domestic consumption.

Rail shipments of wheat and flour for export through east coast ports also enjoy substantial government assistance in the form of a freight rate hold-down and subsidy program. The "At and East" rates[16] for wheat from any of the railway points along Georgian Bay, along Lake Huron or along any waterways directly or indirectly connecting with Lake Huron and not being farther east than Prescott, Ontario to any of the ports of Halifax, Saint John, West Saint John, Montreal and to those ports on the St. Lawrence River to the east of Montreal have been frozen at their levels of November 30, 1960. The "At and East" rates for flour from any point in Canada east of the 90th degree of west longitude (thus including Thunder Bay and Armstrong, Ontario) to those same eastern ports have been frozen at their levels of September 30, 1966. The railways

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[15] Gordon C. Shaw, "Who Will Pay the Freight? The Merits of User-Pay and Full-Cost Recovery" (paper presented to the Financial Post conference "The Seaway-Great Lakes Transportation System", October 17, 1979), Exhibit 2.

[16] Actually, statutory reference is to the "Eastern rates". Railway Act, Chapter R-2 (1970), Section 272.

are subsequently reimbursed by subsidies amounting to the difference between these rates and current compensatory rates, as determined by the Canadian Transport Commission. These subsidies amounted to some $25.5 million for 1978.[17] Originally this program was intended to encourage the continued use of Canadian east coast ports (in competition with American Atlantic ports) for the export of Canadian wheat and flour. More recently, however, it has been alleged that this traffic (especially the flour) simply cannot bear the burden of increased freight rates because of international market conditions.[18] Since the subsidies paid with respect to this traffic continue to rise as transportation costs increase but the rates paid by shippers remain fixed, the impact of this program on the industries affected has become significantly greater since its inception. If no change is made, the natural advantage of the all water route over rail for grain shipped east from Thunder Bay may eventually be threatened.[19]

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[17] Canadian Transport Commission, The Thirteenth Annual Report of the Canadian Transport Commission 1979 (Ottawa: Minister of Supply and Services, 1980), Appendix H, p. 94.

[18] Canadian National Millers Association, Elimination of the Subsidy on the Movement of Flour and Grain for Export Through Eastern Ports: A Submission by the Canadian National Millers Association to the Minister of Transport (Ottawa: February 16, 1976).

[19] For an historical review of this subsidy program, see Howard J. Darling, An Historical Review of Direct Transport Subsidies in Canada (Ottawa: Canadian Transport Commission, ESAB 75-8, June, 1975), pp. 26-28.

A related feature of the freight rate structure which affects wheat grain and flour shipments for export is the milling-in-transit privilege granted by the railways and the associated government stop-off fee subsidy. Given this privilege, flour millers are able to ship wheat from a given point to their mills, process it there, then forward the flour to its destination and be charged only the through rate from the original point to the final destination plus a stop-off fee. For mills situated east of the 90th degree of west longitude, this stop-off fee has been frozen at the level in effect on September 30, 1966 (namely 3 cents per cwt.) as part of the "At and East" rates. Again, the railways are subsequently reimbursed by subsidies amounting to the difference between this level and a current compensatory level, as determined by the Canadian Transport Commission. By February of 1981 this compensatory level was estimated to be some 32 cents per cwt. Thus, the railways received 29 cents in subsidies per cwt. of export flour milled in-transit within this region. In order to avoid direct discrimination against mills in Western Canada, the federal government (by authority of special Cabinet decision) subsidizes mills west of the 90th degree of west longtitude by the same amount for stop-off fees paid on export flour shipments. It is to be noted, however, that this subsidy is paid to the western mills, as opposed to to the railways on behalf of the eastern mills. Also, it applies to export flour shipments through all ports, not just those named in reference to the "At and East" rates.

Related Research

Unfortunately, there has been little quantitative research conducted to ascertain the regional implications of Canada's grain freight rate structure. This section does summarize, however, the approach and findings of one relevant study: an examination of transportation related distortions affecting the Canadian flour milling industry, by T.G. Johnson. A series of American studies which adopted a more comprehensive analytical approach to a similar type of problem, and upon which the general approach of this thesis is based, is also outlined.

Johnson

T.G. Johnson,[20] in an analysis conducted for the Grain Handling and Transportation Commission (the Hall Commission), investigated a number of transportation related distortions which were thought to impart unequal advantages to flour mills located in different regions of Canada. The approach of the study was, basically, that of an accounting-type cost comparison of the impact of alleged

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[20] T.G. Johnson, "Transportation Related Distortions in the Canadian Flour Milling Industry", in the Grain Handling and Transportation Commission, Grain and Rail in Western Canada, Volume II (Ottawa: Minister of Supply and Services Canada, 1977), pp. 378-434.

distortions upon the relative comparative advantage of two fictitious flour mills: one, representing Western Canadian mills, located in Saskatoon, Saskatchewan and the other, representing Eastern Canadian mills, located in Montreal, Quebec.

The possible distortions considered in the analysis included:

i) Canadian Wheat Board overcharges;

ii) mill diversion charges;

iii) storage and carrying charges;

iv) statutory grain freight rates;

v) Feed Freight Assistance;[21]

vi) the "At and East" subsidy;

vii) St. Lawrence Seaway tolls;

viii) the Canadian import tariff on U.S. corn, and

ix) the stop-off fee subsidy.

The markets for which the two mills were assumed to be competing were the Eastern and Western Canadian domestic markets for flour, the export market for flour, the Eastern Canadian, Prairie province and British Columbia domestic markets for millfeeds and finally, the export market for millfeeds. The findings of the analysis, in

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[21]While a general discussion of possible effects of the Feed Freight Assistance program was included, no estimates of the levels of effective subsidies arising out of this source of distortion were presented.

terms of effective levels of subsidization arising out of each source of distortion, are presented in Table 2.3. With respect to each of the markets for flour, Johnson concluded that mills in Eastern Canada received significantly higher levels of effective subsidies than mills in Western Canada, particularly with respect to the domestic flour markets. Eastern and Western mills were found to receive equal benefits with respect to the millfeeds export market but Western mills received a somewhat higher rate of effective subsidy than Eastern mills with respect to the Eastern Canadian domestic millfeeds market. Finally, in the Prairie province and British Columbia domestic millfeeds markets, where the Eastern mills were assumed not to be competing, Western mills received small effective subsidies from these transportation related distortions.

While the approach of this analysis was simple, it was nonetheless successful in several respects. It did sort out some of the very complex distortions which characterize the Canadian grain handling and transportation system and it did provide some evidence of "the sensitivity of locational advantage in the Canadian flour milling industry."[22] Unfortunately, it did not represent a comprehensive analysis of the problem.

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[22] Ibid., p. 422.

Table 2.3

Transportation Related Distortions in the Canadian Flour Milling Industry--
Effective Subsidies to Eastern and Western Mills, 1976*

(cents per hundredweight of flour)

Source of Distortion \ Market	EASTERN MILLS					WESTERN MILLS						
	FLOUR			MILLFEEDS		FLOUR			MILLFEEDS			
	EAST	WEST	EXPORT	EAST	EXPORT	EAST	WEST	EXPORT	EAST	WEST	B.C.	EXPORT
C.W.B. Overcharges	-11.13	-11.13	-11.13	-	-	-22.75	-24.02	-19.78	-	-	-	-
Mill Diversion Charges	-	-	-	-	-	- 4.14	- 3.45	- 5.75	-	-	-	-
Storage & Carrying Charges	30.63	30.63	30.63	-	-	10.21	10.21	10.21	-	-	-	-
Statutory Rates	22.00	22.00	22.00	8.36	8.36	22.00	-	22.00	8.36	-	-	8.36
At and East Subsidy	-	-	-	-	-	-	-	37.00	-	-	-	-
Seaway Tolls	2.76	2.76	-	-	-	-	-	-	2.76	-	-	-
Corn Tariff	-	-	-	5.43	-	-	-	-	5.43	5.43	5.43	-
Stop-off Subsidy	-	-	15.00	-	-	-	-	5.00	-	-	-	-
TOTAL	44.26	44.26	56.50	13.99	8.36	5.32	-17.26	48.68	16.55	5.43	5.43	8.36

*The original source does not make clear the base date for which these estimates were made. However, it would appear that information available to mid-1976 is reflected in the figures.

SOURCE: T. G. Johnson, "Transportation Related Distortions in the Canadian Flour Milling Industry," in The Grain Handling and Transportation Commission, Grain and Rail in Western Canada, Volume II (Ottawa: Minister of Supply and Services Canada, 1977), Table VII-5, p. 408.

American Studies

Traditionally, freight rates for wheat and flour in the United States were equal. On account of the weight loss characteristic of the flour milling activity, that industry had therefore found it advantageous to locate near the wheat supply regions or at points intermediate between the supply regions and the major markets for the flour. During the early 1960's, however, the relationship between the rates for wheat and flour changed significantly. Technological improvements which favored bulk shipments of grain lead to the rates for wheat being reduced relative to those for flour. The effect of this was to change the most profitable pattern of flour mill location to one of market orientation. A series of three analyses were conducted to investigate this development.

Wright[23] developed a linear programming transhipment model to examine the effects of the change in the freight rate structure upon the profitability and subsequent reorientation of the U.S. wheat flour economy. The model analyzed the flow patterns of wheat and wheat flour between some seventy-one producing regions, twenty-eight milling centers, ten export positions and fifty-seven market areas.

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[23] Bruce H. Wright, Regional and Sectoral Analysis of the Wheat-Flour Economy: a transportation study (Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, Marketing Research Report Number 858, October, 1969).

Optimum (least total cost) shipment patterns were determined, first under the assumption that transportation rates for wheat and flour were equal and, then, under the assumption that they were twenty percent less for wheat. Comparison of the two solutions clearly illustrated that under the new rate structure significant incentives did exist for flour mills to relocate nearer their major markets and for the shipment patterns of wheat and flour to change accordingly. Whether such reorientation would actually occur, however, was said to depend upon the magnitudes of the associated costs of relocation.

By examining the "dual" solutions to the model, Wright was also able to observe the changed values of wheat and flour in each of the regions which would theoretically arise as a result of the changes made to the freight rate structure: in surplus regions, producers received more for their wheat but consumers had to pay more for their flour; in deficit regions, producers received less for their wheat but consumers had to pay less for their flour.

<u>Leath and Blakley</u>[24] developed a more elaborate transhipment model to further Wright's analysis. They

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[24] Mack N. Leath and Leo V. Blakley, <u>An Interregional Analysis of the U.S. Grain-Marketing Industry, 1966-67</u> (Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, Technical Bulletin Number 1444, November, 1971).

formulated four basic models, each incorporating five primary commodities (hard wheat, soft wheat, durum wheat, feedgrains and soybeans) and two processed products (hard wheat flour and soft wheat flour). Their first model determined optimum (least total cost) flow patterns between 42 domestic and 13 export regions, assuming 1966/67 supplies, demands and competitive conditions. Regional milling capacities were restricted to levels in existence at the time. Their second model, however, relaxed the milling capacity restraints, allowing regional milling activities to seek optimum (equilibrium) levels. This analysis provided guidelines by which the flour milling industry could make locational adjustments consistent with the existing transportation rate structure. Their results reaffirmed that significant incentives for such adjustments did exist, although they conceded that other factors--primarily costs related to abandonment of existing capacity and uncertainty with respect to future changes in the transportation rate structure--may well have outweighed these incentives. Their third model introduced a minimum inventory level restriction equal to fifteen percent of each region's annual requirements (five percent of volume handled in export regions). Thus, the model was made to more realistically represent actual conditions. Finally, the fourth part of Leath and Blakley's analysis involved time-staging of their model. Solutions were determined simultaneously for each of the four quarters of the marketing year. It was then possible to examine seasonal utilization of regional storage capacities and to determine the effect of this upon optimal grain shipment patterns.

In a third study of the U.S. grain marketing system, Schnake and Franzmann[25] argued that a transportation rate structure based upon any concept other than cost of service could foster an allocation of resources which might be highly inefficient. Therefore, they conducted a study to estimate cost of service transportation rates for the different modes servicing the grain marketing industry. Then, by duplicating Leath and Blakley's first model, but substituting cost of service rates for actual rates, they were able to observe the short run effects on grain shipment patterns of actually replacing existing freight rates by cost of service rates. They found that the more efficient flow patterns which resulted lead to a reduction in total marketing costs for the system of approximately nineteen percent. Schnake and Franzmann's second model relaxed the regional flour milling and storage capacity restraints, allowing these activities to seek optimum levels. The solution to this model illustrated the longer run impact upon the various market sectors of introducing cost of service rates, specifically indicating where future flour milling and storage capacity should be developed.

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[25] L.D. Schnake and John R. Franzmann, Analysis of the Effects of Cost-of-Service Transportation Rates on the U.S. Grain Marketing System (Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, Technical Bulletin Number 1484, October, 1973).

CHAPTER III

CONCEPTUAL FRAMEWORK

This chapter presents theoretical models which help to explain the relationships under investigation in this study. As outlined earlier, the object of this thesis is to consider the effects of a modified freight rate structure for wheat grain and flour upon the regional distribution of flour milling activity, upon the total real cost of wheat grain and flour transportation and upon interregional price relationships in the Canadian wheat flour economy. The sections which follow describe the role of transportation costs in the determination of industrial location patterns, interregional trade flows and spatial price equilibrium.

Transportation Costs and Industrial Location

Industrial location theory attempts to systematically specify, interpret and describe the effects of economic factors which influence the location decisions of industry. Factors which are likely to affect the profitability of firms in various locations include not only the transportation costs of supply procurement and product distribution, but also: differences in processing costs; economies of scale; characteristics of the supply of inputs and of the demand for products; and, inter-industry relations and other agglomerating influences. In addition, environmental, technological or institutional considerations and the historical pattern of an industry's, a region's or a nation's development may enter into the location decision process.

While a number of attempts have been made, no completely general theory has yet been developed which satisfactorily incorporates all of the relevant factors into a single model.[1] As a result, spatial researchers have relied upon partial equilibrium models as a basis for analyzing practical location problems. In applications where one location-determining factor is of overriding interest, this approach has proven successful.

In this study, where the effects of a particular group of freight rates upon the location pattern of a single industry (the flour milling industry) are of primary concern, a partial equilibrium approach is adopted which concentrates exclusively upon the role of transportation costs. The optimal plant site, therefore, is deemed to be where the total cost of assembling required raw materials and distributing finished products is minimized. In this way, the implications of the current rate structure may be

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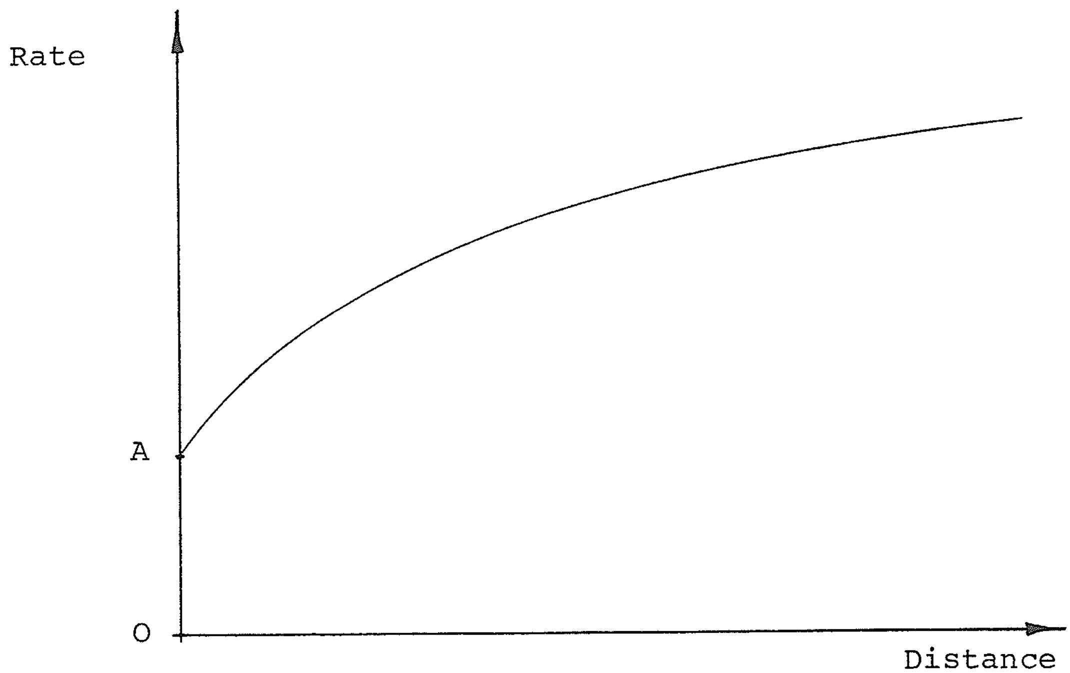
[1]For a review and criticism of some attempts at a general location theory, see Harry W. Richardson, Regional Economics (London: Weidenfeld and Nicolson, 1969), pp. 101-116 and/or David M. Smith, Industrial Location (New York: John Wiley and Sons, Inc., 1971), pp. 143-158.

evaluated and compared with those of alternative rate structures in isolation from the complex of interrelationships which actually determine site selection.

If only a limited number of alternative locations are available for consideration, site selection becomes a relatively simple task, requiring only the calculation and comparison of costs which would be incurred at each. The role played by transportation costs in the determination of industrial location is given a more general treatment in this section, however. Specifically, the effects of a number of factors which may lead to variations in total transportation costs from one location to another are described. The principles outlined apply equally as well in complex situations as in simple cases.

Two characteristics of freight rates, themselves, tend to influence industrial location decisions. Tariffs charged for transporting goods normally consist of a fixed portion and a variable portion which increases (at a decreasing rate) with the distance to be travelled. Figure 3.1 illustrates a typical rate: distance relationship.

Figure 3.1: A Typical Rate: Distance Relationship



The fixed portion of the tariff, or "terminal charge" (OA in Figure 3.1), is meant to cover the costs incurred in the operation of the fixed facilities (primarily loading and unloading costs). It is levied equally for all shipments, regardless of the distance to be travelled. As such, it represents a relatively greater portion of the tariff charged and, consequently, a relatively greater burden for shorter hauls than for longer ones. The variable portion of the tariff, or "line-haul charge" (the portion above A in Figure 3.1), relates to the costs of actually carrying the shipment from the point of origin to the destination. In most instances, this line-haul charge increases less than proportionately with the distance to be travelled (resulting in the non-linear line segment in Figure 3.1). The effect of these characteristics of freight rates is that line-haul charges per ton-mile are generally less for longer shipments than for shorter ones.

Terminal charges which are not related to distance and line-haul charges which increase less than proportionately with distance establish the basis for an important general principle of industrial location theory. Individual shippers will, whenever possible, attempt to avoid terminal charge levies and, at the same time, will attempt to take advantage of the lower rates per ton-mile asssociated with longer haul shipments. Thus, the economic advantages associated with long haul shipments tend to encourage industries to locate at either the source of their raw materials or at the market for their products, but not at intermediate points.

Physical characteristics of the transportation infrastructure may also influence industrial location decisions. Particular modes of transport may be better suited to the carriage of certain commodities in either finished or raw form. If the choice of mode for some routes is limited, this may dictate that the manufacturing process must occur before or, conversely, that it must occur after the goods are transported. As another example, if a particular journey is made up of two distinct segments and the goods being shipped must be transferred from one carrier to another at the junction, manufacturing firms may find it advantageous to locate at the breaking-point. Plants located there would incur only the same transportation expenses as, and may therefore be equally as competitive as plants located at either the sources of their raw material or the markets for their product.

A practical aspect of the rate structures of many transportation agencies, the granting of "in-transit" privileges, results in a similar situation. Under such an arrangement consignees are allowed to unload, process and reload their goods at some intermediate point but are only charged the applicable through rate. While a fixed "stop-off" fee may in some cases be levied for this service, in-transit privileges may nonetheless remove some or all of the competitive advantage with respect to transportation costs otherwise enjoyed by sources of raw material and market centers vis-a-vis intermediate locations.

Total transportation costs facing a manufacturing firm depend not only upon distances, however, but also upon the weight of material to be shipped and the rate charged per unit weight per distance (for example, per ton-mile). Either or both of these factors are likely to influence the level of transport costs at alternative plant locations.

Most production processes involve at least some change in total product weight. A finished product may weigh significantly more or less than the basic raw materials required to produce it. The processing of primary commodities, for example, usually involves the removal of some unwanted portion of the raw material and consequently a considerable decrease in weight. Such manufacturing activities generally minimize their transportation expenditures by locating at or near the source of their raw material, (in which case they are referred to as "input-, resource- or supply-oriented" processes). Simply stated, "it costs less to ship product than material in weight-losing processes because there is less weight to transport."[2] For equivalent reasons, weight-gaining processes often find it most economical to locate at or near the markets for their products (and are therefore referred to as "market-oriented"). Of course, still other industrial processes find no particular advantage in locating at either the source of their inputs or the market for their products (and may be referred to as "foot-loose").

The freight rates charged for shipping a finished product and its raw material may differ substantially. While a given commodity in its natural state may facilitate bulk handling, for example, in finished form it may require more specialized handling, it may be fragile or perishable, it may be in smaller lots or it may require special containers or other equipment. In any case, a rate differential for raw material and finished product will affect

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[2]Raymond G. Bressler Jr. and Richard A. King, Markets, Prices, and Interregional Trade (New York: John Wiley and Sons, Inc., 1970), p. 356.

the minimum transportation cost plant location. Thus, both the weight of material to be shipped and the rate charged per unit weight per distance for shipping that material must be taken into consideration when determining a least transportation cost plant location. In general, if the total cost of shipping finished product exceeds that of shipping raw material, transportation costs will be minimized if the plant site is at the market center. Conversely, if the cost of shipping raw material exceeds that of shipping finished product, the optimal location will be at the source of the raw material.

These general principles of industrial location theory are helpful in explaining the spatial distribution of economic activities. While they are posed in relatively simple terms and may ignore practical considerations which contribute to the variation of transport costs between alternative locations, as general principles their validity and relevance remain undiminished. Alone, they cannot explicitly define optimal location patterns when multiple inputs, multiple products or multiple point systems are under consideration, but they do govern the development of optimal patterns. In multi-dimensional problems, each segment must be treated relative to the remainder. Practical solutions will amount to aggregates of individual effects and influences. At the base of these may be found the fundamental principles described in this section.

Transportation Costs, Interregional Trade Flows and Spatial Price Equilibrium

Transportation costs, by their nature play a key role in the determination of price differentials over space. They are thus an integral determinant of a region's comparative advantage vis-a-vis its competitors and, therefore, exert considerable influence over the level and pattern of trade flows between regions. As such, freight rates have the potential to significantly enhance or detract from the level of economic activity and general prosperity of regions.

This section presents a simple economic model which attempts to explain the theoretical justification of price differentials over space. At the same time, this model illustrates the determination of equilibrium levels of interregional trade flows. It is of particular relevance to this study because it demonstrates the role played by transportation costs in each of these respects.[3]

Consider a situation in which there are two spatially separated regions (A and B) and suppose that the existing levels of supply and demand for some homogeneous commodity in each are known. Figure 3.2 illustrates the initial supply-demand relationships of these

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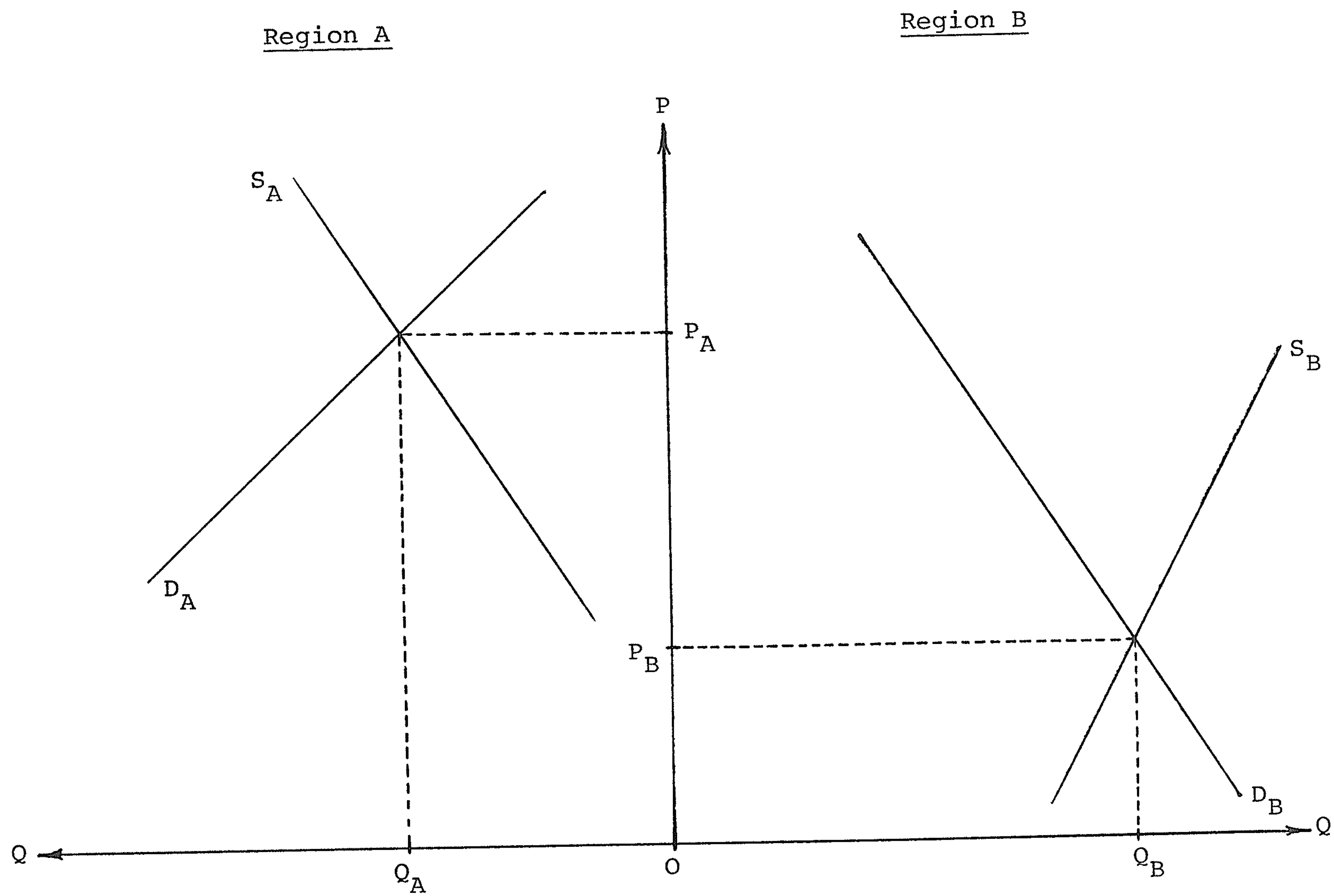
[3]This section follows similar treatments by Bressler and King, ibid., pp. 86-92, and Richardson, op. cit., pp. 13-18.

Figure 3.2: Two Region Spatial Equilibrium Model



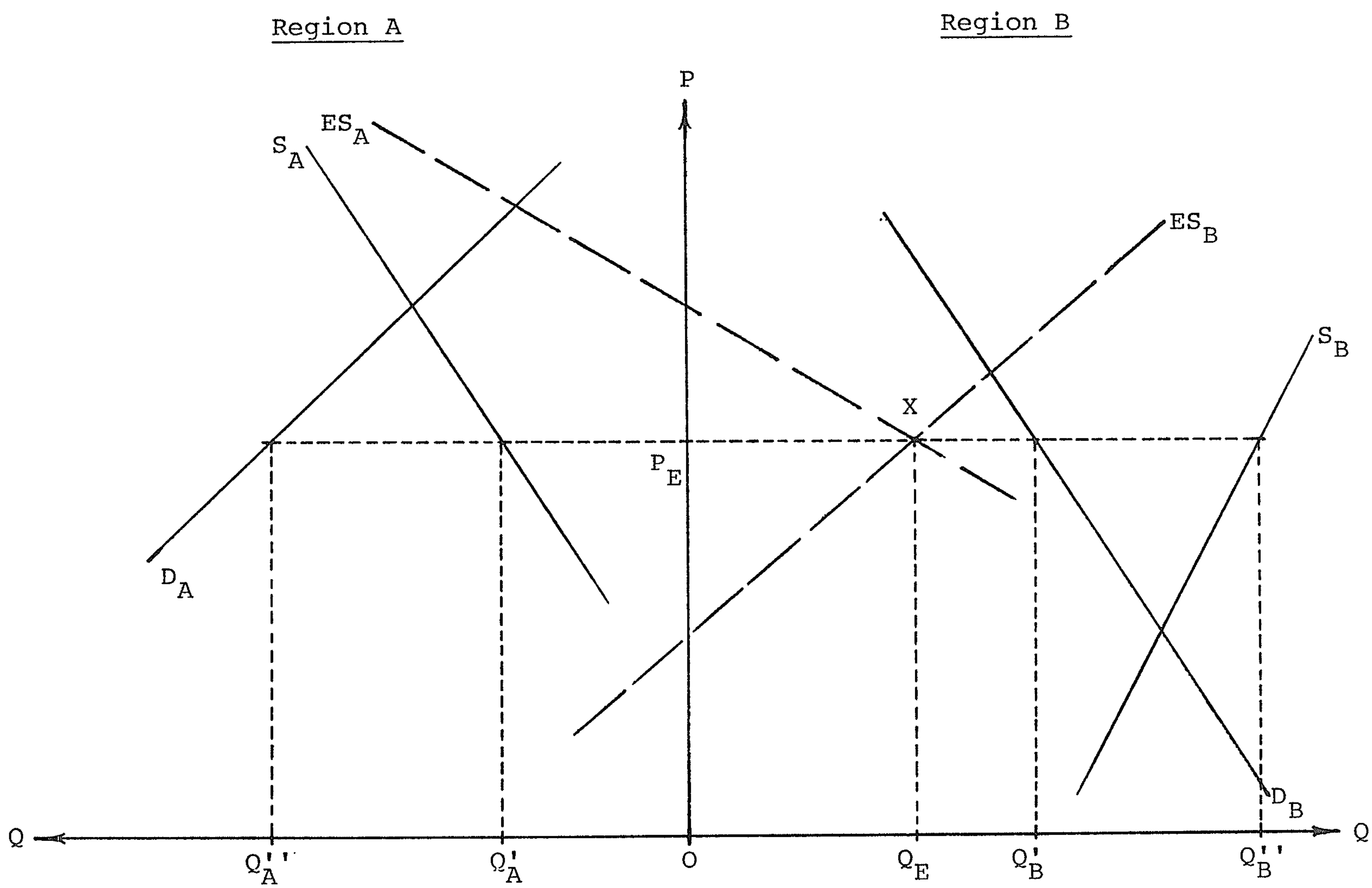
two regions in a "back-to-back" diagram. Region B's supply and demand curves (S_B and D_B, respectively) have been plotted in the conventional manner on the right-hand side of the diagram. The price of the commodity is plotted on the vertical axis and the quantity of commodity is plotted on the horizontal axis, increasing to the right. Region A's supply and demand curves (S_A and D_A, respectively), however, have been plotted in reverse form on the left-hand side of the diagram. In this way a common vertical price axis is employed for the two regions. Quantities of commodity in Region A are plotted on the horizontal axis, increasing to the left.

In the initial autarchic situation portrayed in Figure 3.2, equilibrium prices and quantities supplied and demanded are equal to OP_A and OQ_A, respectively, in Region A and are equal to OP_B and OQ_B, respectively, in Region B. Clearly the equilibrium price in Region A is much higher than in Region B. As long as this relationship persists, there may be some incentive for entrepreneurs to purchase quantities of the commodity in Region B, ship them to Region A and sell them at the higher price which prevails there. Indeed, if we assume, for the time being, that transportation and all other transaction costs are equal to zero we can be certain that this will occur. The questions remain, however, "How much of the commodity will be exported from Region B to Region A?" and "What will the new equilibrium situations in each region be?" In order to answer these questions, we must define "excess" supply functions for each region as being equal to "the amount by which the quantity offered for sale exceeds the quantity purchased or demanded at various levels of price."[4]

Excess supply functions for Regions A and B have been plotted in Figure 3.3 as ES_A and ES_B, respectively. With completely free interregional trade, the excess of S_B over D_B at prices greater than OP_B will be exported from Region B in order to offset the deficit of S_A under D_A at prices less than OP_A in Region A. The intersection of the excess supply functions at point X represents the determination of the new equilibrium position. The prevailing price in each region will be equal to OP_E and the quantity shipped from Region B to Region A will be equal to OQ_E. This quantity is equal to the amount by which supply exceeds demand in Region B at a price of OP_E (ie. $Q'_BQ''_B$) and, at the same time, is equal to the amount by which demand exceeds supply in Region A at a price of OP_E (ie. $Q'_AQ''_A$). The effect of the escalated price level in Region B is a reduction in consumption by local residents but an increase in output by local producers. The effect of the lowered price level in Region A is an increase in consumption but a decrease in production. These changes

[4]Bressler and King, op. cit., p.88.

Figure 3.3: Two Region Spatial Equilibrium Model With Excess Supply Functions



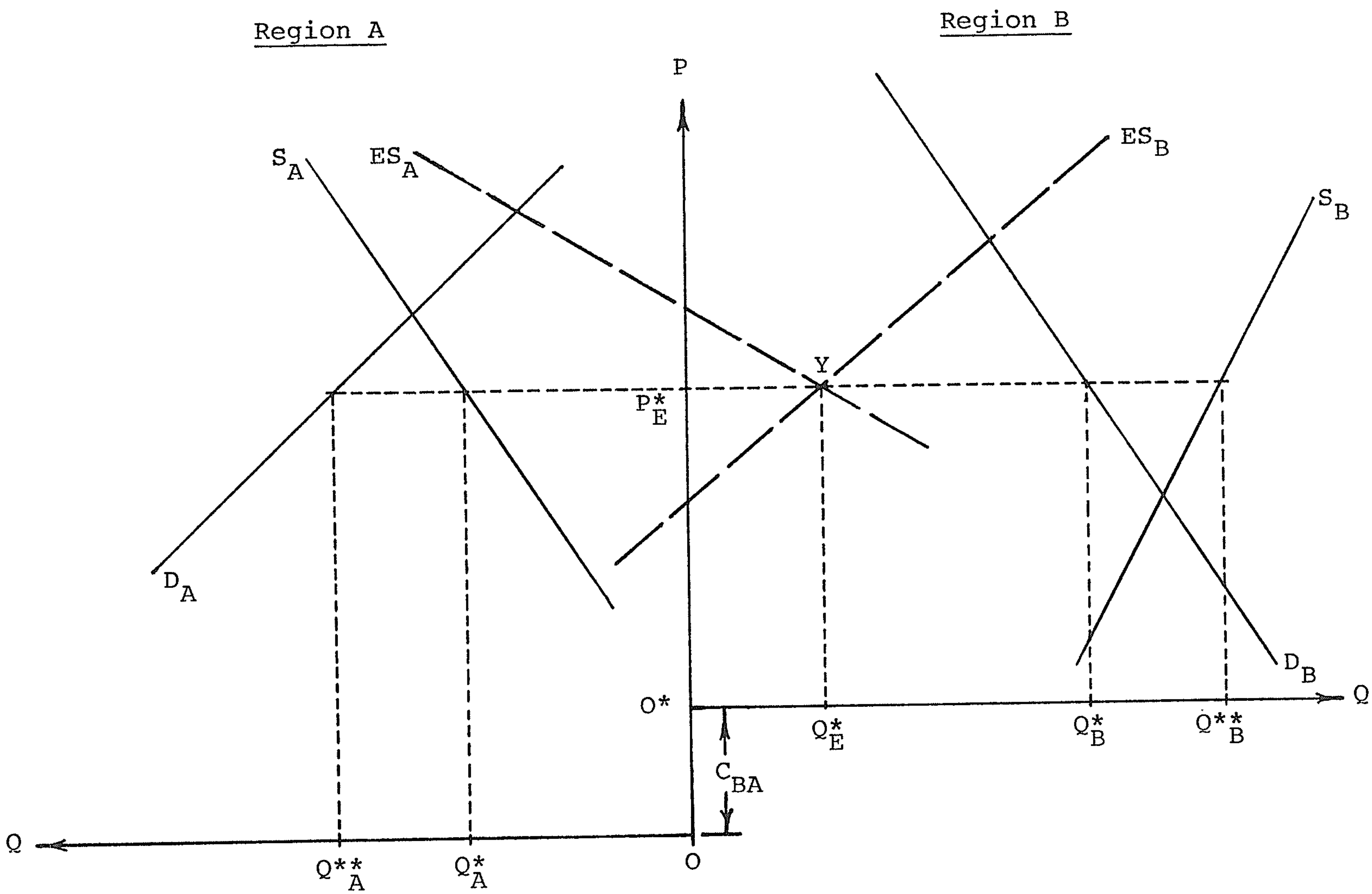
reflect the relative comparative advantage of Region B over Region A in the production of this commodity.

If we now remove the assumption that transaction costs equal zero, we will be able to observe the effects that transportation costs exert upon interregional trade flows and spatial price differentials. Assume, instead, that the cost of shipping a unit of the commodity from Region B to Region A is some positive amount, C_{BA}, and that this amount is independent of the volume of commodity shipped.[5] In Figure 3.4 the side of the diagram which represents Region B has been displaced upwards by an amount equal to this unit cost. With this adjustment, the vertical price axis of the back-to-back diagram is no longer strictly common to both regions. Rather, any point on the scale represents prices in the two regions which differ by an amount exactly equal to C_{BA}.

As before, the intersection of the excess supply functions ES_A and ES_B determines the equilibrium position, now at point Y. The new price in Region A is equal to OP_E^* and the new price in Region B is equal to $O^*P_E^*$. The difference between these is equal to C_{BA}, the unit cost of transportation. The quantity of commodity shipped from

[5]This latter assumption is not necessary to the analysis but is made in order to simplify the graphical treatment.

Figure 3.4: Two Region Spatial Equilibrium Model With Excess Supply Functions and Transportation Costs



Region B to Region A is equal to $O^*Q_E^*$, $Q_A^*Q_A^{**}$ or $Q_B^*Q_B^{**}$, each of which is equivalent.

Comparison of Figure 3.4 with Figure 3.3 yields some important observations as to the effects of transportation costs upon spatial price differentials and interregional trade flows. The price differential between two regions which will persist in equilibrium becomes exactly equal to the unit costs of transportation. The greater this transportation cost, the greater will be the persistent price differential. Consequently, the final equilibrium price will be higher in the deficit region and will be lower in the surplus region. The introduction of transportion costs into the model also reduces the volume of commodity which will be traded in equilibrium. The actual extent of this reduction depends upon the prevailing conditions in each region. However, it may be stated that as the cost of transportation increases the volume of commodity traded will gradually decrease until the point is reached where the initial price differential between the regions no longer exceeds the unit cost of transportation. At this point all trade will cease. Any further shipments would incur a loss for the entrepreneur undertaking them. The reduced volume of interregional trade will induce decreased consumption but increased production in the deficit region and increased consumption but decreased production in the surplus region. Transportation costs thus act as an obstacle to interregional trade flows and as an insulator of spatial price differentials.

Transportation Costs and the Canadian Wheat Flour Economy

Chapter II outlined the complex freight rate structure for wheat grain and flour shipments within Canada. Several apparent distortions of essentially political or institutional origin were discussed, including: the federal government's stop-off fee subsidy program, the subsidization of St. Lawrence Seaway tolls, the "At and East" freight rate hold-down and subsidy program and the statutory "Crow's Nest Pass" rates. Each of these has had the effect of keeping freight rates at levels which are almost certainly lower than they would otherwise have been.

The theoretical economic models developed in this chapter provide useful insights into the role of transportation costs in the industrial location-decision process and in the determination of equilibria within and between spatially separated markets. The approach of this analysis is to apply a linear programming transportation model (developed in the following chapters) to simulate the effects of making cost oriented adjustments to the grain freight rate structure. The focus of this analytical approach is strictly upon the relative efficiency of wheat grain and flour milling and distribution patterns, taking local supply and demand conditions as pre-determined parameters. However, the principles underlying the economic models discussed above can be shown to be entirely compatible with and, in fact, implicit in the linear programming model.[6]

In general, reduced levels of freight rates would be expected to diminish the relative importance of transportation in the determination of industrial location patterns. Furthermore, whereas flour milling is a significantly weight-reducing process, reduced freight rates would appear to have de-emphasized the inherent transport cost advantage of mills located near the source of their raw wheat supplies. Reduced freight rates would not inhibit trade flows as much as otherwise, and interregional shipments of both wheat grain and flour may therefore be surmised to have been greater. Finally, reduced freight rates would be expected to lower the level of spatial price differentials which would persist in equilibrium. Thus, wheat prices would likely have been raised somewhat in surplus regions and lowered somewhat in deficit regions, relative to their natural levels.

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[6] Paul A. Samuelson, "Spatial Price Equilibrium and Linear Programming", American Economic Review, June, 1952, pp. 283-303.

CHAPTER IV

ANALYTICAL PROCEDURES

The general approach of this study is to develop and apply a linear programming transportation model to the problem of determining efficient wheat grain and flour shipment patterns within Canada. This chapter outlines some of the analytical procedures followed in the implementation of this approach. In the sections which follow the system of regions adopted for the study, the specific formats of the empirical model which were examined and the study's data requirements are discussed in some detail.

Region Delineation

The analysis of certain economic problems necessitates the consideration of smaller spatial units than the total area of interest. In some cases, in fact, the degree of precision which may be achieved by a particular approach is closely related to the number of regions into which the overall study area is divided. A regional breakdown which aggregates important variables across too great an area may well conceal evidence which is critical to the analysis. At the same time, however, the computational burden associated with examining a large number of relatively smaller regions often proves to be prohibitive. A relevant and consistent system of regionalization is therefore of considerable importance if the exact nature of the study problem is to be discovered.

The American Association of Geographers offers the following functional definition of a region:

> ...a region is not an object either self-determined or nature given. It is an intellectual concept, an entity for the purposes of thought created by the selection of certain features that are relevant to a real interest or problem, and by the disregard of all features that are considered to be irrelevant.[1]

Thus, any given area might justifiably be regionalized in several different ways depending upon the specific nature of the problem being examined. Considerations which are generally relevant to the delineation of regional boundaries include: (i) structural factors, including physiographic conditions; (ii) functional factors which assist in community development in spite of structural barriers (for example, transportation and communications facilities which help to overcome problems related to distance); (iii) production and marketing factors (in particular, inter-industry relations and consumption patterns); and, (iv) cultural and social conditions which might influence local autonomy.[2]

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[1] Regional Economic Planning (Paris: Organization for European Economic Co-operation, 1961), p. 379, cited in T.N. Brewis, Regional Economic Policies in Canada (Toronto: The MacMillan Company of Canada Limited, 1969), p. 45.

[2] See Pierre Camu, E.P. Weeks and Z.W. Sametz, Economic Geography of Canada, with an Introduction to a 68-region System (Toronto: MacMillan of Canada, 1964), pp. 266-267.

Given these considerations, at least three distinct types of regions can be differentiated. The "homogeneous" region encompasses an area within which the most relevant characteristics are all held in common. "Nodal" regions, on the other hand, are defined as areas surrounding dominant central points such as large cities. These regions, despite some apparent heterogeneity, normally exhibit strong functional relationships within their boundaries. Finally, "administrative" regions may be defined in such a way as to facilitate the implementation of specific policies and/or programs. These regions would therefore usually coincide with existing boundaries of political jurisdiction.

Perhaps the most important consideration of all in the delineation of regional boundaries, however, is the purely pragmatic one of data availability. It is simply beyond the time and budget limitations of most applied analyses to attempt to develop original statistics. Therefore researchers are often forced to accept restrictions imposed by published data sources. Secondary sources of Canadian economic information generally aggregate and report statistics on the basis of provincial boundaries. In the case of export statistics, data are reported on the basis of broad geographic groups of ports.

In view of these considerations, the particular regional demarcation outlined in Table 4.1 was adopted for

Table 4.1

Regional Demarcation of the Canadian Wheat Flour Economy

REGION	REPRESENTATIVE CENTER
Domestic Regions	
1. British Columbia	Vancouver
2. Alberta	Calgary
3. Saskatchewan	Saskatoon
4. Manitoba	Winnipeg
5. Ontario	Toronto
6. Quebec	Montreal
7. Maritime	Halifax
Export Regions	
8. Pacific Seaboard	Vancouver
9. Churchill	Churchill
10. Thunder Bay	Thunder Bay
11. St. Lawrence	Montreal
12. Atlantic Seaboard	Halifax

this analysis. Seven domestic regions were defined: the first six corresponding to the provinces west of, and including, Quebec and the seventh consisting of the four Maritime provinces as a single group. Also, five export regions were defined, representing the major port areas of Canada: the Pacific Seaboard, Churchill, Thunder Bay, the St. Lawrence ports and the Atlantic Seaboard. In order to accommodate the empirical model, all activities considered were assumed to take place at one particular point within each region. Therefore, a "representative" center was designated for each region. These points were selected not so much on the basis of their central location within the regions as on their relative position in terms of a number of important variables. Thus, due consideration was paid to such factors as the location of existing flour milling capacity, wheat production patterns, population (and therefore consumption) patterns, shares of export volumes and the application of freight rate maps within each region.

This delineation of regions reflects some of the characteristics of each of the three types of regional classification discussed above. First, the boundaries are those of administrative regions. Inasmuch as they are defined as a set of points representing larger geographic areas, however, they may also be considered nodal regions. At the same time, they each represent relatively homogeneous units. Most importantly, however, the system of regions outlined in Table 4.1 and adopted for this study reflects the essential properties of the Canadian wheat flour economy and the operating practices of the grain handling and transportation system.

Format of the Empirical Model

The empirical model developed for this analysis was a modified transhipment varient of the linear programming transportation model.[3] It was formulated in such a way as to determine efficient Canadian wheat and wheat flour shipment patterns. The basic problem was to distribute available but remote stocks of wheat to satisfy predetermined requirements for wheat grain, derived requirements for milling wheat and predetermined requirements for wheat flour. The objective function of the model was to minimize direct transportation user costs.[4] Thus, the model was designed to simulate normative reactions of wheat grain and flour shippers to the prevailing freight rate structure.

The model considered shipments of wheat to satisfy requirements in seven domestic and five export regions, as outlined in the preceding section. Wheat transhipped through the domestic regions was considered to have been

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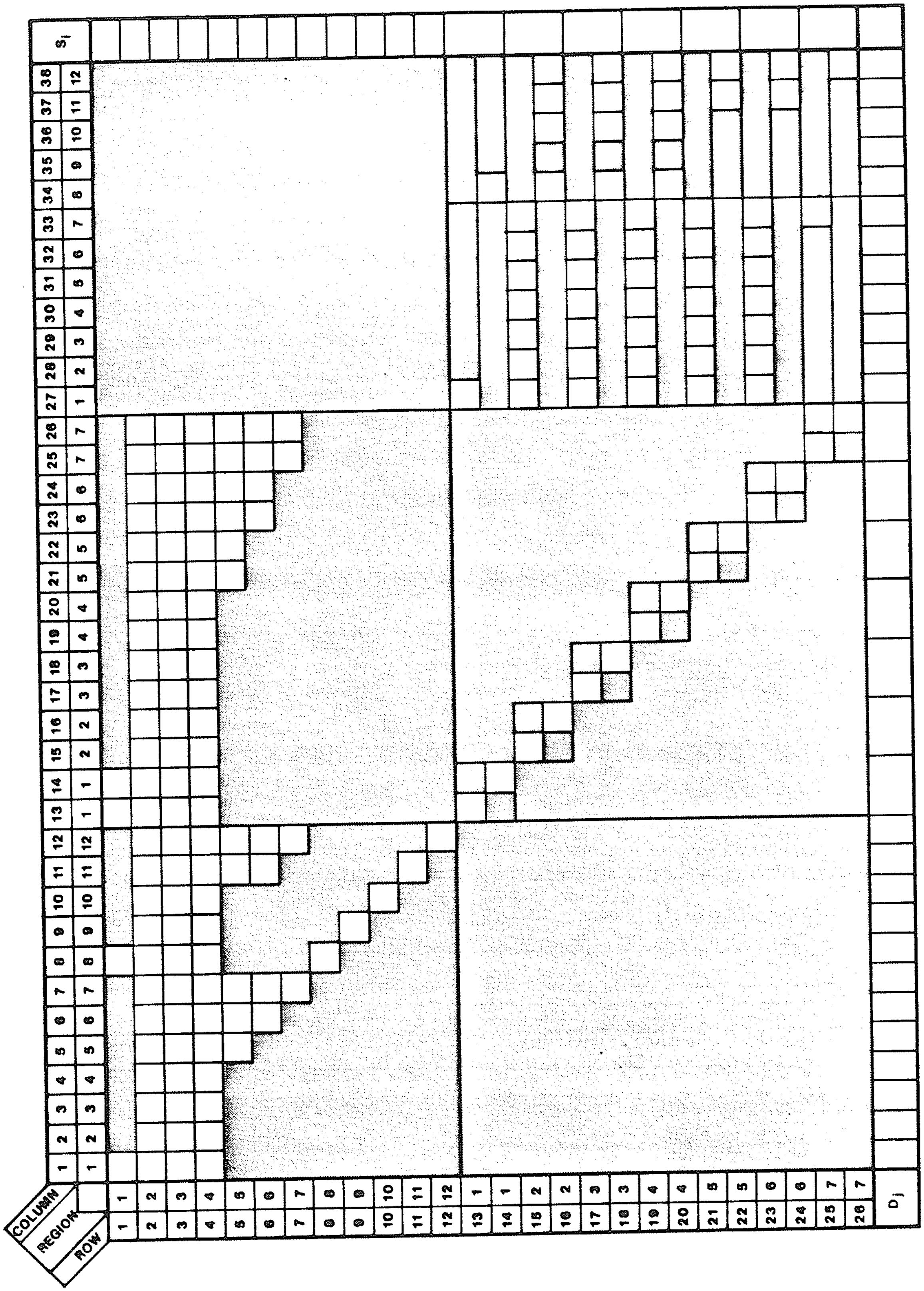
[3]See Appendix A for a more general introduction to the linear programming transportation model.

[4]It should be noted that this differs from total transportation costs, which would include, for example, the costs to the government of various transport subsidy programs.

converted to flour and, subsequently, was distributed to meet flour requirements in each of the regions. It was necessary to segregate wheat shipments for flour to be exported from wheat shipments for flour to be used domestically because of the different freight rate schedules which apply for the two movements. Therefore, the flour milling activities in each region for export and for domestic use were treated as separate activities. Each had to share in their region's total flour milling capacity, however.

Figure 4.1 illustrates the basic format of the transhipment model developed for this analysis in the tabular form which is introduced in Appendix A. The model consists of twenty-six rows (each representing a source) and thirty-eight columns (each representing a destination). The quantities of wheat or flour available at each source are presented in the right-hand column (under the heading "S_i") and the quantities required at each destination are presented in the bottom row (to the right of the heading "D_j"). Cells located at the intersections of rows and columns are reserved for information concerning the tariffs for and/or the quantities of shipments between the corresponding sources and destinations. All other row-column intersections (shaded) represent infeasible source-destination combinations which have been excluded from the analysis.

Figure 4.1: Transhipment Model of the Canadian Wheat Flour Economy



Rows one through seven in the tableau represent the domestic regions as sources of wheat while rows eight through twelve represent the export regions as sources of wheat. Columns one through seven represent the domestic regions as destinations of wheat while columns eight through twelve represent the export regions as destinations of wheat. Thus, the intersections of the first twelve rows with the first twelve columns comprise a matrix of direct wheat shipments between regions. The freight rates for "shipments" from any region to itself are, of course, equal to zero. Therefore, regional requirements are satisfied first out of locally available stocks, as much as possible, and then out of stocks available in other regions.

Columns thirteen through twenty-six represent the domestic regions as intermediate destinations of wheat. That is, wheat shipments into these destinations are converted to flour and subsequently transhipped to final destinations. Rows thirteen through twenty-six correspond to columns thirteen through twenty-six and represent the domestic regions as sources of flour. Shipments of wheat from rows one through seven into columns thirteen through twenty-six are converted to flour and then are transhipped out of rows thirteen through twenty-six to meet flour requirements. As mentioned above, wheat shipments for flour to be exported are considered separately from wheat shipments for flour to be used domestically. Therefore, the milling industry of each region was represented by two rows and by two columns: the thirteenth and fourteenth rows and columns represent domestic region number one; the fifteenth and sixteenth rows and columns represent domestic region number two; the seventeenth and eighteenth rows and columns represent domestic region number three; the nineteenth and twentieth rows and columns represent domestic region number four; the twenty-first and twenty-second rows and columns represent domestic region number five; the twenty-third and twenty-fourth rows and columns represent domestic region number six; and, finally the twenty-fifth and twenty-sixth rows and columns represent domestic region number seven. The first row and column of each of these pairs are reserved for shipments of flour to be used domestically. The second row and column are reserved for shipments of flour destined for export.

Columns twenty-seven through thirty-eight represent the twelve regions of the model as final destinations for flour: columns twenty-seven through thirty-three representing the domestic regions and columns thirty-four through thirty-eight representing the export regions. Only the appropriate rows (i.e. those from thirteen through twenty-six which are reserved for either domestic or export flour shipments, whichever the case may be) intersect with these columns.

As above, the quantities available at each source are presented in the right-hand column (under the heading "S_i") and the quantities required at each destination are presented in the bottom row (to the right of the heading "D_j"). Since rows and columns thirteen through twenty-six represent the intermediate flour milling activities of the model, however, the corresponding entries in the S_i column and the D_j row are not actually total quantities available or required but, rather, are the total milling capacities of the respective regions. They specify the maximum quantities of wheat which may be milled into flour within (i.e. which may be transhipped through) these regions, including shipments for both domestic and export destinations. Thus, the pairs of activities (i.e. rows or columns) for any given intermediate flour milling region share common S_i and D_j values.

The Canadian wheat flour economy is characterized by excess flour milling capacity. A mechanism was therefore required to ensure that idle capacity would be assigned to the regions on the basis of the objective function of the model. The key to this mechanism lies in the interaction of rows and columns thirteen through twenty-six (i.e. row thirteen with column thirteen, row fourteen with column fourteen, etc.). Entries in the cells corresponding to these intersections are determined in the same manner as all other shipments determined by the model. However, they represent shipments both into and out of the same regions and, since the costs associated with them are set equal to zero, they merely cancel each other out of the final solution without affecting it. They do draw upon their regions' milling capacities, however, absorbing the excesses. Thus, entries which appear in these cells in the final solution are interpreted as idle flour milling capacity rather than as interregional commodity shipments.

Generally, as discussed in Appendix A, a valuable characteristic of transportation models is that they may be solved more easily than problems in the standard linear programming format. Nonetheless, attempting to solve a problem as complex as the one described here without the aid of a computer would be a preposterous exercise. Unfortunately, at the time that this analysis was being conducted, the University of Manitoba did not have available a pre-programmed computer package capable of solving problems in this specific format. Therefore, for the purpose of actually calculating solutions to the transhipment model implemented in this analysis, the problem was reformulated into standard linear programming format[5] and solved using the conventional MPS/360 Linear

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[5]For a discussion of the methodology involved, see Robert Dorfman, Paul A. Samuelson and Robert M. Solow, <u>Linear Programming and Economic Analysis</u> (New York: McGraw-Hill Book Company, 1958).

and Separable Programming package.[6] Because the nature of the problem may be more clearly demonstrated in the transportation model format, however, all further discussion of the model and its solutions are presented in that format.

Three distinct versions of the general model were solved. These models differed with respect to the nature of several assumptions upon which they were based. Specifically, the freight rates implemented in the various models were either those which were found to have existed in the base year, 1974, or were rates which had been adjusted to reflect the individual, and then combined, withdrawal of a number of government policies and programs which currently, and in the past, have interfered with the purely economic determination of grain freight rates within Canada. Regional flour milling activities were either constrained by capacity limits which existed in the base year, implying a consideration of only the short run period in which no changes to physical plant could take place, or were unrestricted, implying a consideration of the longer run period in which existing flour milling capacities could be expanded without limit.

Model I was based upon existing 1974 freight rates and regional flour milling capacities. The optimal solu-

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[6] See Neil Longmuir, "MPS/360 Short User's Guide" (Winnipeg: University of Manitoba, Department of Agricultural Economics and Farm Management, September, 1969). (Mimeographed)

tion to this model amounted to wheat grain and flour milling and shipment patterns which would minimize transportation user expenditures. This solution was derived as a basis against which to compare the solutions to Models II and III.

Model II retained the assumption of existing 1974 regional flour milling capacities but introduced cost oriented freight tariffs. Thus, differences between the solutions to Models I and II simulated the short run implications for the Canadian wheat flour economy of actually implementing corresponding changes in the freight rate structure. Five versions of Model II were solved: Model II(a) simulated the effects of withdrawing the federal stop-off fee subsidy program; Model II(b) simulated the effects of terminating government subsidization of the St. Lawrence Seaway and of the associated changes in the toll structure which would be required; Model II(c) simulated the effects of cancelling the federal government "At and East" freight rate hold-down and subsidy program; Model II(d) simulated the effects of raising the statutory "Crow's Nest Pass" rates by a factor of three; and, Model II(e) simulated the effects of implementing all of these changes together.[7]

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[7]See Chapter II, above, for descriptions of the nature of these federal government policies and programs. See the following section of this chapter for a discussion of the methods used to estimate the necessary adjustments to the freight rate structure.

Model III was also based upon cost oriented freight rates. However, optimal regional flour milling activities were determined by the model without regard for existing capacity limits. Thus, the differences between the solutions to Models I and III were interpreted as indicating the long run implications of implementing the modified freight rate schedule. As with Model II, five separate versions of Model III were solved in order to identify the individual, and then combined, effects of the government policies and programs examined.

Data Requirements

The data requirements of linear programming transportation-type models include four broad kinds of information: (i) quantities of commodities available, by region; (ii) quantities of commodities required, by region; (iii) levels of any capacity restraints imposed upon the model; and, (iv) transportation rates or costs for shipping commodities between regions. The definitions of each of these classes of information for wheat and for wheat flour, as used in this analysis, are presented in this section. The sources of this information are provided in the footnotes.

A preliminary step in this, as in every analysis, was the selection of an appropriate time period for study. A primary consideration was, of course, that all required data be readily available in its final form for the period in question. At the same time, however, it was also important that the period selected be as recent as possible in order that the results of the analysis might be considered to be current. In addition, it was necessary that the period selected be representative of a greater time span than simply that single period examined. The most recent statistics available at the time that this analysis was initiated were for the year 1975. However, one particularly important piece of information was available only from the report of the Commission on the Costs of Transporting Grain by Rail (the Snavely Commission), which conducted its analysis and based its results upon 1974 conditions. As 1974 was considered to be equally as representative of longer run production and marketing conditions in the Canadian grains industry as 1975, therefore, the former was selected. Data were compiled on the basis of the calendar year, as opposed to the crop year. Calendar year 1974, then, constituted the period of study of this analysis.

The total quantity of wheat available in each region was defined as the sum of the stocks on hand, in all positions, as of July 31, 1974[8] plus actual production during 1974.[9] As export regions were not defined to include any production capacity, the total quantities available in these regions amounted to the quantities in store, only, of course. Availabilities of flour by region were not preassigned but, rather, were restricted by regional flour milling capacities. Unfortunately,

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[8] Statistics Canada, Grain Trade of Canada, 1974-75 (Ottawa: Catalogue Number 22-201, annual), Table 84, p. 81. A number of manipulations had to be performed in order to allocate the various sub-classifications listed to the regions defined for this analysis: (i) "On farms", "Primary elevators" and "In transit rail-Western division" were allocated to the regions according to the distribution of primary elevator capacity; (ii) "Process elevators" was allocated to the regions according to the distribution of process elevator capacity; (iii) "Interior terminals" was distributed between Saskatchewan and Alberta according to terminal elevator capacity; (iv) "In transit rail-Eastern division", "Eastern elevators" and "In transit lake" were allocated to the regions of Ontario, St. Lawrence and Atlantic Seaboard according to the distribution of transfer elevator capacity (these distributions being derived from Canada Grains Council, Canadian Grains Industry Statistical Handbook 74 (Winnipeg: 1974), Table 34); (v) "Vancouver" and "Victoria-Prince Rupert" were assigned to the Pacific Seaboard; (vi) "Churchill" and "Thunder Bay" were assigned to their respective regions; and, (vii) "Eastern and Western mill bins" was allocated to the regions according to the distribution of flour milling capacity (as determined for this analysis - see the text which follows).

[9] Statistics Canada, Quarterly Bulletin of Agricultural Statistics, January-March 1976 (Ottawa: Catalogue Number 21-003, September 1976), Table 2, pp. 17-30.

specific information on these capacity levels was not available by region. It was therefore necessary to estimate them by multiplying the number of flour mills operating within each region during 1974[10] by the average capacity per mill for Canada as a whole.[11] While average mill capacities may in fact vary from region to region, the extent of this variation is not thought to be as great as it once was and the resulting estimates were deemed to be acceptable.

Requirements of wheat grain at export positions were established at levels equal to the amounts of actual

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[10] Statistics Canada, Flour and Breakfast Cereal Products Industry, 1974. (Ottawa: Catalogue Number 32-228, annual), pp. 14-15.

[11] Total Canadian flour milling capacity was computed on the basis of: Actual production x 100 ÷ the percentage of capacity in operation (Statistics Canada, Grain Trade of Canada, 1974-75, op. cit., Tables 105 and 106, p. 93). This was then divided by the total number of mills operating in Canada during 1974 (see footnote number 10) to arrive at the average capacity per flour mill for Canada as a whole.

exports through those ports in 1974[12] plus the levels of closing inventories there.[13] Closing inventory levels were included in order to balance the inclusion of opening inventory levels in the quantities available. In the case of domestic regions, wheat requirements were equal to the sum of requirements for flour production (which, in turn, was determined by flour requirements), for seed purposes,[14]

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[12]Bulk wheat exports by port of departure were obtained from Statistics Canada, Grain Trade of Canada, op. cit., (1973-74, Table 67, p. 60; 1974-75, Table 63, p. 65). Seed wheat exports were not available by port of departure. However, after examining the major destinations of these shipments (Statistics Canada, Exports By Commodities, December 1974 (Ottawa: Catalogue Number 65-004, monthly), Table 3, p. 34) and the most common ports of departure of bulk wheat exports to those nations (Canadian Grain Commission, Canadian Grain Exports (Ottawa: Information Canada, 1973-74 and 1974-75), Table 3), seed wheat exports to the United States were assigned to the export region of Thunder Bay and all other seed wheat exports were allocated to the St. Lawrence and Atlantic Seaboard regions according to the distribution of bulk wheat exports from them.

[13]The levels of closing inventories were actually determined as a residual factor. It was distributed amongst the twelve regions according to the relative distribution of "stocks in all positions" as of July 31, 1975 (see Statistics Canada, Grain Trade of Canada, 1974-75, op. cit., Table 84, p. 81). The methods used to distribute this quantity amongst the regions were similar to those described in footnote number 8.

[14]Total Canadian seed wheat requirements for the 1973-74 crop year (Statistics Canada, Grain Trade of Canada, 1973-74, op. cit., Table 88, p. 76) were allocated to the regions on the basis of the distribution of the total number of acres seeded to wheat (Statistics Canada, Quarterly Bulletin of Agricultural Statistics, January-March 1976, op. cit., Table 2, pp. 17-30).

for other uses (including "industrial", "loss in handling" and "feed, waste and dockage")[15] plus the level of closing inventories within the regions.[16] Flour requirements consisted of actual exports through the various export regions[17] and consumption in the various domestic regions. Total flour consumption was estimated for each domestic region by multiplying its population[18] by the apparent per capita domestic disappearance of flour for Canada in 1974.[19]

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[15]The averages (of crop years 1973-74 and 1974-75) of these classifications (Statistics Canada, Grain Trade of Canada, op. cit., (1973-74, Table 88, p. 76; 1974-75, Table 84, p. 81) were allocated to the regions according to the distribution of the numbers of cattle and hogs, as of July 1, 1974 (Canada Grains Council, Canadian Grains Industry Statistical Handbook 75 (Winnipeg: 1975), Tables 59 and 60, pp. 216-217).

[16]See footnote number 13.

[17]Total Canadian flour exports (Statistics Canada, Grain Trade of Canada, op. cit., (1973-74, Table 67, p. 60; 1974-75, Table 63, p. 65) were allocated to the export regions according to the distribution of exports of "cereals, milled" by port of departure (Statistics Canada, Exports: Merchandise Trade 1973-75 (Ottawa: Catalogue Number 65-202, annual), Table 10, p. 944).

[18]Statistics Canada, Canadian Statistical Review, January 1976 (Ottawa: Catalogue Number 11-003 E, monthly), Table 1, p. 20.

[19]Statistics Canada, Apparent Per Capita Domestic Disappearance of Food in Canada, 1975 (Ottawa: Catalogue Number 32-226, annual), pp. 8-9.

The primary requirement of this analysis, in terms of freight rate data, was to connect the twelve point regional system of the model by means of a network of freight tariffs levied for movements of wheat grain and flour during 1974. Subsequently, it was necessary to estimate and remove the effects of a number of non-economic considerations from this network, thus obtaining a rate schedule more closely reflecting actual cost patterns.[20] This involved the determination and removal of the effects of the federal government's stop-off fee subsidy program, its subsidization of St. Lawrence Seaway tolls, its "At and East" freight rate hold-down and subsidy program and the statutory "Crow's Nest Pass" grain freight rates, all of which have been said to interfere with the natural economic rate determination process.[21]

The freight rate structure which applies to shipments of wheat and wheat flour within Canada is very complex. Compounding this is the fact that specific freight rate statistics are not well documented in any readily available source documents. The collection of consistent

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[20] Throughout this thesis, this modified freight rate schedule is referred to as "cost oriented" (as opposed to "cost of service"), reflecting the recognition that there are undoubtedly numerous persistent sources of divergence between the embodied freight tariffs and the associated actual costs of services.

[21] See Chapter II, above, for a discussion of these policies and programs.

freight rate data therefore proved to be a difficult task. In certain cases it consisted simply of finding the appropriate rate level. For the majority of routes, however, it required either the combination of various trip segments in order to connect a given origin-destination pair, the parallel consideration of more than one rate level depending upon whether for wheat or for flour and whether for export or domestic use, the comparison and selection of the most economical of several alternative routes and/or modes of transport or various combinations of these. Moreover, there simply were no rates quoted for shipping wheat or flour between certain points represented in the model (for example, between the ports of the Atlantic Seaboard and Churchill). While this did not present any particular conceptual difficulty, it did necessitate extensive data searches in the interests of certainty and completeness. Eventually, however, a "basic" freight rate schedule, suitable for application in Model I of this analysis, was established. This involved the collection of information from published secondary data sources[22], from written requests to (and corresponding replies from) both public

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[22]Statistics Canada, Grain Trade of Canada, 1973-74, op. cit., Tables 98-111; Canadian Grain Commission, Canadian Grain Exports, Crop Years 1973-74 and 1974-75, op. cit., Table 12; Canada Grains Council, Canadian Grains Industry Statistical Handbook 75, op. cit., Tables 50-52.

and private organizations[23] and from personal conversations with knowledgeable individuals.[24]

The modified rate schedules required for Models II and III were obtained by adjusting the basic rate schedule to remove the effects of the federal government policies and programs referred to above. The impacts of each of these sources of economic distortion were first determined individually and then were added together to arrive at a combined effect. The adjusted rate schedule was then employed in stages as described in the previous section of this chapter.

The stop-off fee subsidy offered to flour millers in both Eastern and Western Canada amounted to six cents per hundredweight of flour (i.e. approximately 4.35 cents per hundredweight of raw wheat milled) in 1974.[25] For the first applications of Models II and III, therefore, this amount was simply added to the basic rates for those routes and shipments which were affected by this subsidy program.

Based upon the limited information available, it was estimated that in 1974 St. Lawrence Seaway tolls were

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[23] Namely, the Canadian National Millers' Association, Canadian National Railway and Canadian Pacific Railway.

[24] In particular, employees of the Canadian Transport Commission Traffic and Tariffs Branch, the Canadian Wheat Board and the railways' rate quotations departments.

[25] Johnson, op. cit., p. 404.

approximately 0.829 cents per hundredweight of grain less than the level of costs incurred on behalf of that grain.[26] Therefore, in the second applications of Models II and III, this amount was added to the rates specified in Model I for shipments involving lake transport from Thunder Bay to Montreal and from Thunder Bay to Halifax. This did not affect the rates for lake shipments from Thunder Bay to the Georgian Bay ports, however, since the tolls involved were for passage through the Welland Canal and the Montreal-Lake Ontario sections of the Seaway, only. Further, it did not affect direct exports from Thunder Bay since the rates for these shipments were beyond the scope of this analysis.

The extent of the distortions introduced into the grain freight rate structure by the existence of the "At and East" hold-down and subsidy program were accepted

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[26] Estimates of current costs and cost increases in the past were obtained from "Ottawa to bail out Seaway authority", The Globe and Mail (Toronto), March 3, 1977, p. B1. Using these, it was possible to work back in time, achieving an estimate of the 1974 gap between the tolls levied and the costs incurred. More recently available information confirms that this estimate is at least approximately accurate. Increasing the level of tolls which were levied in 1974 by the ratio of total operating expenses to total revenues received by the St. Lawrence Seaway Authority in 1974 (as reported in: Gordon C. Shaw, "Who Will Pay the Freight? The Merits of User-Pay and Full-Cost Recovery", a paper presented to the Financial Post conference "The Seaway-Great Lakes Transportation System", October 17, 1979, Exhibit 2) would lead to tolls amounting to within four percent of those estimated and applied in this analysis.

as being equal to the differences between the rates actually levied by the railways in 1974 and "compensatory" rate levels for that period, as estimated by the Canadian Transport Commission for subsidy purposes. The basic rate schedule was modified to reflect these differences in the third applications of Models II and III.

The statutory "Crow's Nest Pass" grain freight rates were increased by a factor of three in order to raise them to approximately the level of costs incurred on this traffic. This factor was based upon the estimate that these rates fell short of variable costs by a factor of 2.61.[27] A contribution to system constant costs of approximately fifteen percent over variable costs was assumed. Thus, the rates for those routes and portions of routes over which the statutory rate levels applied in the basic rate schedule were increased to three times their original levels for the fourth applications of Models II and III. It should be noted that the relationship between the rates for wheat grain and flour was not changed. That is, the rates which applied for flour shipments remained equal to those which applied for grain shipments, despite the fact that the actual costs associated with their movement may well not be equal.

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[27] The Commission on the Costs of Transporting Grain by Rail, op. cit., p. 205.

Finally, for the fifth applications of Models II and III, the cumulative effects of these four separate sets of modifications were applied to the basic framework of freight rates developed for Model I.

CHAPTER V

EMPIRICAL RESULTS

This chapter presents and examines empirical results obtained through the application of the linear programming transhipment model developed in the previous chapters. Three distinct modifications of the basic model were solved in order to analyze the impact of replacing observed 1974 grain freight rates by a set of cost oriented rates. Comparisons of the solutions to these three versions of the model reveal implications concerning the regional distribution of the Canadian flour milling industry (CFMI), concerning the cost of wheat grain and flour transportation in Canada and concerning interregional price equilibrium in the Canadian wheat economy.

The solutions to the transhipment model implemented in this analysis amount to wheat grain and flour shipment patterns which would satisfy Canadian domestic and export requirements out of available supplies and which, at the same time, would minimize the total direct transportation user expense involved. Of course, the shipment patterns derived are normative, describing only the situation which <u>should</u> develop in order to achieve the stated objective, as opposed to predictive, attempting to estimate the situation which <u>would</u> arise. Furthermore, the objective is satisfied with respect to the entire system rather than to any individual region or shipper. Therefore, while overall system costs are minimized, particular sub-system costs may not be.

Regional Analysis

Model I

Model I determined wheat grain and flour milling and shipment patterns which would minimize required transportation user expenditures given 1974 quantities available and required, freight rates and regional flour milling capacities. The solution to this model forms a basis for comparison against subsequent versions of the model. In general, the optimal patterns derived resemble actual patterns of movement within the Canadian grain transportation network,[1] reflecting the strong regional differences in production and consumption patterns which are evident. The predominant interregional flows were from the Prairie producing regions to the more highly populated consuming regions of Central Canada and to the principal export regions.

Table 5.1 outlines the individual wheat grain shipments which collectively make up the optimal flow

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[1]While directly comparable data are not available, Appendix B presents a rough comparison of the optimal wheat grain and flour shipment patterns derived in this analysis with actual grain and grain product shipment patterns for 1974.

pattern. These shipments are identified by the nature of their intended end use. That is, individual shipments out of any origin might be intended to satisfy one of four possible requirements: (i) for domestic use, as seed or feed grain and for industrial and other uses; (ii) for export, in the form of grain; (iii) for milling, and subsequent domestic use as flour; and, (iv) for milling, and subsequent export in the form of flour. Shipments from a region to itself represent transfers from one sector to another within the same region (e.g. from the producing sector to the consuming or milling sector) and include total closing inventories. Wheat grain transhipped through the domestic regions was, by definition, converted to flour. Shipments of flour to satisfy regional requirements are presented in Table 5.2 and are discussed below.

As may be observed in Table 5.1, local wheat grain requirements are satisfied out of local supplies wherever possible in the solution. Interregional flows also follow a clear pattern. Shipments out of Alberta are directed westwards for domestic use in British Columbia and especially for export through the Pacific Seaboard ports. Shipments out of Manitoba, on the other hand, are directed eastwards to Ontario and the Maritimes to be milled for domestic use, and to Thunder Bay for export. Shipments out of Saskatchewan, the Prairie region which produces the greatest quantity of wheat and which is

Table 5.1: Optimal Wheat Grain Shipments--Model I

Region of Origin	Region of Destination	Nature of Shipment	Quantity of Shipment ('000 hundredweight)
1. British Columbia	1. British Columbia	- for domestic use	2,410.8
2. Alberta	1. British Columbia	- for domestic use	218.2
	2. Alberta	- for domestic use	53,797.9
		- to be milled, for domestic use	7,507.3
		- to be milled, for export	2,396.2
	8. Pacific Seaboard	- for export	50,342.6
3. Saskatchewan	1. British Columbia	- to be milled, for export	1,409.1
	3. Saskatchewan	- for domestic use	78,685.3
		- to be milled, for domestic use	4,135.1
		- to be milled, for export	109.3
	6. Quebec	- for domestic use	5,406.0
		- to be milled, for domestic use	9,903.5
	7. Maritimes	- for domestic use	723.3
	8. Pacific Seaboard	- for export	45,810.5
	9. Churchill	- for export	165.9
	10. Thunder Bay	- for export	155.6
	11. St. Lawrence	- for export	106,861.5
	12. Atlantic Seaboard	- for export	11,587.8
4. Manitoba	4. Manitoba	- for domestic use	21,208.0
		- to be milled, for domestic use	3,133.6
		- to be milled, for export	6,769.9
	5. Ontario	- to be milled, for domestic use	12,161.3
	7. Maritimes	- to be milled, for domestic use	1,414.8
	10. Thunder Bay	- for export	11,235.4
5. Ontario	5. Ontario	- for domestic use	27,637.5
		- to be milled, for domestic use	2,610.9
6. Quebec	6. Quebec	- for domestic use	1,224.6
7. Maritimes	7. Maritimes	- for domestic use	467.4
8. Pacific Seaboard	8. Pacific Seaboard	- for export	3,327.6
9. Churchill	9. Churchill	- for export	165.0
10. Thunder Bay	10. Thunder Bay	- for export	17,696.4
11. St. Lawrence	11. St. Lawrence	- for export	22,077.6
12. Atlantic Seaboard	12. Atlantic Seaboard	- for export	2,775.6

geographically centered between the others, travel in three directions: west--to British Columbia to be milled and subsequently exported as flour through the Pacific Seaboard ports; north--for export through Churchill; and east--for domestic use and to be milled for domestic use in Quebec and the Maritimes, and for export in the form of grain through Thunder Bay and the St. Lawrence and Atlantic Seaboard ports. Shipments of wheat grain for export which originate in the export regions themselves merely represent transfers out of inventory supplies.

Table 5.2 presents the individual wheat flour shipments which together comprise the optimal flow pattern derived by Model I. These shipments, either for domestic use or for export, are linked to the wheat grain shipments outlined in Table 5.1. That is, for example, export flour shipments from British Columbia through the Pacific Seaboard ports of 1,409,100 hundredweight-wheat-equivalents (Table 5.2) are matched by wheat grain shipments into British Columbia (from Saskatchewan) which are destined for milling and subsequent export as flour (Table 5.1).

In all cases but one (viz. British Columbia), local domestic flour requirements are satisfied as much as possible out of local millings. In fact, in Ontario, Quebec and the Maritimes the entire local grindings of flour are consumed within those regions. In the case of British Columbia the total quantity of flour milled within

Table 5.2: Optimal Wheat Flour Shipments--Model I

Region of Origin	Region of Destination	Nature of Shipment	Quantity of Shipment ('000 hundredweight-wheat-equivalents)
1. British Columbia	8. Pacific Seaboard	- for export	1,409.1
2. Alberta	1. British Columbia	- for domestic use	4,377.9
	2. Alberta	- for domestic use	3,129.4
	8. Pacific Seaboard	- for export	791.9
	12. Atlantic Seaboard	- for export	1,604.3
3. Saskatchewan	3. Saskatchewan	- for domestic use	1,654.9
	7. Maritimes	- for domestic use	2,480.1
	10. Thunder Bay	- for export	109.3
4. Manitoba	4. Manitoba	- for domestic use	1,844.5
	6. Quebec	- for domestic use	1,289.1
	10. Thunder Bay	- for export	788.2
	11. St. Lawrence	- for export	3,013.0
	12. Atlantic Seaboard	- for export	2,968.7
5. Ontario	5. Ontario	- for domestic use	14,772.2
6. Quebec	6. Quebec	- for domestic use	9,903.5
7. Maritimes	7. Maritimes	- for domestic use	1,414.8

the region is exported through the Pacific Seaboard ports while local domestic requirements are satisfied from the neighbouring region of Alberta. This likely is due to the fact that the statutory "Crow's Nest Pass" rates apply on shipments of grain to British Columbia if they are destined for milling and subsequent export but not if they are destined for subsequent domestic consumption. Again, the dominant inter-regional flows are those exiting the Prairie regions. In the case of flour shipments, however, while both Manitoba and Saskatchewan ship exclusively eastwards, Alberta ships both east and west.

Table 5.3 summarizes the regional flour milling activities implied by the optimal wheat grain and flour shipment patterns derived in Model I. The levels of these activities are compared to existing (1974) regional milling capacities. It is worth noting that all of the regions except British Columbia and Ontario are milling to capacity in the solution to Model I. Also, as noted above, all of the flour produced in Ontario, Quebec and the Maritimes is destined to satisfy local domestic requirements. The Prairie regions, on the other hand, mill flour for both the domestic and export markets while all of British Columbia's flour production is for export.

The domestic/export market orientation noted here with respect to the eastern and western flour mills coincides with actual patterns in the CFMI (as discussed

Table 5.3: <u>Optimal Regional Milling Activities-Model I</u>

Region	Existing Milling Capacity	Quantity of Flour Milled			Excess Milling Capacity
		for domestic use	for export	total	
	('000 hundredweight-wheat-equivalents)				
1. British Columbia	1,414.8	0.0	1,409.1	1,409.1	5.7
2. Alberta	9,903.5	7,507.3	2,396.2	9,903.5	0.0
3. Saskatchewan	4,244.4	4,135.1	109.3	4,244.4	0.0
4. Manitoba	9,903.5	3,133.6	6,769.9	9,903.5	0.0
5. Ontario	32,540.1	14,772.2	0.0	14,772.2	17,767.9
6. Quebec	9,903.5	9,903.5	0.0	9,903.5	0.0
7. Maritimes	1,414.8	1,414.8	0.0	1,414.8	0.0

in Chapter II, above). This would support the hypothesis that the existing (1974) grain freight rate schedule (upon which this normative solution was based) may have fostered, encouraged or at least reinforced the CFMI's historical development in terms of market orientation. On the other hand, the distribution of overall milling activity, and of excess capacity, differs markedly from the recently observed situation in the industry. Specifically, this solution indicates that, on the basis of transportation expenses alone, mills east and west of the Ontario-Manitoba boundary should account for roughly equal shares of the total Canadian flour production. In reality, however, approximately 65 to 70 percent of the total has been milled in eastern mills during recent years, while only about 30 to 35 percent of the total has been milled in western mills. Furthermore, most of the excess milling capacity observed in recent years has been suffered by western mills, whereas in this solution almost all of the excess was assigned to Ontario. Therefore, it would appear that factors outside the scope of this analysis (that is, other than the expense of transportation) must also have influenced the development of the CFMI in favour of eastern mills, particularly those in Ontario, where the majority of the flour milling activity actually takes place. This concurs with the discussion of Chapter III, where it was noted that transportation is merely one of the variables which might influence industrial location decisions, others including such factors as differences in processing costs, economies of scale, characteristics of the supply of inputs and of the demand for products and, possibly, inter-industry relations and other agglomerating forces.

Model II

Model II was similar to Model I in that it determined wheat grain and flour milling and shipment patterns which would minimize transportation user expenditures given 1974 regional supplies, demands and flour milling capacities. However, in Model II cost oriented freight rates (as discussed in Chapter IV, above) were substituted for the observed freight rates of Model I. The modified freight rate structures which were introduced had been adjusted to remove the direct effects of the stop-off fee subsidy program (Model IIa), the subsidized St. Lawrence Seaway tolls (Model IIb), the "At and East" freight rate hold-down and subsidy program (Model IIc) and the statutory "Crow's Nest Pass" rates (Model IId) individually, and finally their cumulative effects (Model IIe).

Differences between the solutions to Models I and II simulate the normative short run impacts of modifying the actual grain freight rate structure in such fashion. Conversely, they demonstrate the nature and extent of short run economic distortion inherent in the existing rate structure. Table 5.4 presents the optimal patterns of wheat grain shipments derived by Model II while Table 5.5 presents the optimal flour shipment patterns. Table 5.6 summarizes the regional milling activities implied by these patterns. In each of these tables, it is indicated where net changes from the solution to Model I arose. While in most cases these differences do not represent major reformulations of the optimal patterns, they do involve some significant switching of activities within and between regions.

In Model IIa, removing the effects of the stop-off fee subsidy program made the transportation of wheat to flour mills relatively more expensive and lead to several changes in the flour milling sector's supply procurement patterns. Not surprisingly, these changes amounted to the regional milling industries tapping nearer sources of supply. This, in turn, necessitated a number of adjustments in the patterns of shipments to meet both domestic and export wheat grain requirements. The most significant of these changes is evidenced by the shift to local grain supplies by the Ontario milling industry, whereas in the solution to Model I this supply was shipped in from Manitoba. In a corresponding adjustment, the domestic requirement for wheat grain in Ontario, no longer being met out of local supplies, was satisfied by an

Table 5.4: Optimal Wheat Grain Shipments--Model II

Region of Origin	Region of Destination	Nature of Shipment	Quantity of Shipment ('000 hundredweights) IIa	IIb	IIc	IId	IIe
1. British Columbia	1. British Columbia	- for domestic use	2,410.8	2,410.8	2,410.8	2,410.8	2,410.8
2. Alberta	1. British Columbia	- for domestic use	218.2	218.2	218.2	218.2	218.2
		- to be milled, for export	1,409.1(+)	0.0	1,409.1(+)	0.0	0.0
	2. Alberta	- for domestic use	53,797.9	53,797.9	53,797.9	53,797.9	53,797.9
		- to be milled, for domestic use	7,507.3	7,507.3	7,507.3	7,507.3	7,507.3
		- to be milled, for export	2,396.2	2,396.2	2,396.2	2,396.2	2,396.2
	8. Pacific Seaboard	- for export	48,933.5(-)	50,342.6	48,933.5(-)	50,342.6	50,342.6
3. Saskatchewan	1. British Columbia	- to be milled, for export	0.0(-)	1,409.1	0.0(-)	0.0(-)	0.0(-)
	3. Saskatchewan	- for domestic use	78,685.3	78,685.3	78,685.3	78,685.3	78,685.3
		- to be milled, for domestic use	1,654.9(-)	4,135.1	1,654.9(-)	1,654.9(-)	1,654.9(-)
		- to be milled, for export	2,589.4(+)	109.3	2,589.4(+)	2,589.4(+)	2,654.4(+)
	5. Ontario	- for domestic use	12,161.3(+)	0.0	11,276.0(+)	0.0	13,570.4(+)
		- to be milled, for domestic use	0.0	0.0	0.0	1,564.7(+)	0.0
	6. Quebec	- for domestic use	6,212.6(+)	5,406.0	6,630.6(+)	6,630.6(+)	6,630.6(+)
		- to be milled, for domestic use	9,903.5	9,903.5	8,678.9(-)	8,678.9(-)	6,846.1(-)
	7. Maritimes	- for domestic use	723.3	723.3	1,190.7(+)	723.3	723.3
		- to be milled, for domestic use	0.0	0.0	0.0	0.0	1,414.8(+)
	8. Pacific Seaboard	- for export	47,219.6(+)	45,810.5	47,219.6(+)	45,810.5	45,810.5
	9. Churchill	- for export	165.9	165.9	165.9	165.9	165.9
	10. Thunder Bay	- for export	0.0(-)	155.6	0.0(-)	0.0(-)	0.0(-)
	11. St. Lawrence	- for export	105,636.8(-)	106,861.5	106,861.5	106,861.5	106,861.5
	12. Atlantic Seaboard	- for export	0.0(-)	11,587.8	0.0(-)	11,587.8	0.0(-)
4. Manitoba	4. Manitoba	- for domestic use	21,208.0	21,208.0	21,208.0	21,208.0	21,208.0
		- to be milled, for domestic use	5,613.7(+)	3,133.6	5,613.7(+)	5,613.7(+)	4,204.6(+)
		- to be milled, for export	4,289.8(-)	6,769.9	4,289.8(-)	4,289.8(-)	5,698.9(-)
	5. Ontario	- to be milled, for domestic use	0.0(-)	12,161.3	885.4(-)	10,596.7(-)	0.0(-)
		- to be milled, for export	0.0	0.0	0.0	1,409.1(+)	0.0
	6. Quebec	- for domestic use	418.0(+)	0.0	0.0	0.0	0.0
		- to be milled, for domestic use	0.0	0.0	0.0	0.0	1,832.8(+)
	7. Maritimes	- to be milled, for domestic use	1,414.8	1,414.8	1,414.8	1,414.8	0.0(-)
	10. Thunder Bay	- for export	11,390.9(+)	11,235.4	11,390.9(+)	11,390.9(+)	11,390.9(+)
	12. Atlantic Seaboard	- for export	11,587.8(+)	0.0	11,120.4(+)	0.0	11,587.8(+)
5. Ontario	5. Ontario	- for domestic use	15,476.2(-)	27,637.5	16,361.6(-)	27,637.5	14,067.1(-)
		- to be milled, for domestic use	14,772.2(+)	2,610.9	13,886.8(+)	2,610.9	16,181.3(+)
6. Quebec	6. Quebec	- for domestic use	0.0(-)	1,224.6	0.0(-)	0.0(-)	0.0(-)
		- to be milled, for domestic use	0.0	0.0	1,224.6(+)	1,224.6(+)	1,224.6(+)
	11. St. Lawrence	- for export	1,224.6(+)	0.0	0.0	0.0	0.0
7. Maritimes	7. Maritimes	- for domestic use	467.4	467.4	0.0(-)	467.4	467.4
	12. Atlantic Seaboard	- for export	0.0	0.0	467.4(+)	0.0	0.0
8. Pacific Seaboard	8. Pacific Seaboard	- for export	3,327.6	3,327.6	3,327.6	3,327.6	3,327.6
9. Churchill	9. Churchill	- for export	165.0	165.0	165.0	165.0	165.0
10. Thunder Bay	10. Thunder Bay	- for export	17,696.4	17,696.4	17,696.4	17,696.4	17,696.4
11. St. Lawrence	11. St. Lawrence	- for export	22,077.6	22,077.6	22,077.6	22,077.6	22,077.6
12. Atlantic Seaboard	12. Atlantic Seaboard	- for export	2,775.6	2,775.6	2,775.6	2,775.6	2,775.6

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

Table 5.5: Optimal Wheat Flour Shipments--Model II

Region of Origin	Region of Destination	Nature of Shipment	IIa	IIb	IIc	IId	IIe
			Quantity of Shipment ('000 hundredweight-wheat-equivalents)				
1. British Columbia	8. Pacific Seaboard	- for export	1,409.1	1,409.1	1,409.1	0.0(-)	0.0(-)
2. Alberta	1. British Columbia	- for domestic use	4,377.9	4,377.9	4,377.9	4,377.9	4,377.9
	2. Alberta	- for domestic use	3,129.4	3,129.4	3,129.4	3,129.4	3,129.4
	8. Pacific Seaboard	- for export	791.9	791.9	791.9	2,201.0(+)	2,201.0(+)
	11. St. Lawrence	- for export	0.0	0.0	1,321.1(+)	0.0	0.0
	12. Atlantic Seaboard	- for export	1,604.3	1,604.3	283.2(-)	195.2(-)	195.2(-)
3. Saskatchewan	3. Saskatchewan	- for domestic use	1,654.9	1,654.9	1,654.9	1,654.9	1,654.9
	7. Maritimes	- for domestic use	0.0(-)	2,480.1	0.0(-)	0.0(-)	0.0(-)
	10. Thunder Bay	- for export	897.5(+)	109.3	897.5(+)	897.5(+)	897.5(+)
	11. St. Lawrence	- for export	1,691.9(+)	0.0	1,691.9(+)	0.0	0.0
	12. Atlantic Seaboard	- for export	0.0	0.0	0.0	1,691.9(+)	1,691.9(+)
4. Manitoba	4. Manitoba	- for domestic use	1,844.5	1,844.5	1,844.5	1,844.5	1,844.5
	6. Quebec	- for domestic use	1,289.1	1,289.1	1,289.1	1,289.1	0.0(-)
	7. Maritimes	- for domestic use	2,480.1(+)	0.0	2,480.1(+)	2,480.1(+)	2,360.1(+)
	10. Thunder Bay	- for export	0.0(-)	788.2	0.0(-)	0.0(-)	0.0(-)
	11. St. Lawrence	- for export	1,321.1(-)	3,013.0	0.0(-)	3,013.0	3,013.0
	12. Atlantic Seaboard	- for export	2,968.7	2,968.7	4,289.8(+)	1,276.7(-)	2,685.9(-)
5. Ontario	5. Ontario	- for domestic use	14,772.2	14,772.2	14,722.2	14,772.2	14,772.2
	6. Quebec	- for domestic use	0.0	0.0	0.0	0.0	1,289.1(+)
	7. Maritimes	- for domestic use	0.0	0.0	0.0	0.0	120.0(+)
	12. Atlantic Seaboard	- for export	0.0	0.0	0.0	1,409.1(+)	0.0
6. Quebec	6. Quebec	- for domestic use	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5
7. Maritimes	7. Maritimes	- for domestic use	1,414.8	1,414.8	1,414.8	1,414.8	1,414.8

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

Table 5.6: Optimal Regional Milling Activities-Model II

Region/Nature of Milling Activity		Milling Capacity	Quantity of Flour Milled				
			IIa	IIb	IIc	IId	IIe
			('000 hundredweight-wheat-equivalents)				
1. British Columbia	- total	1,414.8	1,409.1	1,409.1	1,409.1	0.0(-)	0.0(-)
	- for domestic use		0.0	0.0	0.0	0.0	0.0
	- for export		1,409.1	1,409.1	1,409.1	0.0(-)	0.0(-)
2. Alberta	- total	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5
	- for domestic use		7,507.3	7,507.3	7,507.3	7,507.3	7,507.3
	- for export		2,396.2	2,396.2	2,396.2	2,396.2	2,396.2
3. Saskatchewan	- total	4,244.4	4,244.4	4,244.4	4,244.4	4,244.4	4,244.4
	- for domestic use		1,654.9(-)	4,135.1	1,654.9(-)	1,654.9(-)	1,654.9(-)
	- for export		2,589.4(+)	109.3	2,589.4(+)	2,589.4(+)	2,589.4(+)
4. Manitoba	- total	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5
	- for domestic use		5,613.7(+)	3,133.6	5,613.7(+)	5,613.7(+)	4,204.6(+)
	- for export		4,289.8(-)	6,769.9	4,289.8(-)	4,289.8(-)	5,698.9(-)
5. Ontario	- total	32,540.1	14,772.2	14,772.2	14,772.2	16,181.3(+)	16,181.3(+)
	- for domestic use		14,772.2	14,772.2	14,722.2	14,722.2	16,181.3(+)
	- for export		0.0	0.0	0.0	1,409.1(+)	0.0
6. Quebec	- total	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5	9,903.5
	- for domestic use		9,903.5	9,903.5	9,903.5	9,903.5	9,903.5
	- for export		0.0	0.0	0.0	0.0	0.0
7. Maritimes	- total	1,414.8	1,414.8	1,414.8	1,414.8	1,414.8	1,414.8
	- for domestic use		1,414.8	1,414.8	1,414.8	1,414.8	1,414.8
	- for export		0.0	0.0	0.0	0.0	0.0

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

increased shipment from Saskatchewan. In terms of the optimal distribution pattern for flour, Manitoba's shipments to the Maritimes for domestic use increased by almost 2.5 million hundredweight-wheat-equivalents while its export shipments to Thunder Bay and the St. Lawrence ports decreased by an identical amount. Saskatchewan exhibited offsetting changes in its flour shipments. Overall, the only net changes in regional milling activities reflected this relatively greater domestic orientation of the Manitoba flour milling industry and the correspondingly greater export orientation of Saskatchewan's.

Removing the effects of the subsidization of St. Lawrence Seaway tolls (Model IIb) did not have a noticeable impact on the milling and shipment patterns derived by Model I, apparently because of the relative insignificance of these effects as compared to the total transportation expense. Adjusting the freight rate structure to remove the effects of the "At and East" subsidy program (Model IIc) produced results somewhat similar to those observed in Model IIa. That is, the same effect with respect to flour mill supply procurement was evident, though less pronounced but more general. In addition, exports of wheat grain from Saskatchewan through the Atlantic Seaboard were reduced, being replaced by increased shipments from Manitoba and also the small local Maritime supplies (which, in turn, were replaced by shipments from Saskatchewan for domestic use). Also, export shipments of flour from Manitoba were switched from the St. Lawrence ports to the Atlantic Seaboard while an offsetting shift occurred with respect to flour exports from Alberta.

Model II d simulated the impact of adjusting the freight rate structure to remove the effects of the statutory "Crow's Nest Pass" rates. Of course, this had the effect of making grain and flour shipments out of the Prairie regions more expensive. The most interesting difference in the optimal shipment patterns derived by this model (as opposed to those of Model I) was the elimination of exports of flour milled in British Columbia due to increased grain procurement costs. In fact, this amounted to the complete demise of the British Columbia flour milling industry. Export flour shipments through the Pacific Seaboard was replaced by increased shipments from Alberta. However, the milling industry in Alberta was already operating at capacity in the solution to Model I. Therefore, its export flour shipments through the Atlantic Seaboard were, of necessity, decreased. Flour shipments from Ontario, the only region other than British Columbia which was not already milling to capacity in the solution to Model I, increased by about 1.4 million hundredweight-wheat-equivalents in order to meet the export requirement through the Atlantic Seaboard. Other changes exhibited in the solution to Model IId included a greater domestic orientation of the milling industry in Manitoba, matched by an offsetting greater export orientation of the Saskatchewan milling industry, and a switch to local grain supplies by the Quebec milling industry, necessitating increased grain shipments from Saskatchewan to satisfy domestic requirements there.

The solution to Model IIe, for which the freight rate structure had been adjusted to remove the cumulative effects of the stop-off fee subsidy program, subsidized St. Lawrence Seaway tolls, the "At and East" freight rate subsidy program and the statutory "Crow's Nest Pass" rates, reflected various aspects of the solutions to each of the previous models. The flour milling industries of Ontario and Quebec switched to local grain supplies while non-milling domestic requirements in those regions were satisfied from more distant sources. Saskatchewan wheat grain exports through Thunder Bay and the Atlantic Seaboard decreased while Manitoba shipments through those export positions increased. Flour milling in British Columbia was eliminated and, through a series of adjustments, the milling industry in Ontario increased its shipments to meet domestic requirements. Saskatchewan's flour milling industry became more export market oriented and Manitoba's became more domestic market oriented.

In general, these short run reactions to the cost oriented adjustments in the freight rate structure amounted to shifts of activity between regions within the same major geographical areas of Canada. For example, adjustments in flour milling activity were observed between the Prairie regions and from British Columbia to Alberta. Such shifts of activity between Eastern and Western Canada appeared to occur only because of regional milling capacity limitations.

Model III

As with the previous models, Model III derived wheat grain and flour milling and shipment patterns which would minimize direct transportation user expenses while satisfying given regional requirements out of available supplies. Like Model II, cost oriented freight rates were substituted for the observed freight rates of Model I. In Model III, however, the regional milling activities were not constrained to existing 1974 capacity levels. Rather, in deriving the optimal shipping patterns, the transhipment model was allowed to assign milling activity as though regional capacities could be readily expanded in the most transport-expense-efficient manner. The differences between the solutions to Model III and Model I, therefore, simulate the longer run normative impact of modifying the freight rate structure.

The optimal patterns of wheat grain shipments derived by Model III are presented in Table 5.7 while the optimal flour shipment patterns are presented in Table 5.8. The optimal regional milling activities implied by these shipment patterns are summarized in Table 5.9.

The solutions to Models IIIa and IIIb, where the freight rate structures had been adjusted to remove the effects of the stop-off fee subsidy program and of subsidized St. Lawrence Seaway tolls, respectively, were identical. They exhibited a number of differences from the solution to Model I, particularly with respect to regional milling activities and flour shipment patterns. However, it would appear that these changes were generated rather more by the relaxation of the regional milling capacity constraints than by the adjustments made to the freight rates. The most significant changes amounted to a 120 percent increase in Saskatchewan's milling activity, a 43 percent increase in Quebec's and a 175 percent increase in the Maritimes'. Of course, these increases were at the expense of other regions' milling industries. Specifically, the British Columbia milling industry was completely eliminated while Manitoba's suffered a decrease of more than 80 percent and Alberta's decreased by almost 25 percent. The level of activity of the Ontario flour milling industry remained unchanged from its status in the solution to Model I, operating only to satisfy that region's own

Table 5.7: Optimal Wheat Grain Shipments--Model III

Region of Origin	Region of Destination	Nature of Shipment	Quantity of Shipment ('000 hundredweights) IIIa	IIIb	IIIc	IIId	IIIe
1. British Columbia	1. British Columbia	- for domestic use	2,140.8	2,410.8	2,410.8	2,410.8	2,410.8
2. Alberta	1. British Columbia	- for domestic use	218.2	218.2	218.2	218.2	218.2
	2. Alberta	- for domestic use	53,797.9	53,797.9	53,797.9	53,797.9	53,797.9
		- to be milled, for domestic use	7,507.3	7,507.3	7,507.3	7,507.3	7,507.3
		- to be milled, for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	8. Pacific Seaboard	- for export	52,738.7(+)	52,738.7(+)	52,738.7(+)	52,738.7(+)	52,738.7(+)
3. Saskatchewan	1. British Columbia	- to be milled, for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	3. Saskatchewan	- for domestic use	78,685.3	78,685.3	78,685.3	78,685.3	78,685.3
		- to be milled, for domestic use	1,654.9(-)	1,654.9(-)	1,654.9(-)	1,654.9(-)	1,654.9(-)
		- to be milled, for export	7,671.5(+)	7,671.5(+)	3,098.5(+)	10,684.5(+)	3,098.5(+)
	5. Ontario	- to be milled, for domestic use	12,161.3(+)	12,161.3(+)	1,207.3(+)	0.0	0.0
	6. Quebec	- for domestic use	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
		- to be milled, for domestic use	11,192.6(+)	11,192.6(+)	9,968.0(+)	11,192.6(+)	11,192.6(+)
		- to be milled, for export	3,013.0(+)	3,013.0(+)	3,013.0(+)	0.0	3,013.0(+)
	7. Maritimes	- for domestic use	723.3	723.3	723.3	705.9(-)	1,190.7(+)
		- to be milled, for export	0.0	0.0	4,573.0(+)	0.0	4,573.0(+)
	8. Pacific Seaboard	- for export	43,414.4(-)	43,414.4(-)	43,414.4(-)	43,414.4(-)	43,414.4(-)
	9. Churchill	- for export	165.9	165.9	165.9	165.9	165.9
	10. Thunder Bay	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	11. St. Lawrence	- for export	94,682.8(-)	94,682.8(-)	106,861.5	106,861.5	106,376.7(-)
	12. Atlantic Seaboard	- for export	11,587.8	11,587.8	11,587.8	11,587.8	11,587.8
4. Manitoba	4. Manitoba	- for domestic use	21,208.0	21,208.0	21,208.0	21,208.0	21,208.0
		- to be milled, for domestic use	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)
		- to be milled, for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	5. Ontario	- for domestic use	0.0	0.0	10,954.1(+)	12,161.3(+)	12,161.3(+)
		- to be milled, for domestic use	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	6. Quebec	- for domestic use	5,406.0(+)	5,406.0(+)	6,630.6(+)	5,406.0(+)	5,406.0(+)
	7. Maritimes	- for domestic use	0.0	0.0	0.0	17.4(+)	0.0
		- to be milled, for domestic use	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,427.5(+)
	10. Thunder Bay	- for export	11,390.9(+)	11,390.9(+)	11,390.9(+)	11,390.9(+)	11,390.9(+)
	11. St. Lawrence	- for export	12,178.7(+)	12,178.7(+)	0.0	0.0	484.8(+)
5. Ontario	5. Ontario	- for domestic use	27,637.5	27,637.5	16,683.4(-)	15,476.2(-)	15,476.2(-)
		- to be milled, for domestic use	2,610.9	2,610.9	13,565.0(+)	14,772.2(+)	14,772.2(+)
6. Quebec	6. Quebec	- for domestic use	1,224.6	1,224.6	0.0(-)	1,224.6	1,224.6
		- to be milled, for domestic use	0.0	0.0	1,224.6(+)	0.0	0.0
7. Maritimes	7. Maritimes	- for domestic use	467.4	467.4	467.4	467.4	0.0(-)
		- to be milled, for domestic use	0.0	0.0	0.0	0.0	467.4(+)
8. Pacific Seaboard	8. Pacific Seaboard	- for export	3,327.6	3,327.6	3,327.6	3,327.6	3,327.6
9. Churchill	9. Churchill	- for export	165.0	165.0	165.0	165.0	165.0
10. Thunder Bay	10. Thunder Bay	- for export	17,696.4	17,696.4	17,696.4	17,696.4	17,696.4
11. St. Lawrence	11. St. Lawrence	- for export	22,077.6	22,077.6	22,077.6	22,077.6	22,077.6
12. Atlantic Seaboard	12. Atlantic Seaboard	- for export	2,775.6	2,775.6	2,775.6	2,775.6	2,775.6

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

Table 5.8: Optimal Wheat Flour Shipments--Model III

Region of Origin	Region of Destination	Nature of Shipment	Quantity of Shipment IIIa	IIIb	IIIc	IIId	IIIe
			('000 hundredweight-wheat-equivalents)				
1. British Columbia	8. Pacific Seaboard	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
2. Alberta	1. British Columbia	- for domestic use	4,377.9	4,377.9	4,377.9	4,377.9	4,377.9
	2. Alberta	- for domestic use	3,129.4	3,129.4	3,129.4	3,129.4	3,129.4
	8. Pacific Seaboard	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	12. Atlantic Seaboard	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
3. Saskatchewan	3. Saskatchewan	- for domestic use	1,654.9	1,654.9	1,654.9	1,654.9	1,654.9
	7. Maritimes	- for domestic use	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	8. Pacific Seaboard	- for export	2,201.0(+)	2,201.0(+)	2,201.0(+)	2,201.0(+)	2,201.0(+)
	10. Thunder Bay	- for export	897.5(+)	897.5(+)	897.5(+)	897.5(+)	897.5(+)
	11. St. Lawrence	- for export	0.0	0.0	0.0	3,013.0(+)	0.0
	12. Atlantic Seaboard	- for export	4,573.0(+)	4,573.0(+)	0.0	4,573.0(+)	0.0
4. Manitoba	4. Manitoba	- for domestic use	1,844.5	1,844.5	1,844.5	1,844.5	1,844.5
	6. Quebec	- for domestic use	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	10. Thunder Bay	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	11. St. Lawrence	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	12. Atlantic Seaboard	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
5. Ontario	5. Ontario	- for domestic use	14,772.2	14,772.2	14,772.2	14,772.2	14,772.2
6. Quebec	6. Quebec	- for domestic use	11,192.6(+)	11,192.6(+)	11,192.6(+)	11,192.6(+)	11,192.6(+)
	11. St. Lawrence	- for export	3,013.0(+)	3,013.0(+)	3,013.0(+)	0.0	3,013.0(+)
7. Maritimes	7. Maritimes	- for domestic use	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,894.9(+)
	12. Atlantic Seaboard	- for export	0.0	0.0	4,573.0(+)	0.0	4,573.0(+)

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

Table 5.9: Optimal Regional Milling Activities--Model III

Region/Nature of Milling Activity		Quantity of Flour Milled				
		IIIa	IIIb	IIIc	IIId	IIIe
		('000 hundredweight-wheat-equivalents)				
1. British Columbia	- total	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
	- for domestic use	0.0	0.0	0.0	0.0	0.0
	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
2. Alberta	- total	7,507.3(-)	7,507.3(-)	7,507.3(-)	7,507.3(-)	7,507.3(-)
	- for domestic use	7,507.3	7,507.3	7,507.3	7,507.3	7,507.3
	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
3. Saskatchewan	- total	9,326.4(+)	9,326.4(+)	4,753.4(+)	12,339.4(+)	4,753.4(+)
	- for domestic use	1,654.9(-)	1,654.9(-)	1,654.9(-)	1,654.9(-)	1,654.9(-)
	- for export	7,671.5(+)	7,671.5(+)	3,098.5(+)	10,684.5(+)	3,098.5(+)
4. Manitoba	- total	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)
	- for domestic use	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)	1,844.5(-)
	- for export	0.0(-)	0.0(-)	0.0(-)	0.0(-)	0.0(-)
5. Ontario	- total	14,772.2	14,772.2	14,772.2	14,772.2	14,772.2
	- for domestic use	14,772.2	14,772.2	14,772.2	14,772.2	14,772.2
	- for export	0.0	0.0	0.0	0.0	0.0
6. Quebec	- total	14,205.6(+)	14,205.6(+)	14,205.6(+)	11,192.6(+)	14,205.6(+)
	- for domestic use	11,192.6(+)	11,192.6(+)	11,192.6(+)	11,192.6(+)	11,192.6(+)
	- for export	3,013.0(+)	3,013.0(+)	3,013.0(+)	0.0	3,013.0(+)
7. Maritimes	- total	3,894.9(+)	3,894.9(+)	8,467.9(+)	3,894.9(+)	8,467.9(+)
	- for domestic use	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,894.9(+)	3,894.9(+)
	- for export	0.0	0.0	4,573.0(+)	0.0	4,573.0(+)

Note: (-) indicates a decrease as compared to the solution to Model I.
(+) indicates an increase as compared to the solution to Model I.

domestic requirements. The net effect of these changes was that almost 64 percent of the total flour produced was milled in Eastern Canada whereas only 36 percent was milled in Western Canada.

Many of the same impacts were evident in the solution to Model IIIc, where the freight rate structure had been adjusted to remove the effects of the "At and East" subsidy program. However, in this instance flour exported through the Atlantic Seaboard (a requirement which had been met by flour milled in Manitoba and Alberta in the solution to Model I) was milled in the Maritimes (as opposed to Saskatchewan, as in the solution to Models IIIa and IIIb). Thus, Western Canada's share of total Canadian milling activity was reduced to only 27 percent. Also, the supply procurement patterns of the milling industries in Ontario and Quebec exhibited somewhat of a shift towards nearer sources of supply.

Again, in the solution to Model IIId, where the freight rate structure had been adjusted to remove the effects of the statutory "Crow's Nest Pass" rates, many of the same impacts as in Models IIIa and IIIb may be observed. With this change in the rate structure, however, the model assigned <u>all</u> of Canada's milling activity for export purposes to the Saskatchewan milling industry. In this formulation, Western Canada accounted for some 42 percent of the total flour milling activity in Canada. The Ontario milling industry obtained all of its grain requirements from local supplies while the non-milling domestic requirements of that region were met by grain shipments from Manitoba.

In the solution to Model IIIe, where the cumulative effects of the stop-off fee subsidy program, of subsidized St. Lawrence Seaway tolls, of the "At and East" subsidy program and of the statutory "Crow's Nest Pass" rates had been removed from the freight rate structure, a combination of the individual impacts of these freight rate changes may be observed. Again, the British Columbia milling industry was inactive while Alberta only shipped flour to meet its own and British Columbia's domestic requirements. Also, Manitoba filled only its own domestic flour needs. Similarly, Ontario milled enough flour for its own rather large domestic requirement. Saskatchewan, Quebec and the Maritimes, on the other hand, milled flour to meet export requirements, as well as to meet their own domestic requirements. Finally, the milling industries in both Ontario and the Maritimes obtained as much as possible of their grain requirements out of local supplies. The strong resemblance of this solution to that of Model IIIc, where the effects of the "At and East" rates alone had been removed from the rate structure, would seem to imply that these rates have a greater effect on wheat grain and flour shipment patterns than the other rate distortions examined.

Summary

Model I derived optimal wheat grain and flour milling and shipment patterns which implied the approximate domestic/export market orientation which Eastern and Western Canadian flour mills actually exhibit. This suggests that the existing freight rate structure has at least reinforced the regional pattern of development of the CFMI. In contrast to the current situation, however, overall flour production in the solution was divided more or less equally between eastern and western mills. This clearly indicates that factors other than transportation cost efficiency have also influenced the regional distribution of flour milling activity in Canada. Specifically, such factors must account for the relatively greater flour production in Eastern Canada in spite of transportation costs which suggest otherwise.

In general, the solution to Model II seemed to indicate a lack of flexibility to respond completely to given freight rate changes in the short run because, as in Model I, most regions' milling activities were constrained by their existing capacity levels. As expected, this problem was not so evident in the solutions to Model III, where regional milling activities were allowed to expand beyond existing capacity levels, as would be possible in the longer run.

In the short run, removing the effects of the stop-off fee subsidy program and of the "At and East" program from the freight rate structure had similar results. In each case, it lead to significant changes in the grain procurement patterns of the milling industries located outside of the Prairie provinces. Also, a shift in domestic/export flour market orientation by the milling industries of Manitoba and Saskatchewan was evident. In both instances, Saskatchewan became more dedicated to the export market while Manitoba shipped more to the domestic market. Adjusting the rate structure to remove the effects of subsidized St. Lawrence Seaway tolls did not appear to affect the optimal wheat grain and flour milling and shipment patterns. Adjusting the rate structure to offset the effect of the statutory "Crow's Nest Pass" rates lead to the demise of the flour milling industry in British Columbia, with its former share of the overall market being met by increased milling activity in Ontario. Again, the milling industries of Manitoba and Saskatchewan shifted flour market orientation between each other. With the cumulative effects of all of these programs removed from the freight rate structure, the grain supply procurement patterns of the Ontario and Quebec milling industries were affected, the milling industry in British Columbia disappeared while the output of Ontario's milling industry grew. Finally, the milling industries of Saskatchewan and Manitoba shifted domestic/export market orientations.

In the longer run, a number of changes in the optimal milling and shipment patterns appeared due to the relaxation of the regional milling capacity constraints, irrespective of adjustments in the freight rate structure. For example, the levels of milling activity in British Columbia, Alberta, Manitoba and Ontario were identical in the solutions to each of the five versions of Model III, though in each case these levels were lower than they had been in the solution to Model I. The milling industry in Saskatchewan, on the other hand, experienced a net increase in its level of activity due to the relaxation of regional capacity levels. While its shipments to the domestic market decreased, its shipments for export increased by more than enough to offset the decreases. These export shipments increased somewhat less in Models IIIc and IIIe, where the effects of the "At and East" program had been removed from the rate structure, but increased relatively more in Model IIId, where the effects of the statutory "Crow's Nest Pass" rates had been removed. The milling industry in Quebec experienced both increased domestic and export flour shipments on account of the relaxation of regional milling capacities. In Model IIId, where the effects of the statutory "Crow's Nest Pass" rates had been removed from the rate structure, however, Quebec did not mill any flour for the export market. Finally, the Maritimes experienced increased milling activity for shipments to the domestic market because of the relaxation of regional milling capacities but also showed increased shipments for export in the solution to Model IIIc, where the effects of the "At and East" program had been removed from the rate structure.

Comparative Cost Analysis

It has been suggested that the existing freight rate structure in Canada induces grain shipment patterns which are less efficient than those which would develop given a system of cost oriented freight rates. This implies that there is a net cost to society of maintaining the status quo with respect to grain freight rates. As a test of this hypothesis, it is possible to compare and draw observations as to the relative efficiencies of the shipment patterns derived as solutions to the various models formulated for this study.

Table 5.10 compares the total direct transportation user expenses associated with the shipment patterns derived as solutions to Models II and III (which were based upon cost oriented freight rates) with similar costs which have been calculated for the shipment pattern derived in Model I (which was based upon the existing (1974) freight rate structure). The total "real" costs of each of these

Table 5.10: Comparative Cost Analysis

Freight Rate Basis	Total Cost Implied by Optimal Shipment Patterns ($'000)					
	Model I		Model II		Model III	
	Direct User Cost	"Real" Cost	Direct User Cost	"Real" Cost	Direct User Cost	"Real" Cost
Existing (1974) rate structure	115,613	231,977	-	-	-	-
(a) Effects of the stop-off fee subsidy program removed.	116,078	231,977	116,078	231,977	113,558	228,945
(b) St. Lawrence Seaway tolls increased.	116,739	231,977	116,739	231,977	114,276	228,945
(c) Effects of the "At and East" subsidy program removed.	118,029	231,977	118,029	231,977	113,682	228,318
(d) Statutory "Crow's Nest Pass" rates increased.	227,969	231,977	227,869	232,010	225,203	228,534
(e) Cumulative effects of the above four cost oriented adjustments.	231,977	231,977	231,910	231,910	228,318	228,318

shipment patterns, as reflected in the cost oriented freight rate structure introduced in Models IIe and IIIe, are also compared.

As expected, the direct user cost implied by the shipment pattern derived in Model I increases when re-calculated on the basis of freight rate structures which have been adjusted to introduce cost oriented rates. Similarly, the "real" cost of each of the solutions is higher than its direct user cost (except where the cumulative effects of the cost oriented adjustments have already been implemented and the two costs are therefore identical by definition) simply because the same shipment patterns are evaluated at higher cost oriented rate levels. The important comparison is between the total "real" costs of each of the shipment patterns derived.

In general, the variation in total "real" costs between the different solutions is small. In fact, the shipment patterns derived in Models IIa, IIb and IIc (where the effects of the stop-off fee subsidy program, of subsidized St. Lawrence Seaway tolls and of the "At and East" program, respectively, had been removed from the freight rate structure) appear to be no more efficient than the solution to Model I. While the shipment pattern derived by Model IId (for which the statutory "Crow's Nest Pass" rates had been increased) was marginally less costly in terms of direct user expense than the Model I shipment pattern, it was actually less efficient in terms of total "real" cost. Only the solution to Model IIe (where the cumulative effects of the cost oriented adjustments were introduced into the freight rate structure) was really more efficient that the shipment pattern derived as a solution to Model I, and that by less than 0.03 percent.

The shipment patterns derived by Model III (where the regional milling capacity constraints were relaxed, in addition to the freight rates being adjusted) were somewhat more efficient, with total "real" costs of from 1.3 to 1.6 percent less than the solution to Model I. These cost savings imply some incentive for relocation of the flour milling industry in the long run.

These observations offer little support for the hypothesis that a cost oriented grain freight rate structure would induce more efficient transportation flows in Canada. The fact that changes in the freight structure alone did not lead to significant cost savings, in Model II, but that relaxing regional milling capacity constraints at the same time did lead to "real" cost savings in Model III, suggests only that Canadian flour milling capacity is not now distributed efficiently in terms of transportation costs. That is to say, factors other than transportation cost must be largely responsible for the existing regional distribution of flour milling capacity in Canada.

Spatial Price Equilibrium Analysis

Transportation costs act as an impediment to trade between regions and perpetuate equilibrium price differentials over space. As noted in Appendix A, the dual values of linear programming transportation models provide a means by which the relative advantage of trading regions may be estimated. In fact, this method amounts to measuring the transportation cost differentials of various locations with respect to an exogenously pre-determined base price. This section presents the system of implicit spatial price differentials of the model implemented in this study and discusses the impact upon these price levels of introducing cost oriented freight rates.

Table 5.11 presents the equilibrium prices of wheat in the various domestic and export regions of the model given the existing (1974) freight rate structure and, also, given freight rate structures adjusted to remove the non-economic effects of the stop-off fee subsidy program, of subsidized St. Lawrence Seaway tolls, of the "At and East" program and of the statutory "Crow's Nest Pass" rates. The unweighted 1974 annual average of Canadian Wheat Board monthly average selling quotations for 1 CW(13.5 percent protein) wheat, basis in store Thunder Bay, of $9.262 per hundredweight was accepted as a base price for this

Table 5.11: Implicit Spatial Wheat Price Equilibrium*

REGION	Existing (1974) Freight Rates	Cost-Oriented Freight Rates: Existing (1974) Rates Adjusted to Remove the Effects of: (a) Stop-off free Subsidy Program	(b) Subsidized St. Lawrence Seaway tolls	(c) "At and East" Program	(d) Statutory "Crow's Nest Pass" Rates	(e) Cumulative
	(Dollars Per Hundredweight)					
Domestic						
1. British Columbia	10.162	10.162 (0.0)	10.162 (0.0)	10.162 (0.0)	9.802 (-0.360)	9.802 (-0.360)
2. Alberta	9.082	9.082 (0.0)	9.082 (0.0)	9.082 (0.0)	8.722 (-0.360)	8.722 (-0.360)
3. Saskatchewan	9.042	9.042 (0.0)	9.042 (0.0)	9.042 (0.0)	8.602 (-0.440)	8.602 (-0.440)
4. Manitoba	9.122	9.122 (0.0)	9.122 (0.0)	9.122 (0.0)	8.842 (-0.280)	8.842 (-0.280)
5. Ontario	9.540	9.540 (0.0)	9.540 (0.0)	9.540 (0.0)	9.540 (0.0)	9.540 (0.0)
6. Quebec	9.560	9.560 (0.0)	9.568 (+0.008)	9.560 (0.0)	9.560 (0.0)	9.568 (+0.008)
7. Maritimes	9.722	9.722 (0.0)	9.730 (+0.008)	9.722 (0.0)	9.722 (0.0)	9.730 (+0.008)
Export						
8. Pacific Seaboard	9.282	9.282 (0.0)	9.282 (0.0)	9.282 (0.0)	9.322 (+0.040)	9.322 (+0.040)
9. Churchill	9.252	9.252 (0.0)	9.252 (0.0)	9.252 (0.0)	9.232 (-0.020)	9.232 (-0.020)
10. Thunder Bay	9.262	9.262 (0.0)	9.262 (0.0)	9.262 (0.0)	9.262 (0.0)	9.262 (0.0)
11. St. Lawrence	9.560	9.560 (0.0)	9.568 (+0.008)	9.560 (0.0)	9.560 (0.0)	9.568 (+0.008)
12. Atlantic Seaboard	9.722	9.722 (0.0)	9.730 (+0.008)	9.722 (0.0)	9.722 (0.0)	9.730 (+0.008)

*Values in parentheses are equal to the difference between a given price and the equilibrium price based upon the existing (1974) freight rate structure.

analysis.[2] This price is assumed to reflect competitive world wheat prices upon which equilibrium prices within Canada would be established.

The spatial price equilibria outlined in Table 5.11 reflect traditional Canadian wheat production and consumption patterns. Given the existing (1974) freight rate structure, the primary surplus regions of Saskatchewan, Alberta and Manitoba exhibit price levels of $9.042, $9.082 and $9.122 per hundredweight of wheat, respectively. These prices represent competitive export prices less the cost of placing wheat from those regions in export position. Equilibrium prices in the deficit regions of Ontario, Quebec, the Maritimes and British Columbia are relatively higher, at $9.540, $9.560, $9.722 and $10.162 respectively, reflecting the cost of transportation from the surplus regions. Differences in prices between export regions reflect differences in the cost of positioning wheat stocks in those locations. Churchill, with an equilibrium price of $9.252 per hundredweight, has a slight assembly cost advantage over Thunder Bay ($9.262) which, in turn, has a slight advantage over the Pacific Seaboard ports ($9.282). By comparison, positioning wheat at the St. Lawrence and

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[2] Canadian Wheat Board, Annual Report (1973-74 and 1974-75) (Winnipeg: 1975 and 1976), Statistical Table XXIV.

Atlantic Seaboard ports is relatively more costly, with equilibrium prices of $9.560 and $9.722 per hundredweight being exhibited in those regions.

Adjusting the freight rate structure to remove the effects of the stop-off fee subsidy program and of the "At and East" program had no measurable impact upon the spatial price equilibrium implied by existing (1974) rates. Removing the effects of subsidized St. Lawrence Seaway tolls lead to equilibrium price increases of less than 0.1 percent in the domestic regions of Quebec and the Maritimes and the St. Lawrence and Atlantic Seaboard export positions. Increasing the statutory "Crow's Nest Pass" rates by a factor of three had significant effects, however, especially in Western Canada. Equilibrium wheat prices fell by $0.440 per hundredweight in Saskatchewan (4.9 percent), by $0.360 in Alberta (4.0 percent) and British Columbia (3.5 percent) and by $0.280 in Manitoba (3.1 percent). In addition, the price at Churchill dropped by $0.020 per hundredweight (0.2 percent) while the price at the Pacific Seaboard ports increased by $0.040 (0.43 percent). Considering 1974 production levels, Prairie wheat producers would have suffered a loss in gross income amounting to about $112.6 million while consumers in British Columbia and the Prairies would have benefited from decreased wheat prices. The cumulative impact upon the spatial price equilibrium of adjusting the freight rate structure to remove the effects of all of these programs simultaneously was simply additive.

To a certain extent, these observations were induced by construct. That is, in accepting an exogenously pre-determined export price as the basis of these spatial price equilibria estimates, it was implicitly assumed that the cumulative foreign demand for Canadian wheat was perfectly elastic with respect to price (in particular, the transport component of price) while the Canadian wheat supply was perfectly inelastic, at least in the short run. As a result, the entire increase in transportation costs were absorbed by Canadian wheat producers while none was passed on to foreign buyers. More realistically, while it is recognized that Canadian wheat supply is likely to be <u>relatively</u> inelastic and that foreign demand for Canadian wheat is likely to be <u>relatively</u> elastic, they are not likely to be <u>perfectly</u> so. Therefore, the expected impact of adjusting the freight rate structure as above would be somewhat mollified, with at least some of the increased transportation cost being absorbed by foreign buyers.

CHAPTER VI

SUMMARY

The general problem of non-economic freight rates adversely affecting resource allocation in industries which are served by the transportation system is of widespread concern. Disturbance of the transport price mechanism by government has the effect of masking underlying economic relationships and distorting the effective level and structure of freight rates. This may result in inefficient transportation patterns in the short run, and sub-optimal industrial location decisions in the long run which are based not so much upon inherent regional advantages as upon institutional considerations.

In Canada, government intervention in the freight rate determination process has been linked to the unification and growth of the Dominion. Nowhere has this been more apparent than in the development of Western Canada and the Prairie grains industry. The legacy which remains after many years of heated political debate over the freight rate structure for grain includes the statutory "Crow's Nest Pass" and "At and East" rates, as well as the subsidization of flour millers' in-transit stop-off fees and the operation of the St. Lawrence Seaway with a toll structure which, until recently, did not generate sufficient revenues to cover even its cost of operation. Recent federal government initiatives with respect to transportation would appear to be in the direction of promoting economic efficiency, however.

The Canadian flour milling industry (CFMI) is particularly vulnerable to changes in the freight rate structure. This industry, which depends heavily upon the transportation system, has unfortunately suffered a prolonged period of decline in international markets. At the same time, there has been a notable shift in flour milling activity to mills located in Eastern Canada, to some extent at the expense of mills in Western Canada. This regional transfer of activity has taken place in spite of the fact that flour milling is a significantly weight reducing process and, as such, might be expected to find advantage locating near its principal sources of wheat grain supplies, on the Prairies.

The purpose of this research has been to investigate the influence which the prevailing grain freight rate structure may have had upon the development of the CFMI, and the Canadian wheat economy generally, and to suggest possible implications of changes in these freight rates in the future. An empirical framework was developed within which three distinct versions of a specialized linear programming transhipment model were applied in such a way as to simulate normative short and long run reactions of the CFMI and other wheat grain and flour shippers to the introduction of cost oriented freight rates.

Model I, which was based upon existing (1974) freight rates and regional milling capacities, derived wheat grain and flour milling and shipment patterns to satisfy all regional requirements out of available supplies while minimizing total direct transportation user expenditures. Model II differed from Model I in that it was based upon a system of cost oriented freight rates. Thus, differences between the optimal solutions to Models I and II simulated the normative reactions of the CFMI to the introduction of such rates. Since regional flour milling capacities were restricted to their estimated 1974 levels, these reactions were deemed to be short run in nature. In Model III, also, cost oriented freight rates were introduced. In addition, however, the regional flour milling capacity constraints were relaxed, allowing the model to seek an optimal solution under the assumption that extra capacity could be constructed wherever necessary. Thus, differences between the solutions to Models I and III were deemed to represent the normative long run reactions of the CFMI to the adoption of cost oriented freight rates.

Conclusions

The principal objective of this analysis has been to measure the impact of freight rates upon the regional distribution of flour milling activity within Canada. Normative empirical results obtained through the application of the linear programming transhipment models described above offer some support for the hypothesis that freight rates have influenced the locational development of the CFMI. However, these results do not fully explain the current regional distribution of Canadian flour milling activity.

The optimal milling and shipment patterns derived by Model I closely resemble the actual pattern of domestic and export market orientation currently exhibited by mills in Eastern and Western Canada. Thus, the existing (1974) freight rate structure would appear to have enhanced the relative regional advantage of Eastern Canada in respect of domestic flour shipments and of Western Canada in respect of export shipments. In contrast to reality, however, the solution to Model I assigned almost perfectly equal shares of the overall milling activity to Eastern and Western Canadian mills. In fact, in this solution, all three Prairie regions were milling to the full extent of their capacities while milling activity in British Columbia amounted to some 99.6 percent of its capacity. Factors outside the scope of this model (that is, factors other than the cost of transportation) must therefore explain the current dominance of eastern mills in the overall production of Canadian flour and the persistent problem of excess capacity suffered particularly by western mills.

The short run implications of introducing cost oriented freight rates were examined in Model II. Generally, the regional milling capacity constraints appeared to limit the ability of the solution to fully respond to the modified freight rates. The introduction of cost oriented St. Lawrence Seaway tolls did not affect the solution at all. Removal of the effects of the stop-off fee subsidy program and of the "At and East" rates from the rate structure did not affect the overall level of milling activity in any region. However, each of these two adjustments to the rate structure did lead to a shift in market orientation between Manitoba and Saskatchewan. That is, domestic flour shipments from Manitoba increased but were offset by decreased shipments for export. At the same time, perfectly opposing changes in the pattern of flour shipments from Saskatchewan offset those in Manitoba. In addition to similar market reorientation adjustments, removing the effects of the statutory "Crow's Nest Pass" rates from the rate structure also had the effect of reducing flour milling activity in British Columbia to zero. Ontario, the only region other than British Columbia with available capacity, benefited from increased milling activity as a result. Consequently, overall milling activity in Western Canada was reduced while that in Eastern Canada increased. Finally, with the cumulative effects of all four of these modifications introduced into the freight rate structure, all of these effects were evident.

The longer run implications of introducing cost oriented freight rates were examined in Model III. Relaxation of the regional milling capacity constraints had a number of impacts, apparently irrespective of changes in the freight rate structure. The solutions to Models IIIa and IIIb, wherein the effects of the stop-off fee subsidy program and of subsidized St. Lawrence Seaway tolls had been removed from the freight rate structure, were identical to each other. This would suggest that neither of these cost oriented adjustments to the freight rate structure would have significant effects on the optimal pattern of wheat grain and flour milling and distribution in Canada. However, the pattern of regional milling activities in these solutions differed considerably from the solution to Model I. Specifically, milling activity in Saskatchewan, Quebec and the Maritimes was significantly higher. Conversely, it was lower in British Columbia, Alberta and Manitoba. The net effect of these changes was that almost 64 percent of the total flour produced was milled in Eastern Canada whereas only 36 percent was milled in Western Canada. This pattern closely resembles the actual situation. Again, however, these effects appeared to be induced by relaxing the regional milling capacity constraints, not by adjusting the freight rate structure.

Removal of the effects of the "At and East" rates from the rate structure did result in changes to the optimal pattern of regional milling activity. Flour destined for export through the Atlantic Seaboard ports was milled in the Maritimes rather than in Saskatchewan, thus further reducing Western Canada's share of total Canadian milling activity to only 27 percent. Removal of the effects of the statutory "Crow's Nest Pass" rates from the rate structure had the opposite effect, shifting milling activity to satisfy export requirements through the St. Lawrence ports from Quebec mills to those in Saskatchewan. In this formulation, Western Canada accounted for some 42 percent of the total milling activity in Canada. Finally, with the cumulative effects of these adjustments removed from the freight rate structure, the optimal solution resembled that of Model IIIc, where the effects of the "At and East" rates alone had been removed from the rate structure. This would imply that these rates have a greater effect on the regional distribution of Canadian flour milling activity than the other rate distortions which were examined, including the statutory "Crow's Nest Pass" rates.

A second objective of this analysis has been to examine the normative impact of introducing cost oriented adjustments to the grain freight rate structure upon the relative efficiency of existing transportation patterns. That is, the effects of these freight rate changes on the total "real" cost of grain transportation were measured. While in some cases these changes induced marginal cost savings, the overall results of this analysis suggest that introducing cost oriented freight rates will not significantly improve the relative efficiency of present shipment patterns. To a large extent, factors outside the scope of this analysis dictate the transportation patterns, allowing little room for improvement. Such considerations as transport infrastructure limitations, for example, will remain and continue to influence the actual milling and shipment patterns whether or not cost oriented freight rates are adopted.

Finally, a third objective of this analysis has been to measure the impact of introducing cost oriented adjustments to the freight rate structure upon spatial wheat price equilibrium in the Canadian economy. Removing the effects of the stop-off fee subsidy program and of the "At and East" rates from the freight rate structure did not have a measurable impact on the equilibrium levels of wheat prices across Canada. Raising the level of St. Lawrence Seaway tolls to cost oriented levels only marginally increased wheat prices in Eastern Canada. Increasing the statutory "Crow's Nest Pass" rates by a factor of three had significant effects, however, particularly in Western Canada. The equilibrium prices of wheat dropped by 44 cents per hundredweight in Saskatchewan (4.9 percent), by 36 cents per hundredweight in Alberta (4.0 percent) and British Columbia (3.5 percent) and by 28 cents per hundredweight in Manitoba (3.1 percent). Thus, wheat producers in these provinces would bear the brunt of additional transportation expenses associated with raising these rates. In fact, these are not new costs but costs which are presently borne by the railways (directly), and to some extent by the federal government (indirectly, through subsidization of the railways), which would be transferred to the producers if these rates were raised. Considering 1974 production levels, this would amount to an annual loss of gross income in the order of $112.6 million for Western Canadian wheat producers. On the other hand, purchasers of wheat in these provinces would enjoy the benefits of lower prices. Not only would this contribute to lower food costs in Western Canada, but it would also encourage increased livestock feeding and other industrial processes which use wheat as a raw material. Furthermore, similar effects could be expected with respect to other grains which would also be affected by raising these rates. In addition, the price of wheat in export position at Churchill dropped by two cents per hundredweight while the price of wheat in export position on the Pacific Seaboard rose by four cents per hundredweight. These changes demonstrate the distortion inherent in the present rate structure in terms of the comparative advantage of the various export channels in

Canada. Wheat prices in Eastern Canada were not affected by removing the effects of the "Crow's Nest Pass" rates from the freight rate structure. Finally, all of these effects upon spatial wheat price equilibrium were simply additive when the cumulative effects of these cost oriented adjustments were introduced into the rate structure simultaneously.

Thus, it would appear that the implications within the Canadian wheat flour economy of introducing cost oriented adjustments to the freight rate structure may be primarily distributional rather than substantive. That is, while the changes simulated in this analysis implied only relatively minor shifts in the optimal wheat and wheat flour milling and shipment patterns derived, significant shifts in the burden of transportation costs were observed. Specifically, the transportation expenses facing Prairie grain producers were higher as a result of the increased freight rates but the railways received greater commercial revenues and the federal government's subsidy expenditures decreased.

In addition to the limited regional implications noted above, rationalization of the grain freight rate structure would impact upon resource allocation within the Prairie agriculture industry. Whereas the profitability of grain production, especially for export, has been enhanced relative to other agricultural production by artifically low freight rates, total output of such grain may be expected to have been somewhat greater than otherwise principally at the expense of other forms of output. Furthermore, livestock production on the Prairies, for example, suffers not only by this direct competitive disadvantage to Prairie grain production but also indirectly, because competing livestock producers in other regions have been able to obtain Prairie feed grains at lower delivered prices than they would otherwise be able to. The introduction of cost oriented adjustments to the grain freight rate structure would thus be expected to remove some such distortions and may therefore induce more economic allocation of available productive resources.

Limitations

By its very nature, an economic analysis which develops a complex empirical model to simulate actions and reactions in the real world will be subject to certain limitations. Many of these will relate to simplifying assumptions required by the model. Nonetheless, such a limited analysis may yet provide useful new insights into difficult policy matters provided its findings are interpreted carefully and are understood within the strict confines of those limitations.

Perhaps the most restrictive limitation of the present analysis is that its results are normative, describing only the situation which should have existed, rather than attempting to predict that which will happen.

While it serves to clarify the nature of the impact of transportation costs on the Canadian wheat flour economy, it does not attempt to demonstrate the importance of transportation relative to other factors.

The objective function of the empirical model was to minimize total direct transportation user expenditures required to satisfy all regional requirements out of available supplies. This approach did not consider total transportation costs, including those assumed by government and those absorbed by the carriers, but only those facing wheat grain and flour shippers. In addition, the objective was satisfied with respect to the entire system, as though decisions were made by a single body. Thus, while overall shipper costs were minimized across the entire system, those of particular regions or sub-systems may not have been. Furthermore, the model assumed that all activities take place at a single representative center within each region.

Wheat was the only grain considered and flour was assumed to be the only product of the milling process. In fact, a significant by-product of flour milling is millfeeds. By ignoring this by-product it was implicitly assumed that there exists a universal demand for millfeeds at all flour mill locations so that no further transportation implications would derive from its marketing. Furthermore, all wheat grain and flour was considered to be perfectly homogeneous, thereby simplifying the transportation requirements of the system.

All freight rates were assumed to be independent of the volumes shipped. It was further assumed that sufficient transportation capacity existed at all stages of the marketing process. No consideration was made of the seasonality of the grain transportation problem. In addition, for lack of accurate information, it was assumed that the cost of handling and transporting wheat grain and flour were equal on a simple weight basis, as are existing freight rates for these two commodities. Another parameter of the model which is of uncertain reliability is the estimation of regional milling capacities. Finally, as noted in Chapter V, the analysis of spatial price equilibrium implicitly assumed that aggregate export demand for Canadian wheat is perfectly elastic with respect to price while the supply is perfectly inelastic, at least in the short run. As this is not absolutely true, more realistic conclusions with respect to the incidence of increased transportation expenses would be somewhat mollified.

Suggestions for Further Research

This study has identified a number of problem areas to which further research effort might well be directed. The present analysis represents only a first step in the examination of factors influencing the regional distribution of flour milling activity in Canada, concentrating on the effects of transportation cost. Subsequent study to identify other important factors and to explore the nature of inter-relationships between these factors would be a useful supplement to this analysis. For example, identification of possible differences in processing costs between alternative locations and/or the presence of economies of scale in flour processing may help to explain the regional distribution of the CFMI. In addition, investigations of the effects of introducing cost oriented grain freight rates upon other grains and grain processing industries would provide equally valuable information. Finally, further study of the incidence of increased transportation costs is required before a final evaluation of the existing freight rate structure can be complete.

APPENDIX A

THE LINEAR PROGRAMMING TRANSPORTATION MODEL

THE LINEAR PROGRAMMING TRANSPORTATION MODEL

Linear programming is a mathematical technique in which a given linear function is optimized subject to a number of limiting side constraints, also in the form of linear equations. Under sterile mathematical conditions, the technique is incapable of generating any economic information. As a tool of economists, however, it has become a highly valued computational procedure. Its ability to scan complex systems of interrelationships and to illustrate succinctly the implications of given economic conditions thereupon has proven particularly useful in applied research. At the same time, it is also an important tool of theoretical analysis since it is a decision model based upon optimal (ie. "rational") patterns of individual behaviour.[1]

The transportation model is a specialized computational technique which can be applied to a particular subset of linear programming problems. Its primary advantage is that a much simpler solution procedure may be employed. In addition, however, it provides a convenient format within which many problems may be more easily conceptualized. As the name suggests, it is especially

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[1]For a more complete discussion of the role played by linear programming in economic analysis, see William J. Baumol, Economic Theory and Operations Analysis (3rd ed.) (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972), especially pp. 70-102.

suited to problems which deal with transportation. In fact, the technique was originally formulated so as to assign flows of a commodity between a number of spatially separated surplus and deficit regions in such a way that total transportation costs for the system would be minimized.[2] The model is currently applied to a much wider range of problems than this, but transportation and location economics remain its primary fields of employment.

For every linear programming model, there exists a complementary formulation which is referred to as its "dual". It is, in fact, merely the original problem re-specified in a format which facilitates the observation of values which were implicitly imposed upon the various resources by the original model. Generally, these values represent the marginal value productivity of the resources concerned. In transportation models, where the difference between the value of a good at its origin and at its destination is precisely equal to the cost of transporting it from one point to the other, these values indicate the comparative locational advantage of the various regions. These dual values may thus be used to determine the relative

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[2] F.L. Hitchock, "The Distribution of a Product from Several Sources to Numerous Localities", Journal of Mathematical Physics, Vol. 20, 1941, pp. 224-230.

spatial equilibrium for the model under consideration.[3]

In order to define the basic transportation model, one must first assume the existence of a single homogeneous commodity and a number of geographically distinct regions which are connected by a transportation network. Then one must define S_i (the quantity of commodity available at the i^{th} source), D_j (the quantity of commodity required at the j^{th} destination), X_{ij} (the number of units of commodity transported from the i^{th} source to the j^{th} destination), C_{ij} (the cost of transporting one unit of commodity from the i^{th} source to the j^{th} destination) and TTC (the total transportation cost for the system). This done, the transportation model may be expressed mathematically as:

$$\text{Minimize:} \quad TTC = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \qquad \begin{matrix}(i=1,2,\ldots,m)\\(j=1,2,\ldots,n)\end{matrix} \tag{1}$$

$$\text{Subject to:} \quad \sum_{j=1}^{n} X_{ij} \leq S_i \tag{2}$$

$$\sum_{i=1}^{m} X_{ij} = D_j \tag{3}$$

$$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_j \tag{4}$$

$$X_{ij}, S_i, D_j \geq 0 \tag{5}$$

[3]For a more complete explanation of the "dual" to transportation models, see Robert Dorfman, Paul A. Samuelson and Robert M. Solow, Linear Programming and Economic Analysis (New York: McGraw-Hill Book Company, 1958), pp. 122-127.

Equation (1) states the objective of the problem, which is to minimize total transportation costs for the system (these costs being equal to the sum of the unit cost of transportation from each source to each destination multiplied by the actual number of units of commodity transported over those routes). Equation (2) ensures that the total of all shipments out of each source does not exceed the total quantity of commodity initially available there. Equation (3) requires that the total quantity of commodity shipped to each destination exactly equals the quantity required there. Equation (4) states that the total of the quantities of commodity available at all sources must equal the total of the quantities required at all destinations (an operational requirement of the basic model). Finally, equation (5) requires that all quantities of commodity be greater than or equal to zero. That is, negative quantities are infeasible.

Representation of the transportation problem in tabular form, as in Figure A.1, more clearly illustrates the fundamental properties of the model. Each row of the tableau represents a source in the original problem while each column represents a destination. The quantity of commodity available at each source is given in the right-hand column and the quantity required at each destination is given in the bottom row. The totals of each of these (which are equal) are given in the lower right-hand corner

Figure A.1: Tableau Format of the Basic Transportation Model

	i \ j	Destinations 1	2	...	j	...	n	S_i
Sources	1	$C_{11} X_{11}$	$C_{12} X_{12}$	...	$C_{1j} X_{1j}$	...	$C_{1n} X_{1n}$	S_1
	2	$C_{21} X_{21}$	$C_{22} X_{22}$	...	$C_{2j} X_{2j}$	...	$C_{2n} X_{2n}$	S_2
	⋮	...	...	...	...	...	...	⋮
	i	$C_{i1} X_{i1}$	$C_{i2} X_{i2}$	...	$C_{ij} X_{ij}$	...	$C_{in} X_{in}$	S_i
	⋮	...	...	...	...	...	...	⋮
	m	$C_{m1} X_{m1}$	$C_{m2} X_{m2}$	...	$C_{mj} X_{mj}$	...	$C_{mn} X_{mn}$	S_m
	D_j	D_1	D_2	...	D_j	...	D_n	$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_j$

where the bottom row and the right-hand column intersect. Within each cell of the tableau the relevant transport cost and quantity information is given. In the cell located at the intersection of the second row and the first column, for example, C_{21} represents the cost of transporting one unit of the commodity from the second source to the first destination and X_{21} represents the number of units shipped over that route.

The transportation model is a powerful tool of spatial economic analysis. In the relatively simple form presented above, however, its effective range of application is severely limited by its abstract nature. Fortunately, a number of extensions and modifications to the basic framework have been developed which enable it to more realistically model complex situations.

Perhaps the most restrictive aspect of the transportation model is that it requires the total of all quantities available and the total of all quantities required at the various locations to be exactly equal to each other. In fact, it would be more realistic to expect either that total quantities available will exceed total quantities required (ie. $\sum_{i=1}^{m} S_i > \sum_{j=1}^{n} D_j$) or that total quantities available will be insufficient to fulfill total requirements (ie. $\sum_{i=1}^{m} S_i < \sum_{j=1}^{n} D_j$). In either situation, however, only a minor adjustment of the basic framework is required in order for the model to accept the more realistic problem. The adjustment involves the definition of a fictitious location to absorb the difference between the quantities available and required. In the case of excess supply capacities, for example, an additional destination (j=n+1) would be defined with commodity requirements exactly equal to the excess of quantities available over quantities required (ie. $D_{n+1} = \sum_{i=1}^{m} S_i - \sum_{j=1}^{n} D_j$). The transportation cost of shipping commodity to this destination would be set equal to zero (ie. $C_{i(n+1)} = 0; i=1,2,...,m$) since, in the final solution, any shipments to it (ie. $X_{i(n+1)} > 0; i=1,2,...,m$) would really only represent the absorption of excess capacity by the originating source and not an actual shipment of commodity. By means of this simple manipulation, the strict format requirements of the transportation model technique can be maintained while investigating a more realistic problem situation than would otherwise be possible.

Another limitation of the basic transportation model is that it assumes each source to be directly linked with each destination via the existing transport infrastructure. In reality, however, the transportation network may be such that connections between particular pairs of points are simply not feasible. It may become necessary, therefore, to prohibit positive X_{ij} values from entering certain cells of the tableau which represent such inadmissable routes. The procedure used to overcome this difficulty is, in effect, to price shipments between such pairs of points out of the optimal solution. That is, the C_{ij} values corresponding to the infeasible routes are set at an arbitrarily high level (usually designated as "M") which is great enough to ensure that such shipments do not take place. This simple but effective manipulation of the transportation model enables it to simulate this complexity of existing transportation networks.

The basic transportation model permits only direct shipments of commodity from sources to destinations. One of the most valuable extensions to this model is the transhipment varient which incorporates the possibility of linked paths through intermediate locations.[4] In this reformulation of the original model, any point in addition to being a source or a destination, may also act as a distribution center. Although the resulting problem is considerably more complex, it may be specified in such a way that it can be solved in precisely the same manner as the simple transportation problem. This is accomplished by defining the transhipment activities as standard transportation activities and including certain features to compensate for the differences.

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[4]Alex Orden, "The Transhipment Problem", Management Science, Vol. 2, 1956, pp. 276-285.

In the transhipment model some or all of the original sources may act as intermediate distribution centers which both receive and dispatch commodity shipments. Similarly, some or all of the original destinations may both accept and issue shipments. The original sources must therefore be redefined simply as points 1,2,...,m and the original destinations as points (m+1), (m+2),..., (m+n). The first subscript on a variable now refers to any point from which a shipment is delivered and the second subscript now refers to any point which receives a shipment. With appropriate adjustments made to accommodate these changes, the variables S_i, D_j, X_{ij}, C_{ij} and TTC remain as defined for the general transportation model.

In order to accommodate transhipments out of the original destinations and into the original sources, artificial stockpiles of commodity must be established at those points from which, and into which, transhipments may be made. Fictitious availabilities [S_i; i=(m+1), (m+2),..., (m+n)] and requirements (D_j; j=1,2,...,m) are therefore specified as temporary buffer inventories at these points. Additions to, and compensating withdrawals from, these stockpiles are interpreted as intermediate transhipments of commodity through the locations involved. The cost of transportation from any location to itself is, of course, equal to zero ie.[C_{ij} = 0; i=j=1,2,...,m, (m+1), (m+2),..., (m+n)]. Excess inventories therefore cancel themselves out and never appear in the final solution.

The transhipment model can be mathematically defined as:

$$\text{Minimize:} \quad TTC = \sum_{i=1}^{m+n} \sum_{j=1}^{m+n} C_{ij} X_{ij} \begin{bmatrix} i=1,2,\ldots,m,(m+1),(m+2), \\ \ldots,(m+n) \\ j=1,2,\ldots,m,(m+1),(m+2), \\ \ldots,(m+n) \end{bmatrix} \tag{6}$$

$$\text{Subject to:} \quad \sum_{j=1}^{m+n} X_{ij} - \sum_{j=1}^{m+n} X_{ji} \leq S_i \tag{7}$$

$$\sum_{i=1}^{m+n} X_{ij} - \sum_{i=1}^{m+n} X_{ji} = D_j \tag{8}$$

$$\sum_{i=1}^{m+n} S_i = \sum_{j=1}^{m+n} D_j \tag{9}$$

$$X_{ij},\ S_i,\ D_j \geq 0 \tag{10}$$

The objective function (6) remains, as before, to minimize total transportation costs for the system. Equations (7) and (8) are simply modified versions of equations (2) and (3), respectively, which in addition, maintain a commodity balance at all locations. Specifically, equation (7) states that the net amount of commodity shipped out of each point (ie. total outflows minus total inflows) must not exceed the total quantity available there to begin with. Equation (8) requires that the net amount of commodity received at each point (ie. total inflows minus total outflows) equals the quantity required there. In addition, equations (7) and (8) ensure that no uncompensated shipments into or out of transhipment centers persist in the final solution. Equation (9) is equivalent to equation (4) in stating that the total of all quantities available must exactly equal the total of all quantities required. Finally, equation (10) states the non-negativity assumptions of the model.

A general transhipment model in tableau format is illustrated in Figure A.2. Comparison of this with Figure A.1 reveals the nature of the modifications which are required in order to pose the more complex transhipment problem within the framework of the simple transportation model. Further, it is interesting to note that the transhipment problem may be separated into four distinct sub-sections. The upper left-hand sub-section is an (m x m) matrix representing commodity shipments from original sources to other sources for transhipment purposes. The upper right-hand matrix of size (m x n) is interpreted as shipments of commodity directly from original sources to destinations. The lower left-hand sub-section is an (n x m) matrix representing commodity shipments from destinations acting as intermediate points to sources acting as intermediate points. Finally, the lower right-hand sub-section is an (n x n) matrix of shipments from intermediate destination points to final destinations.

Figure A.2: Tableau Format of the General Transhipment Model

	i \ j	Destinations: Sources: 1	2	...	m	Destinations: (m+1)	...	(m+n)	S_i
Sources: Sources	1	C_{11} X_{11}	C_{12} X_{12}	...	C_{1m} X_{1m}	$C_{1(m+1)}$ $X_{1(m+1)}$	...	$C_{1(m+n)}$ $X_{1(m+n)}$	S_1
Sources: Sources	2	C_{21} X_{21}	C_{22} X_{22}	...	C_{2m} X_{2m}	$C_{2(m+1)}$ $X_{2(m+1)}$	...	$C_{2(m+n)}$ $X_{2(m+n)}$	S_2
Sources: Sources	⋮	...	...	...	...	...	...	...	⋮
Sources: Sources	m	C_{m1} X_{m1}	C_{m2} X_{m2}	...	C_{mm} X_{mm}	$C_{m(m+1)}$ $X_{m(m+1)}$	...	$C_{m(m+n)}$ $X_{m(m+n)}$	S_m
Sources: Destinations	(m+1)	$C_{(m+1)1}$ $X_{(m+1)1}$	$C_{(m+1)2}$ $X_{(m+1)2}$	...	$C_{(m+1)m}$ $X_{(m+1)m}$	$C_{(m+1)(m+1)}$ $X_{(m+1)(m+1)}$	...	$C_{(m+1)(m+n)}$ $X_{(m+1)(m+n)}$	$S_{(m+1)}$
Sources: Destinations	⋮	...	...	...	...	...	...	...	⋮
Sources: Destinations	(m+n)	$C_{(m+n)1}$ $X_{(m+n)1}$	$C_{(m+n)2}$ $X_{(m+n)2}$	...	$C_{(m+n)m}$ $X_{(m+n)m}$	$C_{(m+n)(m+1)}$ $X_{(m+n)(m+1)}$	...	$C_{(m+n)(m+n)}$ $X_{(m+n)(m+n)}$	$S_{(m+n)}$
	D_j	D_1	D_2	...	D_m	$D_{(m+1)}$	...	$D_{(m+n)}$	$\sum_{i=1}^{m+n} S_i = \sum_{j=1}^{m+n} D_j$

Thus, the transhipment varient enables the general transportation model to consider problems involving indirect routes between locations. Through similar modifications, it may be further extended to consider problems concerned with multiple decision variables. That is, problems in which more than one commodity,[5] more than one mode of transport,[6] more than one time period[7] or more than one stage of the production-distribution process[8] are to be considered simultaneously may be formulated within the general format of the transportation problem. This is accomplished by defining each of the multiple variables

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[5]Richard A. King and William R. Henry, "Transportation Models in Studies of Interregional Competition", Journal of Farm Economics, Vol. 41, No. 5, December, 1959, pp. 997-1,011.

[6]K. Brian Haley, Mathematical Programming for Business and Industry (Toronto: The MacMillan Company of Canada Limited, 1967), pp. 58-62.

[7]Mack N. Leath and James E. Martin, "Formulation of a Transhipment Problem Involving Time", Agricultural Economics Research, Vol. 19, No. 1, January, 1967, pp. 7-14.

[8]Gordon A. King and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments", Journal of Farm Economics, Vol. 46, No. 1, February, 1964, pp. 94-108.

in the problem as distinct transportation activities and solving as before.[9, 10]

Suppose, for example, that a particular problem consists of minimizing total transportation costs for the simultaneous allocation of several commodities from a number of sources to destinations. By treating the quantities available and required of each commodity at each location as separate points in a network, the problem may be solved as a standard transportation problem. The only other modification required is a system of notation by which the identities of all sources, destinations and commodities may be easily recognized. To that end, a third subscript is added to each of the variables previously defined. Shipments from source i to destination j of commodity k would then be represented by X_{ijk}; the unit cost of that shipment would be C_{ijk}; the quantity of commodity k available at source i would be S_{ik} and the

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[9] Verner G. Hurt and Thomas E. Tramel, "Alternative Formulations of the Transhipment Problem", Journal of Farm Economics, Vol. 47, No. 3, August, 1965, pp. 763-773.

[10] It should be noted here that one author, at least, has conceptualized a methodology which considers n-dimensional transportation problems explicitly (see K.B. Haley, "The Solid Transportation Problem", Operations Research, Vol. 10, 1962, pp. 448-463 and "The Multi-Index Problem", Operations Research, Vol. 11, 1963, pp. 368-379). However, no convenient solution procedure for such problems has yet been developed (see Giuseppe M. Ferrero di Roccaferrera, Operations Research Models for Business and Industry (Cincinnati, Ohio: South-Western Publishing Company, 1964) p. 486).

quantity required at destination j would be D_{jk}. As before, total transportation costs for the system are given by TTC. The mathematical definition of the model becomes:

$$\text{Minimize:} \quad TTC = \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{p} C_{ijk} X_{ijk} \quad \begin{matrix}(i=1,2,\ldots,m)\\(j=1,2,\ldots,n)\\(k=1,2,\ldots,p)\end{matrix} \qquad (11)$$

$$\text{Subject to:} \quad \sum_{j=1}^{n} X_{ijk} \leq S_{ik} \qquad (12)$$

$$\sum_{i=1}^{m} X_{ijk} = D_{jk} \qquad (13)$$

$$\sum_{i=1}^{m} S_{ik} = \sum_{j=1}^{n} D_{jk} \qquad (14)$$

$$X_{ijk}, S_{ik}, D_{jk} \geq 0 \qquad (15)$$

Figure A.3 illustrates, in tableau format, the case of an example with two sources, three destinations and two commodities. The essence of the modification to the general transportation problem required in order to incorporate more than one commodity lies in the two-tiered definition of origins and destinations. That is, the quantities of each commodity available and required at each location are treated separately. In this case, the problem would be solved as though it were a standard transportation problem with four origins and six destinations. Shipments of one commodity to satisfy requirements for the other appear in the tableau as blank cells, having been "priced out" of the model beforehand (see above).

Figure A.3: A Two Source, Three Destination, Two Commodity Transportation Model

i \ j		1		2		3		S_{ik}
i	k	1	2	1	2	1	2	
1	1	$C_{111}X_{111}$		$C_{121}X_{121}$		$C_{131}X_{131}$		S_{11}
	2		$C_{112}X_{112}$		$C_{122}X_{122}$		$C_{132}X_{132}$	S_{12}
2	1	$C_{211}X_{211}$		$C_{221}X_{221}$		$C_{231}X_{231}$		S_{21}
	2		$C_{212}X_{212}$		$C_{222}X_{222}$		$C_{232}X_{232}$	S_{22}
D_{jk}		D_{11}	D_{12}	D_{21}	D_{22}	D_{31}	D_{32}	

$$\sum_{i=1}^{2} S_{i1} = \sum_{j=1}^{3} D_{j1}$$

$$\sum_{i=1}^{2} S_{i2} = \sum_{j=1}^{3} D_{j2}$$

This section has presented the general transportation model and a number of useful extensions to it. Given these modifications, individually and in combination, it is possible to fashion complex versions of the model which simulate existing economic systems. This study employs such a model to determine optimal wheat grain and flour shipment patterns under alternative freight rate structures. The specific format of this model is outlined in Chapter IV.

APPENDIX B

A COMPARISON OF OPTIMAL WHEAT GRAIN AND FLOUR SHIPMENT PATTERNS WITH ACTUAL GRAIN AND GRAIN PRODUCT SHIPMENT PATTERNS

A COMPARISON OF OPTIMAL WHEAT GRAIN AND FLOUR SHIPMENT PATTERNS WITH ACTUAL GRAIN AND GRAIN PRODUCT SHIPMENT PATTERNS

In order to assess the "reasonableness" of the normative shipment patterns derived in this analysis, it was considered to be important to compare them to actual shipment patterns for 1974. Unfortunately, as noted in Chapter V, complete statistics concerning interregional shipments of wheat grain and flour within Canada are not available on a basis which is directly comparable. Statistics Canada reports commodity movements by the various modes of transport.[1] However, with respect to water and truck traffic, this data is not compiled on the basis of a sufficiently detailed commodity classification to identify wheat grain and flour separately. With respect to rail traffic, it is not possible to link the origins and destinations of commodities loaded and unloaded in the different regions. The Canadian Transport Commission publishes two series of statistics concerning interregional rail shipments of commodities. One of these only differentiates between three regions in Canada: the Maritimes,

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[1]Statistics Canada publishes a number of data sets with respect to each mode: those relating to the rail mode are included in the catalogue number series 52-2XX; those relating to the truck mode are included in the catalogue number series 53-2XX; and, those relating to the marine mode are included in the catalogue number series 54-2XX.

Eastern and Western Regions.[2] The other is not compiled on the basis of a sufficiently detailed commodity classification to identify wheat grain and flour shipments separately from other grain and grain product shipments.[3]

In spite of these problems, it was felt that even a very approximate comparison would be worthwhile. Therefore, an origin/destination matrix was compiled from the optimal shipment patterns derived in this analysis, with some regional aggregation. Specifically, the domestic regions of Ontario, Quebec and the Maritimes and the export regions of Thunder Bay, St. Lawrence and the Atlantic Seaboard were all combined together into one group referred to as "Eastern Canada". Also, the export region of Churchill was included with the domestic region of Manitoba and the export region of the Pacific Seaboard was included with the domestic region of British Columbia. The domestic regions of Saskatchewan and Alberta were not affected by re-grouping. On the basis of this regional breakdown, it was assumed that all interregional shipments would move by rail. Wheat grain and flour shipments were combined together.

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[2]Canadian Transport Commission, Research Branch, Waybill Analysis Carload All-Rail Traffic (Ottawa: annual-discontinued after 1977).

[3]Canadian Transport Commission, Traffic and Tariffs Branch, Commodity Flow Analysis, Canadian Carload Traffic (Ottawa: annual).

The most nearly comparable origin/destination matrix of actual 1974 shipments possible, was compiled from unpublished detail included in the Commodity Flow Analysis statistics.[4] All grain and grain product shipments were combined on a similar regional basis. Since this comparison of optimal and actual shipment patterns is based on wheat grain and flour shipments on the one hand, and all grain and grain products shipments on the other, only relative proportions of the total volume of shipments can be compared.

The comparison outlined in Table B.1 provides the relative shares of all interregional traffic in wheat grain and flour as derived in this thesis (in parentheses) and of all interregional traffic in all grain and grain products which were actually carried between the pairs of origin/destination regions considered. Shipments within regions are not included in the total since, in the derivation of the normative shipment patterns for wheat grain and flour, inventory transfers were considered as intra-regional shipments.

Even based upon this crude comparison, it is clear that the derived shipment patterns roughly approximate the actual patterns of movement within the Canadian grain transportation network. While the optimal patterns

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[4] Ibid.

Table B.1

<u>A Comparison of the Relative Shares of Interregional Wheat Grain and Flour Shipments as Derived in this Thesis (in parentheses) with the Relative Shares of Interregional Grain and Grain Products Shipments Actually Observed, 1974</u>

(all shares in percentages)

Origin \ Destination	Eastern Canada	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Eastern Canada		(*) *	(*) *	(*) *	(*) 0.1	(*) 0.2
Manitoba	(12.0) 15.3		(*) *	(*) *	(*) 0.5	(12.0) 15.7
Saskatchewan	(49.9) 45.0	(*) 4.0		(*) 0.2	(17.2) 12.6	(67.2) 61.7
Alberta	(0.6) 4.6	(*) 0.4	(*) *		(20.3) 17.2	(20.9) 22.2
British Columbia	(*) *	(*) *	(*) *	(*) *		(*) *
Total	(62.5) 64.8	(*) 4.5	(*) 0.1	(*) 0.2	(37.5) 30.4	(100.0) 100.0

*Less than 0.1 percent of the grand total for all interregional shipments.

Source: Tables 5.1 and 5.2 of the present analysis, and Canadian Transport Commission, Traffic and Tariffs Branch, <u>Commodity Flow Analysis 1974, Canadian Carload All-Rail Traffic</u> (Ottawa: Reference Paper Number 1.2, 1977) plus unpublished detail.

which were derived did not capture some of the minor inter-regional shipments, the major traffic flows (for example, from the Prairie provinces to Eastern Canada and British Columbia) appear to have been very closely simulated.

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