UNIVERSITY OF MANITOBA

PRIMARY ELEVATOR PRICING AND THE EFFICIENCY OF THE WESTERN GRAIN HANDLING AND TRANSPORTATION SYSTEM

© by Bruce D. Kirk

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ABSTRACT

PRIMARY ELEVATOR PRICING AND THE EFFICIENCY OF THE WESTERN GRAIN HANDLING AND TRANSPORTATION SYSTEM

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Major Advisor: Dr. E. W. Tyrchniewicz

The optimal configuration and efficiency of the Prairie grain handling and transport system (GHTS) remains an unresolved problem in western agriculture. Available evidence indicates that rail costs at least could be significantly reduced by rationalizing the branchline and hence elevator network on the Prairies. While the branchline network remains frozen by Order-In-Council until the year 2000, producers could bring about a 'de facto' abandonment of many lines if they could be induced to change their delivery patterns. One reason that this has not occurred previously is due to the pricing structures legislated for the railways and, perhaps, practiced by the elevator companies.

Both the statutory freight rates and primary elevator tariffs for handling grain are characterized by a significant degree of spatial price discrimination. Given the large differences in rail costs per tonne that exist for grain originating on branch versus mainlines, there is a definite pattern of cross-subsidization in favour of producers who

patronize branchline delivery points. Producers thus have little incentive to truck longer distances given the existing statutory freight rate structure. There is also an obvious pattern of price discrimination, and perhaps cross-subsidization, in primary elevator pricing. Thus the magnitude of the inefficiency in the GHTS will depend, in part at least, on whether the pattern of elevator price discrimination is similar to what exists on the rail side. GHTS inefficiency will be larger if branchline elevators have lower price/cost ratios than mainline points and vice versa.

Constrained indirect profit functions and associated output supply and input demand functions were estimated from a sample of 590 primary elevators in order to determine whether there is an overall pattern of price discrimination between branch and mainline elevators in the grain handling function. The constraint was taken to be the tariffs each company filed with the Canadian Grain Commission during 1982-83. While the Commission provides only a minimal level of tariff regulation, the filed tariffs provide a useful benchmark against which handling charges can be assessed.

The results of the empirical analysis indicate that actual handling prices differ significantly from the filed tariffs, although there is no evidence that the differences are greater or lesser for branch versus mainline elevators. A test for structural difference between branch and mainline elevators shows that combining the two samples is statistically appropriate, implying that the profitability of branch and mainline elevators is the same. The pricing and relative profitability analyses taken together suggest there is no systematic pattern of elevator price discrimination favouring producers utilizing either branch or mainline delivery points. Therefore, primary elevator pricing of the grain handling function would appear to be neutral with respect to efficiency in the GHTS. From a policy stance, these results imply that cost-based elevator tariffs would not enhance the on-going consolidation of the GHTS, even if these were combined with cost-based freight rates.

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TABLE OF CONTENTS

PAGE

LIST OF TABLES.. vii
LIST OF DIAGRAMS.. ix

CHAPTER

I INTRODUCTION.. 1
PROBLEM IDENTIFICATION............................ 1
RESEARCH OBJECTIVES............................... 6
STATEMENT OF HYPOTHESES........................... 7

II PRICING AND EFFICIENCY IN THE WESTERN GHTS.............. 9
RAIL PRICING AND EFFICIENCY....................... 10
Background.................................... 10
Western Grain Transportation Act.............. 13
Cross-Subsidization in Grain Freight Rates.... 16
PRIMARY ELEVATOR PRICING AND EFFICIENCY........... 21
Background.................................... 21
Primary Elevator Price Discrimination......... 25
RELATED STUDIES................................... 31

III A THEORETICAL ASSESSMENT OF GHTS PRICING................ 35
THE THEORY OF SPATIAL PRICE DISCRIMINATION........ 35
AN APPLICATION TO THE GHTS........................ 46

IV EMPIRICAL PROCEDURES.................................... 56
DUALITY THEORY.................................... 56
The Unconstrained Indirect Profit Function.... 57
The Constrained Indirect Profit Function...... 60
PROFIT FUNCTION SPECIFICATION..................... 61
ESTIMATION AND TESTING PROCEDURES................. 64
DATA SOURCES...................................... 66
Cost Data..................................... 70
Revenue Data.................................. 71
SPECIFICATION OF VARIABLES........................ 73

V EMPIRICAL RESULTS....................................... 78
MODELLING ESTIMATES............................... 78
Long Run Models............................... 78
Short Run Models.............................. 88
HYPOTHESIS TESTS.................................. 96
Pricing....................................... 96
Profitability................................. 100

TABLE OF CONTENTS

PAGE

CHAPTER

VI CONCLUSIONS AND POLICY IMPLICATIONS.................... 102
- CONCLUSIONS.. 104
- POLICY IMPLICATIONS.................................. 107
- LIMITATIONS OF THE STUDY............................. 109
- SUGGESTIONS FOR FURTHER RESEARCH..................... 110

BIBLIOGRAPHY.. 111

APPENDIX A: The Constrained Multiple Output Profit Function Model...................... 116

APPENDIX B: Estimation of Kilowatt-Hours.................. 122

APPENDIX C: Test for Structural Differences Between Grain-Dependent and Nongrain-Dependent Models.................................. 126

APPENDIX D: Sample Characteristics........................ 140

LIST OF TABLES

TABLE		PAGE
I	Statutory Grain Rail Costs	19
II	Primary Elevator Configuration 1935-85	22
III	Average Elevator Characteristics by Capacity Ranges	27
IV	Characteristics of Prairie Grain Production Handling and Exports by Crop Year	69
V	Correlations Between Output and Input Prices	77
VI	Definition of Variable and Model Pneumonics	79
VII	Long Run Constrained Model I Estimates: Pooled Elevator Sample	82
VIII	Long Run Constrained Model II Estimates: Grain-Dependent Elevator Sample	86
IX	Long Run Constrained Model III Estimates: Nongrain-Dependent Elevator Sample	87
X	Short Run Constrained Model I Estimates: Pooled Elevator Sample	91
XI	Short Run Constrained Model II Estimates: Grain-Dependent Elevator Sample	92
XII	Short Run Constrained Model III Estimates: Nongrain-Dependent Elevator Sample	93
XIII	Significance Tests on the Handling Price Constraint	98
XIV	Means, Variances and Calculated t and F-Statistics on Handling Price Differences Between Grain- and Nongrain-Dependent Samples by Province	99
XV	Significance Tests on the Relative Profitability of Grain- and Nongrain-Dependent Elevators	101
CI	Long Run Constrained Model I Estimates: Pooled Elevator Sample	130
CII	Long Run Unrestricted Constrained Model IA Estimates	131
CIII	Long Run Constrained Model II Estimates: Grain-Dependent Elevator Sample	133
CIV	Long Run Constrained Model III Estimates: Nongrain-Dependent Sample	134
CV	Short Run Constrained Model I Estimates: Pooled Elevator Sample	135
CVI	Short Run Unrestricted Constrained Model IA Estimates	136
CVII	Short Run Constrained Model II Estimates: Grain-Dependent Elevator Sample	138
CVIII	Short Run Constrained Model III Estimates: Nongrain-Dependent Elevator Sample	139

LIST OF TABLES (continued)

PAGE

TABLE

DI Characteristics of Long Run Data by Province and Status of Rail Line.............................. 140
DII Characteristics of Short Run Data by Province and Status of Rail Line.............................. 142
DIII Characteristics of the Entire Long Run Sample.............. 144
DIV Characteristics of the Entire Short Run Sample............. 145

LIST OF DIAGRAMS

DIAGRAM		PAGE
I	Freight Absorption: Single Firm	40
II	Freight Absorption: Multiple Firms	43
III	Freight Absorption: Market Areas	44
IV	Cross-Subsidization Favouring Branchline Delivery Points	48
V	Cross-subsidization Favouring Mainline Delivery Points	54
VI	Relationship of Normalized Profits to Normalized Prices From Models LRCI, LRCII, LRCIII	89
VI	Relationship of Normalized Profits to Normalized Prices From Models SRCI, SRCII, SRCIII	95

CHAPTER I

INTRODUCTION

PROBLEM IDENTIFICATION

The optimal configuration and efficiency of the Prairie grain handling and transportation system (GHTS) remains an open and highly contentious issue. Conceptually, the problem of GHTS efficiency is one of minimizing the total costs of moving statutory grain from farmgate both to local end-user and predominantly to export position at Thunder Bay, Vancouver, Prince Rupert and Churchill. While there are substantial differences of opinion on this issue, available evidence does indicate that rail costs at least could be significantly reduced.[1] However, the arguments and evidence presented by the different sides in the debate have not been sufficiently robust to settle the efficiency question and thereby determine the optimal handling and rail network on the Prairies.

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[1]CP Rail, "Recent and Potential Efficiency Gains in Grain Related Rail Operations: Focus on Branchlines", presented by David R. Craig to the Workshop on Grain Transportation Research Sponsored by the Transport Institute, University of Manitoba (September 8-9), 1986.

A move to increase efficiency in the GHTS would likely imply a significant rationalization of the branchline and hence elevator network on the Prairies. While the number of primary elevators and grain delivery points has continued to fall over time, the basic rail network, comprising just under 16,000 miles of track in the west, remains frozen by Order-In-Council until the year 2000. A pruning of the branchline network would mean both a different pattern of delivery points and a faster pace of elevator closure than if the basic rail network were to be left intact.

It is worth noting that a reduction in the size of the grain-dependent branchline network would affect not only rail and elevator costs but would increase trucking costs to producers whose delivery points would be affected and, perhaps, provincial expenditures on road/highway maintenance. While this point is recognized, no attempt is made in this study to determine an optimal GHTS and who might gain or lose from it; rather, the focus is on whether primary elevator pricing is neutral with respect to the efficiency of the system.

While some still hold the view that no efficiency gains are possible in the GHTS[2], a more important reason for the prohibition against GHTS consolidation may be one of income distribution. A net overall reduction in GHTS costs may be possible but many producers and their organizations remain unwilling to accept a faster pace of change if

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[2]Gordon C. Hall, Report of the Committee of Inquiry on Crow Benefit Payment, (Ottawa: Supply and Services Canada 1985), pp. 26, 32-33.

it would result in gains to the railways or government and losses to producers. In addition, a more efficient GHTS could upset the pricing structures practiced by the elevator companies and legislated for the railways. This would likely result in income transfers between producers that would be unacceptable to many farmers.

Price discrimination can be thought of as occurring when the selling price of a good or service, relative to its cost, is higher for one or more consumers than it is for other buyers, all other things being equal. Price discrimination can arise even when the price is the same for all buyers so long as the cost of providing the good or service differs amongst them. Cross-subsidization, on the other hand, occurs when a good or service is sold below cost to one or more consumers and above cost to others. It therefore represents a particular form of price discrimination. There is clearly both an element of price discrimination and cross-subsidy in the existing structure of freight rates for moving statutory grain. This rate structure, taken over almost entirely from the Crow rates, does very little to encourage the efficient utilization of railway plant and equipment. It is essentially a distance and weight-related scale that averages total grain rail costs over all delivery points. For delivery points located the same distance from export position, grain producers pay the same rate per gross tonne-mile regardless whether the delivery point is located on a branch or a mainline. Given the large differences in rail costs per tonne that can exist for grain originating on branch versus mainlines, there is a definite pattern of price discrimination/cross-subsidization in favour of those producers who patronize branchline delivery points.

The Canadian Grain Commission provides a minimal level of economic regulation in the western primary elevator industry. It sets maximum handling and storage charges each year but, beyond this, elevator companies are free to file tariffs at or below the maximum levels with the stipulation being that producers and the Commission be given 14 days notice before tariff charges come into effect. Tariffs filed with the Commission reveal a substantial uniformity in handling and storage rates across companies and delivery points within each province, although price competition may still exist in less obvious forms.[3] Available evidence also indicates that elevator costs per tonne vary widely by delivery point.[4] It is likely, therefore, that price discrimination, and perhaps cross-subsidization, also exists in the primary elevator component of the GHTS. Because of this, producers have little financial incentive to truck longer distances to higher throughput, lower cost delivery points.

A necessary condition for price discrimination to persist over time is that some firms possess market power. Jeffrey has argued that the western elevator industry is obligopolistic on the basis of, amongst other factors, continued excess primary elevator capacity, barriers to entry in the form of high capital costs for both primary and terminal

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[3]J. Russell Jeffrey, "Economic Performance in the Western Canadian Primary Elevator Industry," (M.Sc. Thesis, University of Manitoba, 1985), pp. 38-48. Disguised forms of price competition might involve 'de facto' premiums on grades and/or weights determined at the primary elevator. Open price competition such as trucking premiums does not appear to be very widespread.

[4]*Ibid.*, pp. 64-69.

elevator construction, inelastic demand at grain delivery points and vertical integration between primary and terminal elevator operations.[5] Moreover, it is contended that the Manitoba Pool Elevators and the Saskatchewan and Alberta Wheat Pools determine both the level and geographic pattern of primary elevator grain handling prices in their respective provinces. It may be that vertical integration between primary and terminal elevator operations results in a joint maximization strategy with pricing of the former designed to retain or expand market share and pricing of terminal operations designed to maximize total profits.

Price discrimination in the grain handling function, which includes elevation, storage and the removal of dockage, can potentially affect overall system efficiency. The magnitude of the inefficiency in the GHTS will depend, ceteris paribus, on whether the pattern of elevator pricing is similar to what exists on the rail side. That is, GHTS inefficiency will be larger if branchline elevators have lower price/cost ratios or if these delivery points are being cross-subsidized by mainline points and will be smaller if the reverse pattern holds. For example, if branchline elevators were, on average, less profitable than mainline elevators and grain company prices did conform to their filed tariffs, then one could conclude that price discrimination, and perhaps outright cross-subsidization, favours producers who truck their grain to branchline delivery points. The charging of equal handling prices for a given type of grain at all delivery points within a province would not provide any financial

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[5] Ibid., pp. 36-37.

incentives for these producers to truck longer distances to more efficient mainline delivery points. All other things being equal, this would increase the inefficiency found in the rail component of the GHTS. Alternatively, if branchline elevators were more profitable than ones located on mainlines and grain companies strictly adhered to their filed tariffs, then the inefficency on the rail side due to the existence of the branchline would tend to be offset by the relatively higher profitability of elevators located on them. Put another way, branchline consolidation may reduce rail costs but could impose higher costs elsewhere in the system that might increase total GHTS costs.

The question naturally arises whether the observed structure of primary elevator prices, as filed with the Grain Commission, is an accurate reflection of the handling and storage rates charged to producers. Evidence to the contrary might indicate a greater or lesser degree of competitive behavior in the grain industry than Jeffrey's analysis would otherwise indicate. More importantly, it could affect the pattern of price discrimination and its potential impact on GHTS efficiency that would otherwise exist if grain companies strictly adhered to their filed tariffs.

In summary, there is likely price discrimination in grain handling at primary elevators on the Prairies. If this pattern is not offset by the financial aspects of other elevator services, then it may have an impact on GHTS efficiency. Such an impact would exist if elevator pricing practices either enhance or detract in a systematic fashion from the pattern of price discrimination inherent in rail pricing of statutory grain.

1.2 RESEARCH OBJECTIVES

The research objectives of this thesis can be summarized as follows:

1. Determine whether there is an overall pattern of price discrimination between branch and mainline elevators in grain handling operations by conducting a comparative profit structure analysis.

2. Investigate whether elevator companies generally adhere to the primary elevator tariffs that they file with the Canadian Grain Commission.

3. Assess whether concomitant factors such as the number of companies operating at each delivery point can help to account for whatever price discrimination exists in the grain handling function between branch and mainline delivery points.

4. Draw conclusions about elevator price discrimination and its potential impact on the issue of efficiency in the GHTS.

Objectives 1-3 will be fulfilled by modeling the profit structures and grain handling prices of branch and mainline elevators separately using econometric methods and elevator company data.

1.3 STATEMENT OF HYPOTHESES

The null hypothesis that will be tested in this thesis is:

> The pricing of branchline as compared with mainline elevator grain handling services in western Canada is neutral with respect to the issue of GHTS efficiency.

This hypothesis contains a number of subsidiary hypotheses:

1. Branch and mainline elevators have the same profit structure for handling grain.

2. Effective grain handling rates charged to producers delivering to branchline elevators are the same as those delivering to mainline elevators.

3. By extension, elevator companies generally charge producers handling rates as contained in their primary elevator tariffs filed with the Canadian Grain Commission.

4. Concomitant factors such as the number of companies operating at each delivery point do not affect the relative profitability of branch versus mainline elevators.

CHAPTER II

PRICING AND EFFICIENCY IN THE WESTERN GHTS

There are few if any issues in domestic agricultural policy that have generated as much controversy and analysis as the on-going problem of efficiency in the Prairie grain handling and transport system (GHTS). The economic core of the problem continues to be the pricing of both primary elevator and grain rail transportation services for handling and moving statutory grain off the Prairies. In response to income distribution and political concerns, however, successive governments have opted for regulatory/administrative solutions combined with increasing subsidization of the rail component of the GHTS since the late 1960's. Subject to far less economic regulation, the primary elevator network has undergone much more rapid change with much less resistance. The purpose of this chapter is to review the background and issues in GHTS efficiency in light of rail and primary elevator pricing practices. Pricing and efficiency are examined in each component of the GHTS separately with the final section devoted to a review of selected studies that have attempted to estimate the cost-savings from increased system consolidation.

RAIL PRICING AND EFFICIENCY

Background

On June 29, 1897 Parliament passed the Crow's Nest Pass Act,[1] enabling the federal government to enter into an agreement with the Canadian Pacific Railway for the construction of a 300 mile rail line from Lethbridge, Alberta to Nelson, B.C.. In retrospect, the key provision in the agreement was the reduction in perpetuity on eastbound freight rates for grain and flour. The Crow rates were extended to all delivery points in 1925 with west coast ports and Churchill being named eligible export destinations in 1927 and 1931 respectively. Additional crops and crop products were subsequently added to the list of statutory 'grain' over time with the last major addition being canola in 1961.

By the late 1950's statutory grain traffic had become a losing proposition for the railways. Rather than attacking the central problem of the Crow rates being unremunerative, however, successive governments adopted an administrative/regulatory approach that left the railways with steadily mounting losses from moving statutory grain. By the end of the 1970's, Crow-related problems included: the financial inability of the

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[1]An excellent history of the development of the GHTS in the context of the Crow rates is contained in Alberta, A Discussion Paper on Current Issues in Grain Handling and Transportation, (Edmonton: Alberta Economic Development, Alberta Agriculture, no date), pp. 1-33.

railways to expand mainline capacity through the western mountains and hence, the threat of westbound mainline traffic rationing;[2] an increasing incentive to grow and export statutory grain at the expense of crop diversification and the processing of grains/oilseeds on the Prairies;[3] the deterioration of the grain-dependent branchline network and the grain car fleet, requiring increasing government subsidies.[4]

In response to the growing list of Crow problems, the federal government announced in early 1982 that it intended to eliminate railway losses in moving grain with an on-going financial commitment to western grain transportation. The subsequent report of the Gilson consultations recommended, amongst other things, that the federal government should pay an annual Crow Benefit with nearly 81% of the benefit being paid directly to producers after seven years.[5]

The importance of paying the majority of the government's on-going financial commitment directly to producers was deemed to be two-fold. First, historically-based producer payments would eliminate nearly all of

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[2]Canada, Crow Book: Background, Statistical Notes and Analysis of Crow Related Issues, (Ottawa: Transport Canada, February 1982), pp. 47-53.

[3]Z. Ahmadi-Esfahani, "The Impact of Changes in Statutory Grain Freight Rates on Canada's Share of the Export Wheat Market", (Ph.D. Thesis, University of Manitoba, 1987). Chapter II contains a review and references of studies measuring the impacts of the Crow distortion on the domestic agri-food system.

[4]Alberta, op. cit., p. 28 and Canada, op. cit., p. 12.

[5]J.C. Gilson, Western Grain Transportation (Ottawa: Supply and Services Canada, June 1982), Chapter VI.

the freight rate distortion in Prairie agriculture by gradually increasing the Crow rate up to 81% of their compensatory or full-cost level. This would reduce farmgate statutory grain prices, thereby lowering input costs to Prairie grain and oilseed processors. Further, it would make the production of non-statutory crops relatively more attractive.

Second, the railways would have greater financial flexibility to offer freight rate discounts at high volume delivery points as freight rates approached their compensatory levels. Producers would receive financial compensation in the form of lower rates to induce them to truck longer distances rather than continuing to deliver their grain to elevators located on high-cost inefficient branchlines. This would result in a 'de facto' abandonment of such lines, thereby reducing rail costs and lowering subsequent rate levels for all producers.

Opposition to the Gilson report was soon forthcoming, especially over the issue of variable or incentive freight rates. This raised the fear that the railways would unilaterally determine the future shape of the grain rail network. Under the combined pressure of Quebec and the Wheat Pools, the federal government opted for payment of its share of annual grain rail costs directly to the railways while accepting most of Gilson's other recommendations.[6]. The Western Grain Transportation

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[6]K.H. Norrie, "Not Much to Crow About: A Primer on the Statutory Grain Freight Rate Issue", Canadian Public Policy, Vol. 9, No. 4, pp. 434-445.

Act[7] (WGTA) received royal assent in late 1983 and its provisions came into effect on January 1, 1984.

Western Grain Transportation Act

The WGTA ensures that the railways will receive adequate compensation for moving statutory grain in that the federal government committed itself to providing on-going financial support for Prairie grain shippers. Moreover, the legislation provides for a new regulatory environment to oversee grain rail transportation, placing more emphasis and responsibility on industry-generated solutions to existing and potential problems in the GHTS.[8]

Amongst other things, the WGTA specifies a new rate structure for moving statutory grain patterned closely on the old Crow rate structure. The new rate structure, called the base rate scale,[9] was estimated from the rail volumes and the shippers' share of eligible rail costs in the crop year 1981-82. The setting of freight rates for each new crop year will depend on estimates of total eligible rail costs, the shippers' share of these costs and the allocation of total shipper costs across Prairie delivery points using the base rate scale.

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[7]Canada, Western Grain Transportation Act, C-155, (Ottawa: Queen's Printer, 1983).

[8]*Ibid.*, Sections 13-20.

[9]*Ibid.*, Section 34.

The estimated total costs in a forthcoming crop year are allocated across delivery points by multiplying the base rate scale by the ratio of estimated total costs to total base year costs. The resulting average total costs at each delivery point are then split into a government share and the shippers' rate according to their respective percentages of total estimated costs. The railways receive an amount per tonne directly from shippers, varying across delivery points in accordance with the base rate scale. The government payment per tonne is paid after receiving and verifying invoices received from the railways.

The Act permits lower rates if agreed by shippers and railways. However, an application must be submitted to the Canadian Transport Commission (now called the National Transportation Agency) seven months before the start of the next crop year when they would come into effect. Moreover, appeals can be launched by anyone who feels threatened by reduced rates.[10]

As mandated under Section 62 of the WGTA, two reviews of the Act have recommended different alternatives to paying the railways and keeping freight rates well below costs. The Hall Committee of Inquiry on

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[10]*Ibid.*, Section 45. Since August 1, 1987, CN has been offering a reduction of $1.50 per tonne to shippers that can load a minimum of 18 hopper cars in 24 hours or less. In discussions with CN, it appears that only 1% of the amount of statutory grain moved to the end of week forty received the discount. Two reasons for this might be that the discount is not being passed on to producers by the grain companies or that the discount is too small to affect farmers' delivery patterns.

Crow Benefit Payment recommended that the Crow Benefit be paid entirely to producers on the basis of their net sales of grain each year - the Grain Transportation Refund (GTR) - as a rebate for the statutory rates being raised to compensatory levels.[11] The Grain Transportation Agency (GTA), in its 1985-86 review of the WGTA, rejected the GTR proposal on the grounds that the dilution impact was unclear, that it would be administratively cumbersome and that there was little producer understanding or acceptance of the GTR concept. Moreover, GTR payments were considered to be an on-going subsidy to particular agricultural sectors instead of a grain transportation rebate.[12]

The GTA initially recommended that the government buy out, once and for all, its financial commitment to western grain transportation without tackling the question of how this might be done.[13] Reasons for the "pay out" included equity for traditional export grain shippers, the removal of the existing freight rate distortion in Prairie feed grain prices, improved efficiency in the GHTS and an elimination of the export subsidy contained in the existing method payment. On the issue of variable or incentive rates, the GTA recommended not only that they

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[11]Gordon C. Hall, op. cit. pp. 132-134.

[12]Canada, Review of the Western Grain Transportation Act April 1986, Part I (Winnipeg Grain Transportation Agency), pp. 16-19.

[13]Ibid., Chapter II. This was changed to a "pay down" proposal in a follow-up report to the Minister of Transport to reflect the Department of Finance view that a complete pay-out would increase the national debt by an unacceptable amount. Ibid., Part II.

continue to be permitted under the Act in the form of productivity sharing agreements (PSA's) but that the process for implementing PSA's be streamlined. The required public notice should be reduced from seven months to 30 days with such notice to be given at any time rather than before the start of a new crop year. All shippers who could meet the PSA's conditions could benefit from it.

Cross-Subsidization in the Statutory Freight Rates

Following the Gilson consultations, the Report of the Task Force on Rates[14] examined the structure of the Crow rates and concluded that, between 419 and 1250 miles where most shipments occur, the distance-related taper could be expressed as:

$$Y = \underset{(42.1)}{8.2} + \underset{(61.5)}{1.5\, X} \qquad (R_2 = 0.99)$$

where Y = rate in cents per cwt, X = distance in hundred miles and t statistics are shown in brackets below the estimated coefficients.[15] At distances beyond 1,275 miles, the taper disappeared with the statutory

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[14] Canada, Western Grain Transportation Report of the Task Force on Rates, (Ottawa, November 1982).

[15] Ibid., pp. 6 and Enclosure 3, pp. 3-4.

rate becoming nearly constant at 0.436¢ per ton-mile.[16] Cost of service is a major justification for setting rates as railway costs are generally thought to be composed of a fixed component for loading and unloading at origin and destination respectively as well as the associated line-haul costs.[17] The Report was somewhat agnostic on whether the estimated distance taper in the cost of other bulk commodities confirmed the Crow rate taper. Nonetheless, the Task Force's recommendation that this taper be retained was accepted and implemented in the WGTA base rate scale.[18]

The total rail costs incurred by a particular commodity are comprised of two parts. In August 1969, the Canadian Transport Commission defined variable cost as:

> "...the long run marginal cost of output, being the cost of producing a permanent and quantitatively small change in the traffic flow of output, when all resource inputs are optimally adjusted to change."[19]

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[16]The Report noted the many anomalies that existed in the Crow rates due to historical accidents, changes in mileage due to track straightening, voluntary rate reductions due to competitive/contiguous points and the requirements imposed by port parity. Ibid., Chapter 2.

[17]Ibid., Enclosure 3, pp. 3-1.

[18]It was also recommended, and accepted in the WGTA, that many of the anomalies such as differences in mileage scales between CN and CP be eliminated. The new base rate scale was constructed in order to generate the revenues actually obtained by the railways in 1980 from moving statutory grain. Ibid., pp. 43.

[19]Canada, Reason For Order No. R-6313 Concerning Cost Regulations, (Ottawa: Railway Transport Committee, Canadian Transport Commission, August 5, 1969), pp. 337.

Subtracting variable from total costs leaves constant costs, that is:

> "...costs which cannot be associated with output units at this level."[20]

The important distinction between the two components is that variable costs can be causally related to the level of output for a given commodity.

In the case of statutory grain traffic, variable costs are further disaggregated into volume-related and line-related costs. Line-related costs refer to the ownership and maintenance costs of the rail line infrastructure and are only included in variable costs for grain originating on grain-dependent branchlines as defined by Snavely.[21] For grain originating on other than grain-dependent lines, line-related costs are not included in variable costs, presumably on the grounds that it is not possible to separate the causal influence of grain from other traffic on the line-related costs.

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[20]Commission on the Costs of Transporting Grain by Rail, Technical Appendix, Report Volume I, (Ottawa: Government of Canada, November 1977), pp. 118. Constant costs, because they cannot be causally attributed to particular commodities or movements, are mostly a problem in setting rates to ensure that total rail revenues are at least equal to total costs. It is also worth noting that constant costs may vary with the volume of output if there is curvature in the cost function. Ibid.

[21]Snavely, King and Associates, 1980 Costs and Revenues Incurred by the Railways in the Transportation of Grain Under the Statutory Rates, (Ottawa: Transport Canada, January 1982), pp. 62. A line is grain-dependent if at least 60% of traffic originating from it is statutory grain or if revenue from non-grain traffic is less than the ownership and maintenance costs of the line.

Table I gives the volume-related, line-related, and variable costs for statutory grain as well as the line-related as a percent of the total for crop years 1981-82 through to 1987-88.[22] The total variable costs per tonne of grain originating on a grain dependent branchline will therefore be higher than from a mainline point the same distance from port for two reasons. First, the inclusion of line-related costs will, ceteris paribus, make average total costs per tonne higher from grain-dependent lines. Second, operational costs may well be higher from origins on

TABLE I

STATUTORY GRAIN RAIL COSTS

CROP YEAR	VOLUME-RELATED	LINE-RELATED	TOTAL VARIABLE	LINE COSTS AS % OF TOTAL
		- million dollars -		
1981-82	582.9	105.1	688.0	15.3
1982-83	642.8	108.1	750.8	14.4
1983-84	650.9	109.0	759.9	14.3
1984-85	660.4	97.1	757.5	12.8
1985-86	698.6	100.5	799.1	12.6
1986-87	654.9	104.4	759.3	13.7
1987-88	735.6	99.8	835.4	11.9

SOURCE: Transport Canada

[22]Total statutory grain rail costs would equal total variable costs plus 20% as the contribution to railway constant costs. Canada, Western Grain Transportation Act, op. cit. The data after 1983-84 in Table I are the official forecasts made prior to the start of each crop year.

grain-dependent lines, thereby increasing the average volume-related cost. This could well be the case if branchline elevators have smaller car spots for loading grain or if branchline movements require smaller train runs with increased switching costs.

It seems clear, then, that the Crow rate distance taper that was retained in the WGTA's base rate scale can only be based on some sort of averaging of branch and mainline costs. As noted by the Hall Committee of Inquiry, the new base rate scale:

> "...is the perpetuation of a rail rate system which has served prairie grain production well, an expression of the same "pooling" principle that is part of much of the grain elevation and handling system. Its preservation requires system costs to be averaged, and covered by some type of uniform rates scale."[23]

Both the Crow rates and the new rate scale imply a significant pattern of cross-subsidization favouring producers who deliver to primary elevators located on grain-dependent branchlines. There is currently just over 6,000 miles of grain-dependent lines representing nearly 40% of the basic rail network. Eliminating all grain-dependent lines would increase both trucking costs to some producers and, perhaps, provincial road maintenance costs. The implications for primary elevator and total producer delivery costs are unclear. However, grain rail costs would fall at a minimum by an amount equal to 1.2 times the line-related costs or approximately $119.8 million for crop year 1987-88.[24] To the extent

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[23]Gordon C. Hall, op. cit., pp. 71.

[24]The factor 1.2 represents the increase in line-related costs due to constant costs.

that there would be gains in operational efficiency, then a more consolidated grain rail network on the Prairies would reduce statutory grain rail costs even further. Moreover, with conservative volume projections and assuming a reasonable rate of rail cost inflation, total grain rail costs could easily reach $1 billion by the mid-1990's. Thus, a 20% reduction in rail costs would mean additional income to grain producers of about $200 million annually if the government's share of rail costs were to remain unchanged.

PRIMARY ELEVATOR PRICING AND EFFICIENCY

Background

Primary elevator pricing and consolidation over time, while not free of controversy, have not generated the heated concerns so prevalent in debates over statutory grain rail policy. Table II indicates the changes that have occurred in the primary elevator delivery point network on the Prairies from 1935, when the number of elevators peaked, to 1985. The grain elevator system had a marked storage orientation until the late 1960's due to the Canadian Wheat Board (CWB) policy, in line with other wheat exporting countries, of attempting to maximize returns;[25] periodic

[25]Alberta, op.cit., pp. 16.

TABLE II

PRIMARY ELEVATOR CONFIGURATION 1935-1985

YEAR	PRIMARY ELEVATORS -No.-	OPERATING UNITS -No.-	DELIVERY POINTS -No.-	TOTAL ELEVATOR CAPACITY -m.bus-	AVERAGE ELEVATOR CAPACITY -'000 bus-	AVERAGE OPERATING UNIT CAPACITY -'000 bus-
1935	5728	N.A.	N.A.	189.9	33.2	N.A.
1940	5600	N.A.	N.A.	201.3	35.9	N.A.
1945	5463	N.A.	2113	197.1	36.1	N.A.
1950	5309	N.A.	2139	283.0	53.3	N.A.
1955	5367	N.A.	2083	345.2	64.3	N.A.
1960	5299	N.A.	2068	361.8	68.3	N.A.
1965	5143	4062	1983	381.2	74.1	93.8
1970	4971	3539	1907	398.8	80.2	112.7
1975	4165	2623	1556	398.2	95.6	151.8
1980	3324	2162	1295	350.0	105.3	161.9
1985	1925	1807	1139	287.7	149.4	159.2

N.A.: Not Applicable.

SOURCE: Dennis Waithe, Evaluation of the Primary Elevator System in Western Canada, Working Paper #14, (Ottawa: Marketing and Economics Branch, Agriculture Canada, October 1984).

Canada, Grain Elevators in Canada - 1985-86, (Winnipeg: Canadian Grain Commission, 1987).

government subsidies such as the Temporary Wheat Reserves Act of 1956 that provided incentives to increase storage capacity; the CWB's acceptance of producer deliveries without matching sales up to the mid-1960's; and the lack of coordination in transporting grain off the Prairies through much of that decade.[26] The number of elevators, operating units and delivery points decreased gradually up to 1970 as a result, even as total elevator capacity continued to rise, reaching a maximum in the early 1970's. After 1970, the pace of change increased to a marked degree as the industry switched from a storage to a throughput footing. Several factors accounted for the more rapid consolidation since 1970, including: the switch in CWB policy to maximizing sales;[27] the increase in Board sales under long term contracts to countries with centralized purchasing; the concomitant changeover in the 1960's to the block shipping system combined with a revised CWB quota system that only accepted producer deliveries to match sales commitments; the abandonment of about 3,400 miles of Prairie branchlines; technological change in the elevator industry; continuing upward pressure on costs not matched by higher revenues from handling and storage tariffs.[28]

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[26]Dennis Waithe, Evaluation of the Primary Elevator System in Western Canada, Working Paper #14, (Ottawa: Agriculture Canada, October 1984), Chapter 3 and 4.

[27]D.R. Harvey, Government Intervention and Regulation in the Canadian Grain Industry, Technical Report E/16, (Ottawa: Economic Council of Canada, June 1981), pp. 15.

[28]Dennis Waithe, op. cit., Chapters 4 and 5.

It is the role of the Canadian Grain Commission to regulate certain aspects of the domestic grain industry. The Commission has its roots in the General Inspection Act of 1886 where grain grades were first defined.[29] Since the Canada Grain Act of 1912, the Commission (referred to as the Board of Grain Commissioners prior to 1971) has been responsible for regulating elevator tariffs by prescribing maximum charges for elevator services.[30] Maximum primary elevator tariffs were first introduced in 1917, initially covering only elevation and storage services. Tariffs for additional services were introduced over time as deemed necessary. Producers were charged the maximum tariffs up to August 1, 1974 with one major exception. From 1935 to 1974, the actual rates paid were based on CWB handling agreements with the elevator companies for grain delivered to the Board. The Commission introduced a major policy change for the start of crop year 1974-75 by substantially increasing the maximum tariffs and permitting companies to file and charge rates below the prescribed maximums.[31] Beginning in 1975, the costs of cleaning grain in terminal elevators has been paid directly by producers by a tariff for removal of dockage charged at primary elevators.

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[29] Alberta, op. cit., pp. 30-31.

[30] Canadian Grain Commission, Canadian Grain Commission Historical Tariffs and Fees, (Winnipeg: August 1986), pp. 2.

[31] Ibid., pp. 2-4 documents the changes in Commission primary elevator tariff policy since 1971.

In the remainder of this study, the primary elevator handling charges paid by producers will be taken to include the elevation tariff for receiving, elevating and loading out grain plus the removal of dockage tariff covering the costs of terminal clearing. Taken together, these services represent one of two major grain handling functions. The other major function performed by the primary elevator industry is that of storage for which separate rates are charged.[32] While storage charges were an important source of revenue in the industry through the 1960's the change in emphasis to a throughput handling system has seen a marked decline in storage relative to handling revenues in the past twenty years.[33]

Primary Elevator Price Discrimination

Jeffrey[34] has recently investigated primary elevator costs, noting that elevator capacity, capacity utilization and volumes handled are important determinants of average total cost (ATC). His findings, based on elevator cost data for years 1982-83 and 1983-84, indicate that the elasticities of ATC with respect to volume and capacity utilization were -0.35 and -0.28 respectively The corresponding elasticities for a range of elevator sizes increased steadily from -0.10 for capacity of

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[32]Additional services offered at many primary elevators include custom cleaning and drying of grain and the sale of farm supplies.

[33]Dennis Waithe, op. cit., Chapter 5.

[34]J. Russell Jeffrey, op. cit., pp. 64.

2001-3000 tonnes up to -0.19 for capacity 6501-13,000 tonnes. These results imply a significant trade-off between elevator size and utilization in that the scale economies inherent in larger elevators can often be overcome with a higher utilization rate. More important:

> "Many smaller elevators operate at turn rates that are much higher than the industry average. Logically, it is easier to obtain 15,000 tonnes of business for a 2,500 tonne elevator than 60,000 tonnes for a 10,000 tonne elevator."[35]

While this may be true for some small elevators, it is doubtful if all of them achieve sufficient utilization rates to overcome their size disadvantage; it would otherwise be very difficult then to explain the on-going consolidation in the number of elevators and the trend to larger capacity units. At a Grain Commission tariff hearing in April 1984, several of the major elevator companies indicated plans to reduce the number of their elevators by as much as 50 percent by 1990 due to the inherent cost efficiencies of larger units.[36] It is worth noting that by the early 1980's, about the time for which Jeffrey's study applies, 20 percent of delivery points handled 50 percent of grain received at primary elevators.[37]

Table III shows average volumes, capacity, turn rates and total cost per tonne for a range of elevator/operating unit sizes. Volumes

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[35] Ibid., pp. 71.

[36] Dennis Waithe, op. cit., Chapter 5.

[37] Canada, Crow Book, op. cit., pp. 32.

handled increase with mean capacity. The mean turn rate, however, decreases as average elevator size increases. Notwithstanding this, per tonne costs decrease steadily up to the capacity range of 5-6,500 tonnes. As capacity exceeds 6,500 tonnes, the lower achieved rates of capacity utilization overcome the economies of scale that might exist for the largest sized elevators and mean total cost per tonne increases. To the extent that there are still many elevators in the 2-4,000 tonne capacity range, then one would expect to find that many of these units are less profitable or are in fact being cross-subsidized by other elevators.

TABLE III

AVERAGE ELEVATOR CHARACTERISTICS BY CAPACITY RANGES

CAPACITY RANGE - tonnes -	MEAN CAPACITY - tonnes -	MEAN VOLUME - tonnes -	MEAN TURN RATE	MEAN COST PER TONNE - $ -
0-2000	1639	8833	5.50	10.73
2-3000	2528	11149	4.46	9.71
3-4000	3497	14020	4.02	8.68
4-5000	4495	17724	3.94	8.17
5-6500	5619	20051	3.58	7.87
6500 +	7867	21912	2.81	8.31

SOURCE: J. Russell Jeffrey, "Economic Performance in the Western Canadian Primary Elevator Industry", (M.sc. Thesis, University of Manitoba, 1985), pp. 96.

As per Grain Commission regulations, elevator companies are free to file handling tariffs at or below prescribed maximums. The filed tariffs can be changed after giving the Commission 14 days notice. Different rates can be charged at different delivery points but all producers delivering to a given elevator must be charged the same rate. There is substantial uniformity in filed tariffs within each province. Moreover, the filed rates are usually identical at all points in a given company's network and, as well, rates are very similar across companies.[38]

Companies' strict adherence to their filed tariffs is difficult to determine. First, the pricing of board and non-board grains is quite different. In the case of the former, the producer receives the CWB initial price minus the freight rate and elevator handling charge on delivering his grain to the elevator. In the latter, such as canola, flaxseed and off-board feed barley, the spectrum of producer prices in each province is obtained by subtracting the WGTA freight rates from the provincial street price. Each company generally quotes its street price daily where the price, in theory, is equal to the relevant futures prices minus each company's basis for handling grain, including both primary and terminal elevator charges. The street price quotation can vary significantly both between days and across companies; hence, street prices are unlikely to represent actual future selling prices at port backed off by subtracting the relevant basis. Rather, on any given day, they more accurately reflect an elevator company's willingness to receive

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[38] J. Russell Jeffrey, op. cit., pp. 39 and Table 3, pp. 40.

grain from producers. This is due in part, at least, to the way in which rail cars are allocated to move statutory grain into export position. Cars are administratively allocated by the GTA (non-board grains), the CWB (board grains) and the Grain Commission (producer and consigned cars) with the allocation designed to meet elevator companies' and the CWB's sales commitments at the various ports. Each company's daily basis, then, is better thought of as a tap that is used to regulate the flow of producer deliveries of non-board grains.

Second, elevator managers may sometimes offer effective discounts from the handling tariffs in the form of trucking premiums to large volume customers, although how widespread the practice has become is unknown. Third, there is some 'de facto' price competition, beyond what is evident in the filed tariffs, in the assigning of grades and/or weights at primary elevators.[39] Individual customers at particular elevators or all customers at some elevators may receive better grades or higher weights in order to retain their business or to attract additional volumes. The potential for implicit price competition based especially on grading arises because of the practice of blending different grades of grain. Blending of all grades of statutory grain is permitted in primary elevators but, in theory, is prohibited for the top two grades of red spring wheat (CWRS) in terminal elevators, mainly to ensure that their

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[39]One industry official indicated that his company lost nearly $3 million in the 1986-87 crop year as a result of grade/weight competition.

alpha amylase content is kept at or below specified levels.[40] In practice, however, the Grain Commission occasionally permits the blending of No.1 and 2 CWRS subject to Commission supervision.[41] The financial incentives for blending arise because grain quality is a multi-dimensional continuum whereas official grades and contract sales specifications are discrete. For example, it is often possible to blend a No.1 and No.2 feed barley to achieve a minimum No.1 grade that meets contractual obligations. Therefore, actual revenues per tonne generated from handling grain may differ across delivery points and companies in contrast to what the filed tariffs reveal.

Given the likely differences that exist in average total elevator costs across operating units, then companies' adherence to their filed tariffs in the actual charges levied for handling grain would imply significant differences in profitability between elevators/delivery points. As defined in Chapter III below, this also implies a corresponding incidence of either price discrimination if the filed tariffs are set so as to cover the costs of the least profitable stations or cross-subsidization if the losses at some points are offset by high profits at other locations. To the extent that there is implicit

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[40]Maximum content regulations for alpha amylase are specified to help ensure the milling of CWRS into flour for pan bread production. Cf. Canada Grains Council, Wheat Grades for Canada - Maintaining Excellence, (Winnipeg: January 1985), pp. 217.

[41]*Ibid.*, pp. 216.

differences in actual handling charges from what companies file with the Grain Commission, however, the pattern of cross-subsidization may not bear any relationship with what would otherwise be observed if companies adhered to their filed rates.

RELATED STUDIES

In general, there have been two types of studies that have looked at the potential for cost-savings arising from branchline abandonment and system rationalization The first group comprise those studies that have analyzed the impacts of local or small area rationalization. Many of these analyses have been reviewed in Wilson.[42] The second group of studies have attempted to measure the gain in efficiency based on a system-wide rationalization. These studies include the P. S. Ross studies carried out for the Grains Group in the early 1970's and various studies making use of the PHAER model.[43]

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[42] W.W. Wilson, "Financing the Operation and Rehabilitation of Rail Branch Lines", (Ph.D. Thesis, University of Manitoba, May 1980), Chapter II.

[43] P.S. Ross and Partners, Grain Handling and Transportation Costs in Canada, Prepared for the Grains Group, Office of the Minister, The Honourable Otto E. Lang (August 1971). A list of studies using the PHAER - Producer Haul And Elevator Receipts-model is given in Canada, PHAER: An Overview The Producer Haul and Elevator Receipts Information System, (Research Branch, Canadian Transport Commission, August 1985). Other major studies such as the Hall Royal Commission adopted either a line-by-line approach to analyzing efficiency or carried out analyses on small areas. For a review of the Hall Commission, cf. W.W. Wilson, op. cit.

The P.S. Ross report was compiled from several sub-studies evaluating the costs on the various components of the GHTS from rationalizing the grain rail network including primary elevators, farm trucking, farm storage, and terminal elevators. In addition, they looked at various options for reducing system costs such as inland grain terminals and small inland terminals. The separate studies were integrated into an overall analysis of system efficiency where the estimated system costs pertaining to specified scenarios were compared with existing costs. These scenarios included: a rationalized primary elevator network based on the abandonment of light density branchlines; a consolidated system of 389 primary elevators; a combination of a consolidated elevator system comprising 322 primary elevators and 22 inland terminals; a grain handling system on the Prairies made up of only 80-100 small inland terminals.[44] The results indicated that the greatest cost savings would be generated by a network of small inland terminals with a reduction in total GHTS costs from 66.9¢ per bushel to 56.8¢ per bushel.

One major problem with the P.S. Ross study was in the development of the scenarios that were analyzed. These were, in essence, given to the firm on the basis of Grains Group analyses and discussions with informed parties in the industry.[45] Hence, it is very difficult to assess whether the least cost solution that was presented would have been

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[44] P.S. Ross, Ibid., p. 2.

[45] Ibid., pp. 7.

a global optimum. In addition, the proposal to collapse the elevator network to 80-100 small inland terminals would likely have created large changes in income distribution as some producers would have experienced greatly increased trucking distances relative to others. Finally, while the report did indicate a savings in total costs relative to the system that then existed, it is unclear whether these results would now be reliable given the rail line abandonments and branchline upgrading that have occurred in the last decade. That is, it may still be possible to reduce total GHTS costs from the more consolidated existing system but that might not imply an elevator network of only small inland terminals.

The PHAER information system is a simulation model that includes the costs and revenues of the major GHTS components. It includes a farm trucking module as well as relatively up-to-date information on the existing primary elevator and grain rail network.[46] The model has been used to simulate the impacts on each system component from various rationalization proposals. It is currently the only global or system-wide tool available for the analysis of GHTS efficiency.

The most recent study using PHAER was done as a background study for the Hall Committee on Method of Payment.[47] It projected and compared total and sub-system costs assuming a primary elevator network of 300 and 600 delivery points. Compared with the status quo, the PHAER

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[46]Canada, PHAER: An Overview, op. cit., Section III.

[47]Canada, Effects of a Reduction in the Number of Grain Delivery Points on the Canadian Prairies, (Canadian Transport Commission, Research Branch, February 1985).

study indicated that total system efficiency could be improved. In fact, the cost savings may even be higher in that the model does not incorporate the potential for operational savings in rail traffic per se.

One drawback of PHAER-based studies is that the patterns of rationalization chosen may be somewhat ad hoc. This is really a problem with all simulation in contrast to optimization models. A more serious problem might exist in the assumption built into PHAER that producers will deliver to the next nearest delivery point once their existing point is closed. To the extent that rationalization in the future may be brought about by incentive or variable freight rates, then cost estimates of the various components may be over- or understated. Finally, the elevator cost savings are somewhat suspect in that they are based on data provided to the Hall Committee. As per the discussion in Chapter V below, elevator revenues derived from handling grain may not reflect actual monies accruing from handling operations at individual stations.

CHAPTER III

A THEORETICAL ASSESSMENT OF GHTS PRICING

THE THEORY OF SPATIAL PRICE DISCRIMINATION

Price discrimination is usually defined as:

> ...the sale (or purchase) of different units of a good or service at price differentials not directly corresponding to differences in supply cost.[1]

Because a commodity at two different places or at the same place at two different times represents different economic entities, a more general definition is that price discrimination occurs when:

> ...two varieties of a commodity are sold (by the same seller) to two buyers at different net prices, the net price being the price (paid by the buyer) corrected for the cost associated with the product differentiation.[2]

Three conditions generally have to be fulfilled before price discrimination can persist. First, the seller must be an imperfect competitor in the sense that the firm's output decisions affect industry prices.

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[1] F. M.Scherer, Industrial Market Structure and Economic Performance 2nd ed., (Chicago: Rand McNally, 1980), pp. 315.

[2] L. Phlips, The Economics of Price Discrimination, (Cambridge University Press, 1983), pp. 6.

Second, consumers must have different demand intensities and the firm must be able to segment buyers into groups according to their price elasticities of demand. Third, arbitrage opportunities must be absent so that buyers cannot resell the commodity at a profit to higher-priced consumers.[3]

Cross-subsidization can be seen as a special form of price discrimination. A cross-subsidy can be said to occur if one or more buyers purchase a good or service at a price below cost while others pay a price above cost, thereby effectively transferring income to the first group. A pattern of cross-subsidy can exist even if all consumers pay the same price so long as the cost of providing the service is lower than the price to one or more consumers and above the price for other buyers.

The analysis of price discrimination has a long history in economics. Pigou[4] was the first to classify price discrimination into three main types. First-degree discrimination involves the firm pricing its output in such a way as to appropriate all consumer rents for itself. Second-degree discrimination is similar but less perfect. The firm is able to segment consumers into blocks in order of descending reservation

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[3]These conditions are standard and can be found in almost any textbook that discusses price discrimination.

[4]A. C. Pigou, The Economics of Welfare 4th ed., (London: MacMillan, 1920), pp. 240-256. The present discussion follows that given by F. M. Scherer, op. cit., pp. 315-317.

prices each group will pay. Third-degree discrimination involves the separation of buyers into two or more independent groups, each with its own demand function. If these demand functions possess different elasticities at a common price, then the firm will maximize profits by equating the marginal cost of total output with marginal revenue in each market. This gives the standard profit-maximizing rule for a discriminating monopolist that prices will vary inversely with the elasticity of demand across customer groups.[5]

The abstract discriminating monopoly model, although it has formed one of the major justifications for both the introduction and maintenance of economic regulation of certain industries, nonetheless fails to provide an adequate explanation for the incidence of price discrimination that occurs in practice. Moreover, only the idea of predatory pricing, where a firm prices its output in one or more markets below cost in order to drive out the competition and cross-subsidizes by covering losses from excess profits in other markets, is left as an economic rationale for cross-subsidy pricing.

The abstract model fails to take account of spatial and temporal features confronting firms and is, therefore, insufficient for the

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[5]This also forms the basis for quasi-optimal pricing rules like Ramsey-pricing when there are increasing returns to scale over the feasible range of output. Value-of-service pricing in transportation is an approximation of such a pricing strategy. A thorough discussion of Ramsey-pricing is given in A. B. Atkinson and J. E. Stiglitz, Lectures on Public Economics, (Maidenhead: McGraw-Hill, 1980).

analysis of price discrimination.[6] The spatial theory of the firm specifically incorporates buyers at different locations. This allows for geographical price discrimination where transportation costs are important. Following the definition given by Phlips, spatial price discrimination exists if net mill prices charged buyers are different according to their geographic location.[7] While there are, in fact, many types of spatial pricing strategies, some of which are discriminatory, the spatial economics literature has concentrated on three forms of firm/industry pricing: uniform FOB mill prices, nonuniform discriminatory prices and uniform delivered prices throughout a zone. The latter two types of pricing strategies involve an element of cross-subsidization in that the firm absorbs a part of the freight costs for some buyers and charges excess or phantom freight to others. Uniform delivered prices will not be dealt with further for reasons which should become clear in the following section.

A system of nonuniform discriminatory prices represents the spatial analogue of profit-maximization for the discriminating monopolist. In general, this pricing system will lead to a larger output and greater

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[6]Temporal price discrimination is not discussed herein. It is analyzed at some length in L. Philps, op. cit., pp. 67-143.

[7]Ibid., p. 31.

profits[8] for the firm in contrast to uniform FOB prices. Moreover, this will hold both for the monopoly case and where there is geographic competition as well. These points can be illustrated using Diagrams I, II and III below.[9]

Diagram I pertains to the case of a single firm supplying an entire area, where the plant is located at the origin. For simplicity, it is assumed that marginal production costs are constant, the cost of transportation is a linear function of distance and consumers are spread evenly throughout the region. The line P_0P_F represents the case of uniform FOB mill prices where P_0MC gives the constant marginal production costs. The line P_1P_D represents the case of nonuniform discriminatory pricing. At a price higher than P_2, demand for the firm's output falls to zero so that the firm will only be able to supply customers out to a distance Ot_3 using FOB mill pricing. Nonuniform discriminatory prices, where the firm charges phantom freight to customers located near the plant and absorbs some transportation costs for those at greater distances, would allow the firm to supply the area Ot_4. Note also that total consumer surplus is greater than under FOB

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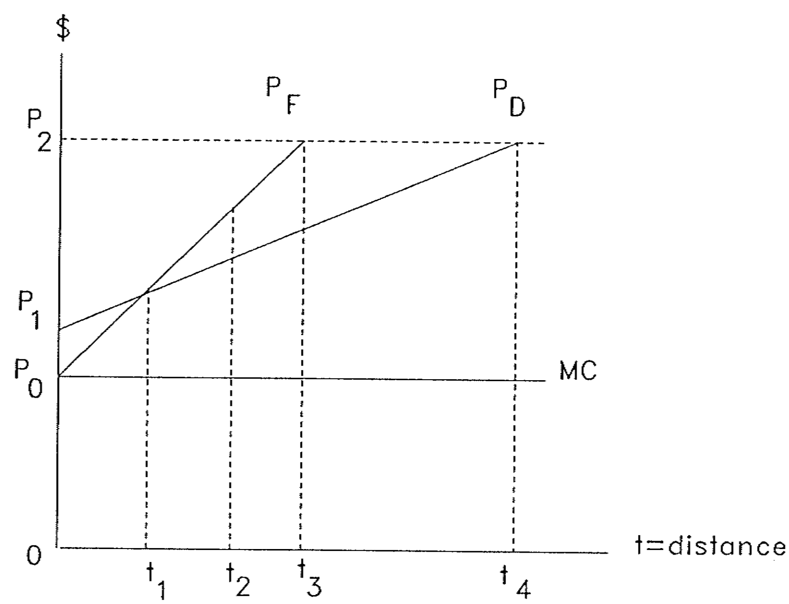
[8]A mathematical proof is given by M. L. Greenhut and H. Ohta, "Monopoly Output Under Alternative Spatial Pricing Techniques," American Economic Review Vol. 62 (September 1972), pp. 705-713.

[9]This discussion follows closely that used by L. Phlips, op. cit., pp. 51-63.

DIAGRAM I

FREIGHT ABSORPTION: SINGLE FIRM



FOB mill pricing.[10] The loss to customers within a radius Ot_1 of the plant is matched by those located a distance t_1t_2 from the point where phantom freight charges equal zero and freight absorption begins. Buyers located at distances beyond Ot_2 gain from discriminatory pricing.

The situation of spatial competition is somewhat more complex so that it is useful to distinguish two cases. In the first case, it is assumed that the firms selling a homogeneous product in the region all have their plants located at the same point. Given the assumptions made above, it can be shown that delivered price P_D in the region will be a linear function of distance t:[11]

$$P_D = \frac{a + Mk}{M + 1} + \frac{M}{M + 1} t = A + \frac{M}{M + 1} t \qquad (1)$$

where M = number of firms and k = constant marginal production costs averaged over the M firms. The slope of equation (1) will be 1/2 in the case of a monopolist and will approach the value one as M increases. Equation (1) also implies that a group of firms producing at the same location will benefit from a policy of freight absorption (nonuniform

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[10] A mathematical proof of this is given by W. L. Holahan, "The Welfare Effects of Spatial Price Discrimination," American Economic Reiview Vol. 65 (1975), pp. 498-503.

[11] J. Greenhut and M. L. Greenhut, "Spatial Price Discrimination, Competition and Locational Effects," Economica Vol. 42 (November 1975), pp. 401-419.

discriminatory delivered prices), but that both the delivered price and the degree of freight absorption will fall as M increases.[12] This case is illustrated in Diagram II where the sales area OB represents the maximum delivered price that consumers are willing to pay. FOB mill price, equal to marginal production cost, plus transportation costs is given by the line KP_F while the line P_DP_F gives the profit-maximizing delivered price schedule. This latter curve will rotate counterclockwise about P_F as M increases.

In Diagram III[13], it is assumed that there are two production centers L_1 and L_2 with consumers located on a line between them. The number of firms at L_1 is M_1 and at L_2 is M_2, where $M = M_1+M_2$ = total number firms. If the distance separating L_1 and L_2 is d, then t, the average cost of transportation, is given by:

$$t = \frac{1}{M_1 + M_2} [M_1 t + M_2 (d - t)] \qquad (2)$$

Substituting (2) into (1) gives the revised function describing delivered prices:

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[12]This can be seen by taking the derivative of P_D with respect to M in (1) where the right hand side terms of the resulting equation will be negative.

[13]This discussion follows closely that used by L. Phlips, <u>op. cit.</u>, pp. 41-45.

DIAGRAM II

FREIGHT ABSORPTION: MULTIPLE FIRMS

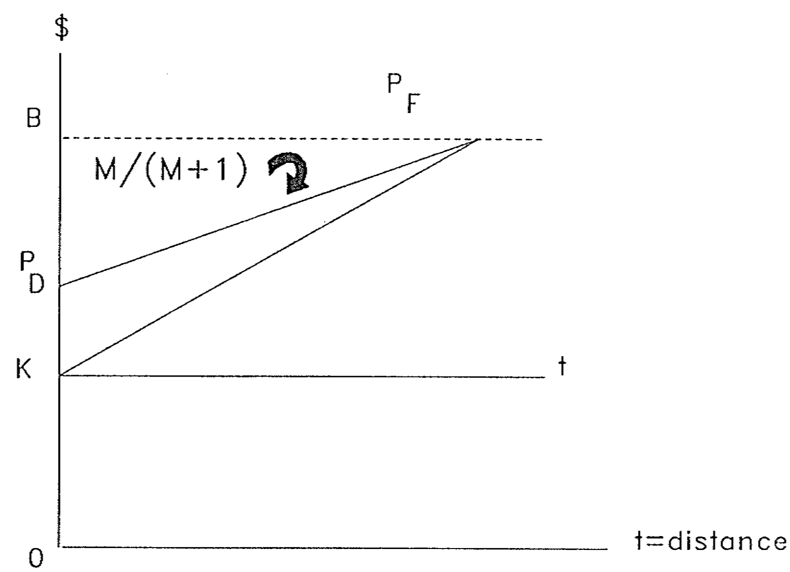
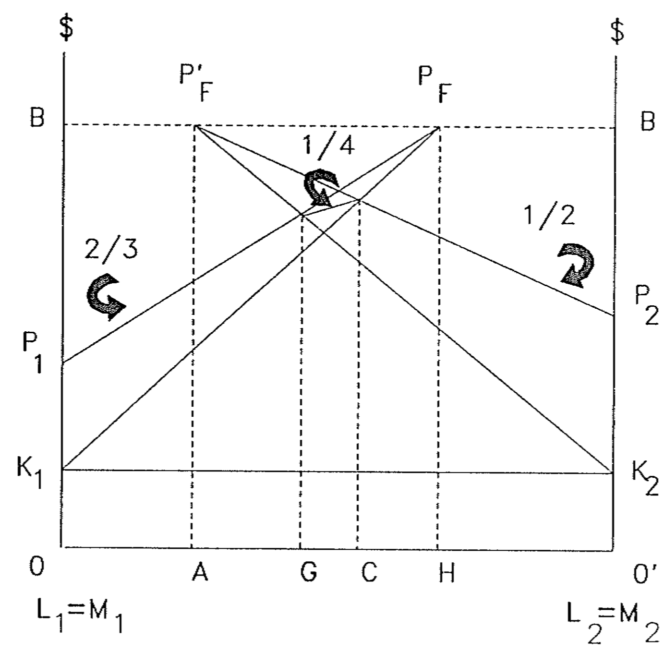


DIAGRAM III

FREIGHT ABSORPTION: MARKET AREAS



$$P_D = \frac{a + Mk}{M + 1} + \frac{1}{M + 1} [M_1 t + M_2 (d - t)] \qquad (3)$$

Delivered prices from L_1 will increase at a constant rate as d increases if $M_1 > M_2$:[14]

$$\frac{\partial P_D}{\partial t} = \frac{M_1 - M_2}{M + 1} \qquad (4)$$

In Diagram III, two firms are located at L_1 and one firm at L_2 and profits are maximized for all firms. If L_2 did not exist, then L_1 would supply the area OH while if L_1 did not exist, then L_2 would supply the area O'A. It is assumed, as before, that marginal production costs k_1 at L_1 and k_2 at L_2 are equal. The lines $k_1 P_F$ and $k_2 P'_F$ give the FOB mill prices plus transport costs from L_1 and L_2 respectively. The lines $P_1 P_F$ and $P_2 P'_F$ give the delivered prices from each center, where the slopes equal 2/3 and 1/2 respectively. Because both centers exist, the natural market for L_1 is OC where the L_1 delivered price equals the FOB mill price, k_2, plus freight from L_2. Similarly, the natural market for L_2 is O'G. Between G and C, L_1 sets delivered prices, as indicated by equation (4).

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[14]This really only applies to the restricted area where L_1 and L_2 come into direct competition, as given in the explanation of Diagram III.

Hence, the straight line joining G and C has a slope of (2-1)/(3+1) = 1/4. In this area, delivered prices for L_2 fall as distance increases.[15]

AN APPLICATION TO THE GHTS

From the producer's perspective, the railway and elevator companies offer a combined service, namely the handling and transport of statutory grain to export position or end-user. Each producer receives a price net of both service charges upon delivering grain to a primary elevator. For the most part, price discrimination/cross-subsidization in the GHTS exists between delivery points. If grain companies adhere closely to their filed tariffs, then most producers delivering a given type of grain to the same delivery point will pay the same amount for handling and rail transport service.[16] In essence, producers can be thought of as paying an FOB mill price for the combined service - a price which need not bear

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[15]This analysis of spatial price competition is based on each firm assuming that changes in its output do not affect or bring about changes in the outputs of other firms. The conclusions will hold with a less restrictive assumption as demonstrated by G. Norman, "Spatial Competition and Spatial Price Competition," Review of Economic Studies Vol. 48 (1981), pp. 97-111.

[16]J. Russell Jeffrey, op. cit., pp. 38-48. As briefly discussed in the previous chapter, this ignores trucking premiums and implicit handling tariff discounts offered to large volume producers at some delivery points or by some companies.

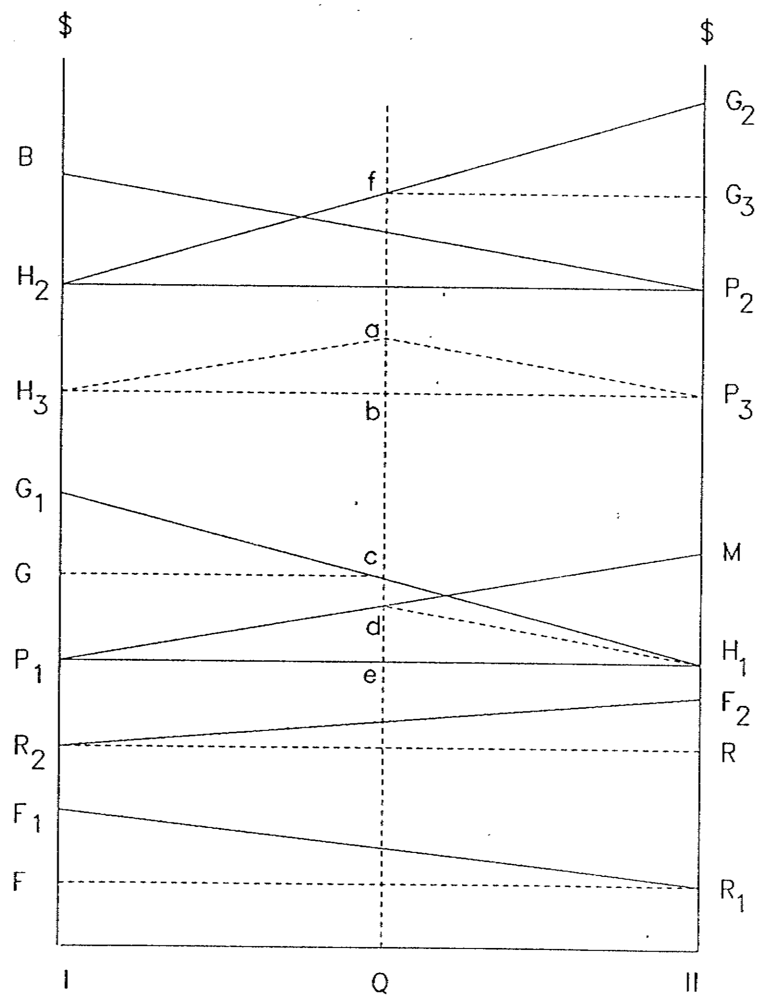
any relation to actual marginal or average elevator and rail transport costs - with the freight costs from farm to delivery point borne by producers themselves.

The problem of inefficiency in the GHTS is based predominantly on the excessive rail costs due both to the statutory freight rate structure and to the retention of the extensive grain-dependent branchline network. This has led many participants in the western grain industry to conclude that both rail and total system costs could be significantly reduced by eliminating the higher cost branchlines. In general, however, changes in the primary elevator network resulting from branchline rationalization can enhance, detract or be neutral with respective to GHTS efficiency; that is, merely subtracting the estimated savings from those elevators that will be closed may either under- or overstate the actual reductions in total system costs.

Diagram IV focuses on cross-subsidization in order to illustrate the polar case where the existing pricing structure in the western primary elevator industry reinforces the inefficiency found on the rail side of the GHTS. To simplify the exposition, the diagram shows a mainline delivery point I and a branchline delivery point II where it is assumed that I and II are equidistant from export positions by rail; that companies adhere to their tariffs; that all farmers delivering their grain to either point are equally spaced between I and II; that they produce identical grain volumes each; and that the total volumes to be handled at either I or II in any given crop year are fixed. These assumptions imply a one-to-one correspondence between distance from each

DIAGRAM IV

CROSS-SUBSIDIZATION FAVOURING BRANCHLINE DELIVERY POINTS



point and total volume so that the horizontal axis has both a volume and distance interpretation. The assumption that the total volume to be moved through the GHTS is fixed implies that local demand for grain and oilseeds on the Prairies is highly inelastic in the short run. While this obviously will not be the case in many areas of the Prairies, especially the feedgrain areas of Alberta, it is a reasonable simplification for present purposes in that about two-thirds of the annual grain crop is moved off the Prairies by rail. What the assumption does do is rule out any static welfare losses from using average instead of marginal costs to evaluate GHTS pricing. The magnitude of these losses would arguably be small given the inelastic demand for GHTS services in any given crop year.[17]

Rail costs per tonne are shown by F_1R_1 and F_2R_2 for delivery points I and II respectively, with the average cost per tonne being higher for branchline than mainline movements for all volumes.[18] If all grain

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[17]A high or perfectly elastic demand for Canadian grain exports at export position implies that actual exports will depend primarily on volumes produced. With volumes fixed in a given crop year, exports and hence the demand for handling and transport services will also be fixed. The demand for grain inputs by local processing industries is likely quite inelastic in any crop year; hence, any GHTS price decreases, resulting in higher producer returns at local elevators, in order to divert grain from local use to the export market would, in the short run, lead to relatively higher prices offered by local processors rather than substantial decreases in volumes purchased. For a more complete discussion on the elasticity of domestic grain exports, cf: D.R. Harvey, op. cit., pp. 19-23.

[18]The assumption that rail costs are higher at II than I reflects mainly the line-related costs of branchlines as well as the lower operational costs from reduced switching and lower car cycle times.

were to be moved through I, then the total rail costs would be I F R_1 II and the appropriate cost-based freight rate would be IF. On the other hand, if all grain were moved through the branchline delivery point II, then total rail costs would be IR_2RII and the appropriate cost-based freight rate would be R_2II. Similarly, H_1G_1 and H_2G_2 represent the combined rail plus elevator average cost at I and II respectively. If all grain were to be delivered to I, the combined average cost would be P_1I whereas it would be P_2II if all grain were moved out of point II. The vertical difference between H_1G_1 and F_1R_1 gives the elevator costs at I and similarly for the vertical difference between H_2G_2 and F_2R_2. By assumption, both the rail and the elevator costs at I are less than at II for all volumes.

If all grain were delivered to I and the sum of elevator plus rail tariffs facing producers were based on costs, then the price line P_1M would represent the geographic distribution of the total price of GHTS services, comprising the average costs of trucking plus elevation plus rail services. The total amount paid by producers would equal the area IP_1MII. The geographic distribution of the total GHTS price faced by producers would be P_2B if all grain were moved through II and the total GHTS costs to producers would be IBP_2II. This amount is obviously greater by construction compared with total GHTS costs in the former case. In fact, if rail and elevator services were based on costs, then delivery point II and the branchline would disappear as all grain would be sent through I.

The effect of an equity rather than a cost-based pricing structure is that the same rail and elevator rates are charged respectively at I and II. The combined tariffs filed with the Grain Commission plus the WGTA's administered freight rate is H_3P_3. Producers located to the right of point Q on the horizontal axis would make use of delivery point II, thereby incurring total rail plus elevator costs equal to the area QfG_3II. They will have a delivered GHTS price line of aP_3. Producers located to the left of Q would truck their grain to I as per the delivered GHTS price line H_3a and they would incur total rail plus elevator costs equal to the area IGcQ. Total trucking costs paid by all producers under administered pricing would be smaller by the amount $P_1MH_1 - H_3aP_3$ compared with the efficient case where the delivered price line is P_1M and the branchline and delivery point II have been closed. However, it is producers located furthest away from I (that is, to the right of Q) who benefit from the reduced trucking costs.

Relative to cost-based pricing, equity pricing results in higher rail plus elevation costs by the amount $P_1H_3P_3H_1$, although, in practice, the federal government bears a large percentage of the additional cost by paying the railways to keep statutory freight rates well below costs. Notwithstanding this caveat, the excess costs shown by the area $P_1H_3P_3H_1$ represent a net loss to the economy. The income transfer to producers and inefficiently employed GHTS inputs located to the right of Q will equal the area daP_3H_1. Producers located near to delivery point I will pay higher costs equal to the area P_1H_3ad minus the government's share of rail costs (not shown). Perhaps the best measure of the cross-subsidy in this case is the area $P_1H_3aP_3M$ which represents a transfer of income to producers located further away from mainland delivery points and to inefficiently employed inputs in the GHTS. It is paid for largely by present and future taxpayers but, to some extent, by producers located nearer to railway mainlines.

The situation of price discrimination without cross-subsidization would exist if grain companies set the handling price so as to cover the costs of the least profitable elevator. In the case of Diagram IV, the combined handling plus rail price would equal the vertical distance IIG_3 for all producers, thereby generating additional revenues equal to twice the area afG_3P_3.

If the situation illustrated in Diagram IV is generally representative of most main and branchline delivery points, then there may be an incentive for companies to reduce losses on branchline elevators by being less accommodating concerning the grades and/or weights assessed producers. Moreover, there would be an incentive for companies to offer implicit price discounts from the filed tariffs in the form of better grades as well as explicit discounts like trucking subsidies at mainline delivery points. This would be more true at multiple-company points, especially if the elevators at these points had greater capacity and could take better advantage of increased turn rates.[19] Hence, if

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[19] For a discussion and empirical estimate of the relative importance of elevator size and capacity utilization, cf. J. Russell Jeffrey, op. cit. If there was more than one company operating at the mainline delivery point, then both the elevator average cost line H_1G_1 the P_1M curve would shift up as a result.

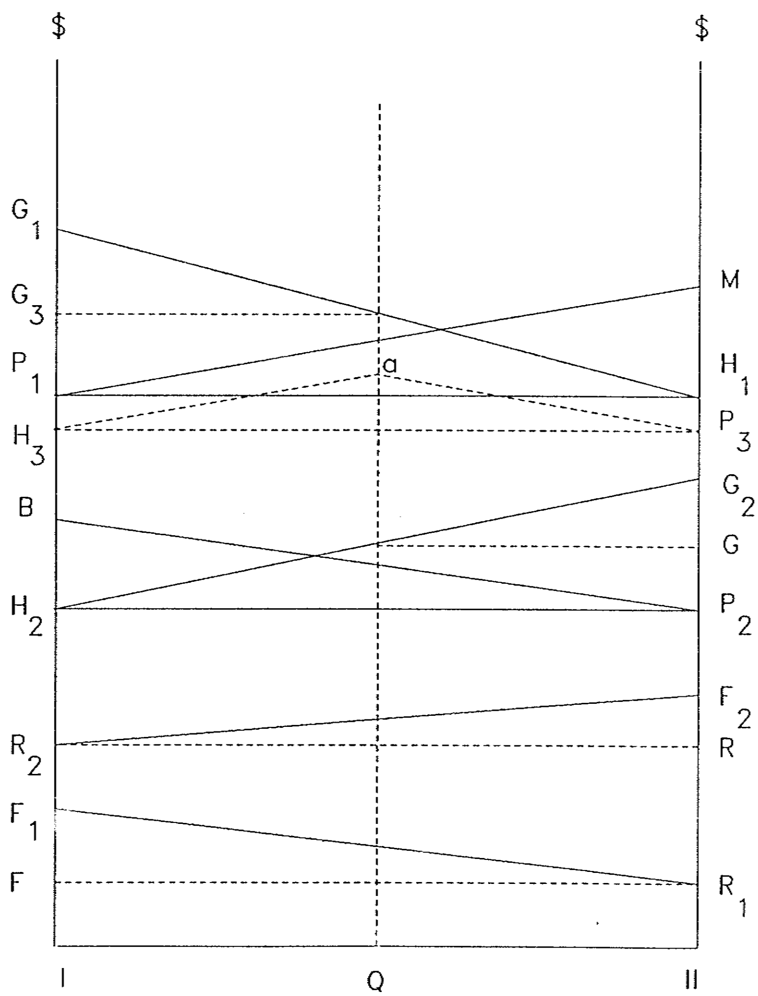
the case analyzed above is characteristic of the GHTS overall, then one would expect profits to be lower and realized returns per tonne over the crop year to be higher at branchline relative to mainline delivery points.

A counter-example to that just discussed is illustrated in Diagram V. The same two delivery points are portrayed with no change in assumed rail costs so that F_1R_1 and F_2R_2 correspond exactly to those given in the previous diagram. It is assumed, however, that average elevator costs are lower for any given volume at II compared with I. Delivery point II is now the low-cost point so that if producers pay cost-based prices for elevator and rail services, then all grain would be trucked to point II. The 'delivered' GHTS price line would be P_2B and producers would pay a total amount for GHTS services equal to IBP_2II. Suppose now that the branchline has been abandoned based solely on the savings in rail costs. All grain would be delivered to I and the total amount producers would pay for GHTS services would be IP_1MII. The net additional cost to producers and the federal government from abandoning the line would be BP_1MP_2.

Charging equal prices for rail plus elevator services at both I and II would raise their combined price to H_3P_3 and the total GHTS cost to producers would be IH_3aP_3II. Equity pricing would thus increase total GHTS costs to producers by the area $BH_3aP_3P_2$ relative to the efficient case of cost-based tariffs. This amount represents the income transfer from producers/government both to producers located nearer the mainline delivery point I and to inefficient factor inputs in the GHTS. As drawn, equity pricing would also reduce GHTS costs to producers,

DIAGRAM V

CROSS-SUBSIDIZATION FAVOURING MAINLINE DELIVERY POINTS



relative to the case where the branchline has been abandoned, by the area $H_3P_1H_1P_3$, although this is simply a consequence of the way the elevator cost curves are drawn. Increasing the absolute slopes of both G_1H_1 and M_2G_2 far enough will raise the line H_3P_3 above P_1H_1.

Given the situation portrayed in Diagram V characterizes the GHTS, one would expect to observe greater price competition at the more profitable branchline delivery points in order possibly to attract greater volumes and to increase economies of utilization. This would imply higher revenues per tonne of grain at mainline in contrast to branchline points. In addition, one would observe lower profits at mainline stations were this situation to prevail.

While most, if not all, grain-dependent branchlines are being cross-subsidized through the statutory freight rate structure, it is unclear whether a similar pattern holds with respect to branch and mainline delivery points. If there is price discrimination favouring producers who deliver to branchline elevators, then it would reinforce both the income transfers and inefficiency generated by the freight rate structure. One would expect to observe lower profits and higher average prices at branchline delivery points if such a pattern were prevalent. On the other hand, if price discrimination favours producers who patronize mainline delivery points, then it would tend to cancel out the pattern of freight rate cross-subsidization, reducing both the income transfers and inefficiency created by the structure of freight rates. Therefore, one would expect to observe the reverse pattern of higher profits and lower average realized prices at branchline delivery points.

CHAPTER IV

EMPIRICAL PROCEDURES

DUALITY THEORY

There are two separate but equivalent approaches to the theory and estimation of consumption and production relationships in modern neo-classical economics. The more traditional approach involves setting up an explicit optimization problem. On the production side, this approach often leads to difficulties in finding optimal and comparative statics solutions. Moreover, highly restrictive assumptions regarding the production technology are required given the intractable problem of deriving output supply and input demand functions from all but the simplest production functions.[1] Duality theory offers an easier and less restrictive approach to econometric estimation.[2] Its central tenet on the production side is that for every well-behaved dual or indirect

[1]Hans P. Binswanger, "The Use of Duality Between Production, Profit and Cost Functions in Applied Econometric Research: A Didactic Note," Occasional Paper No.10, Economics Department, 'Icrisat', (July 1975), pp. 6.

[2]For some of the limitations of duality theory, cf. Reulon D. Pope, "To Dual or Not to Dual," Western Journal of Agricultural Economics, (December 1982), pp. 337-351.

profit function, for example, there exists a well-behaved but unspecified production or transformation function.[3] In addition, the profit function embodies all of the important economic relationships so that output supply and input demand functions can be obtained directly from it.

The Unconstrained Indirect Profit Function

The indirect profit function is defined as the maximum profit attainable for given input and output prices. Under the assumption of competitive behaviour and profit maximization, the firm's problem is to:

$$\text{Max } \Pi' = \sum_{i=1}^{n} P_i * Y_i - \sum_{j=1}^{m} R_j * X_j \qquad (4.1)$$

$$\text{subject to } F(Y_i, X_j) = 0$$

where Π' is profits, Y_i and X_j represent n outputs and m inputs respectively and P_i and R_j are the corresponding output and input prices. F is assumed to be a well-behaved transformation function implying that it is strictly convex, continuous, twice differentiable and strictly increasing in both Y and X.[4] Simultaneous solution of the

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[3]Binswanger, op. cit, pp. 2.

[4]Ibid., p. 30.

first-order conditions for profit maximization yield the output supply and unconditional input demand functions:

$$Y_k = Y_k(P_i, R_j) \quad i,k = 1,\ldots, n \tag{4.2}$$
$$X_h = X_h(P_i, R_j) \quad j,h = 1,\ldots, m$$

Substituting the optimal values of (4.2) into the objective function in (4.1) gives the indirect profit function:

$$\Pi' = \sum_{i=1}^{n} P_i * Y_i(P_i, R_j) - \sum_{j=1}^{m} R_j * X_j(P_i, R_j) \tag{4.3}$$
$$= \Pi'(P_i, R_j)$$

where $\Pi'(P_i, R_j)$ is convex, continuous, twice differentiable, strictly increasing in p_i and strictly decreasing in R_j. Moreover, the function Π' is homogeneous of degree one regardless of the homogeneity property of the transformation function.[5]

By Hotelling's Lemma,[6] the partial derivatives of the indirect profit function give the output supply and unconditional input demand functions directly:

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[5]Ibid., pp. 31-32.

[6]J.R. Beattie, and R.C. Taylor, The Economics of Production (New York: John Wiley and Sons, 1985), Chapter VI.

$$\frac{\partial \Pi'}{P_k} = Y_k(P_i, R_j) \quad i,k = 1,\ldots, n \tag{4.4}$$

$$\frac{\partial \Pi'}{\partial R_h} = - X_h(P_i, R_j) \quad j,h = 1,\ldots, m$$

Following Lau[7], it has become commonplace to use the normalized profit function in which any one of the output or input prices is divided into both sides of (4.3). This reduces the number of variables by one and obviates the need in empirical work to select functional forms that are homogeneous of degree one.[8] Equations (4.3) and (4.4) can be written after normalizing on the n-th output price:

$$\Pi = \Pi(p_i, r_j) \tag{4.5}$$

$$Y_k = Y_k(p_i, r_j)$$

$$-X_h = X_h(p_i, r_j)$$

for $i,k=1,\ldots,n-1;\ j,h=1,\ldots,m$

where normalized profit Π is related to the n+m-1 relative prices p_i, r_j. The derivation of the normalized system (4.5) is identical to

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[7]L.J. Lau, "Applications of Profit Functions" in Production Economics: A Dual Approach to Theory and Applications, eds., M. Fuss and D. McFadden (Amsterdam: North Holland Publishing Company, 1978), pp. 133-216.

[8]Binswanger, op. cit, p. 4.

(4.3) and (4.4) except it is in terms of relative rather than absolute prices. Furthermore, it contains all the relevant properties of (4.3) and (4.4) in that normalizing on one of the prices does not change the profit maximizing problem set out in (4.1)[9]

The Constrained Indirect Profit Function

As demonstrated in Appendix I, equations (4.5) can be generalized to the case where there are constraints on the n-1 output price ratios. Letting Z_i represent the n-1 constrained output price ratios, then the firm's optimization problem can be expressed by the following Lagrange profit maximization function:

$$L = \sum_{i=1}^{n-1} p_i{*}Y_i - \sum_{j=1}^{m} r_j{*}X_j + uF(Y_i, X_j)$$

$$- w \left[\sum_{i=1}^{n-1} Z_i{*}Y_i - \sum_{j=1}^{m} r_j{*}X_j + uF(Y_i, X_j)\right]$$

where u, w are Lagrange multipliers. Simultaneous solution of the first-order conditions gives the output supply and unconditional input demand functions. Substituting optimal values for Y_i and X_j back

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[9] Ibid.

into (4.6) and taking first derivatives with respect to the p_i and r_j yields the constrained indirect profit, supply and input demand functions:

$$\Pi = (p_i, r_j, Z_i) \tag{4.7}$$

$$Y_k = \frac{\partial \Pi}{\partial p_i} = Y_k \; (p_i, r_j, Z_i)$$

$$-X_h = \frac{\frac{\partial \Pi}{\partial p_1} * \frac{\partial \Pi}{\partial r_j}}{\frac{\partial \Pi}{\partial p_1} + \frac{\partial \Pi}{\partial Z_1}}$$

for $i,k=1,\ldots,n-1;\; j,h=1,\ldots,m$

PROFIT FUNCTION SPECIFICATION

The quadratic function was used for estimation purposes in this study for several reasons. First, it is a flexible functional form in that it can represent a local second-order approximation to an arbitrary, unspecified underlying function.[10] The quadratic function has the desirable property of global convexity if it can be shown to be convex at any point of approximation. Moreover, it does not automatically equal zero if a subset of the observations equals zero for one or more of the

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[10] L.J. Lau, "Testing and Imposing Monotonicity, Convexity and Quasi-Convexity Constraints,", in Production Economics: A Dual Approach to Theory and Applications, op. cit., pp. 409-454.

exogenous variables.[11] Finally, the quadratic is efficient in that the share equations are independent, unlike the translog function.[12] Long and short run constrained indirect profit functions and associated factor demand and output supply functions were estimated. The long run models represent the more general class of models having the following quadratic specification:

$$\Pi = a_o + \Sigma a_i p_i + \Sigma b_i Z_i + \Sigma c_j r_j + \frac{1}{2} \Sigma d_{ii} p_i p_i + \frac{1}{2} \Sigma e_{ii} Z_i$$

$$+ \frac{1}{2} \Sigma f_{jj} r_j r_j + \Sigma g_{ii} p_i Z_i + \Sigma h_{ij} p_i r_j + \Sigma k_{ij} Z_i r_j + \Sigma \ell_t M_t$$

$$Y_i = a_i + \Sigma d_{ii} p_i + \Sigma g_{ii} Z_i + \Sigma h_{ij} r_j$$

$$-X_j = \frac{(a_i + a_{ii} p_i + g_{ii} Z_i + h_{ij} r_j)*(c_j + f_{jj} r_j + h_{ij} p_i)}{(a_i + a_{ii} p_i + g_{ii} Z_i + h_{ij} r_j) + (b_1 + e_{ii} Z_i + g_{ii} p_i + k_{ij} r_j)}$$

for $i=1,\dots,n-1$; $j=1,\dots,m$; $t=1,\dots,s$.

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[11]W. J. Baumol, J. C. Panzar and R. D. Willig, Contestable Markets and The theory of Industry Structure, (New York: Harcourt Brace Jovanovitch, 1982), pp. 453.

[12]T. G. Cowing, "The Effectiveness of Rate of Return Regulation: An Empirical Test Using Profit Functions," in Production Economics: A Dual Approach to Theory and Applications, Vol. II, op. cit. pp. 226. It is worth noting that the curvature properties of the constrained model are ambiguous so that the second-order conditions ensuring convexity or quasi-convexity do not have to be maintained or imposed. Ibid., pp. 245-246.

where M_t represents concomitant variables that might influence the level of profits. These include the number of companies operating at each delivery point and dummy variables to account both for the type of rail line each elevator/operating unit is situated on (grain-dependent versus nongrain-dependent lines) and differences in accounting periods and practices across companies. In the case of the short run models, a size variable measured by the tonnage capacity of each elevator in the sample was included.

The justification for the long run models is that estimates from cross-section data are usually thought to give a better approximation of a long run function in that the sample covers a range of plant sizes.[13] Because duality theory requires that profits be non-negative, however, the long run models can only be reliably estimated on a subset of the full sample. The resulting parameter estimates could be biased if elevators with negative profits were predominantly located on branch-lines, for example. This problem is overcome to a large extent by estimating short run models on the full sample. Furthermore, these latter models reduce the possibility of a specification error by excluding input costs that were allocated to each elevator from the head office.

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[13]W.W. Wilson, op. cit., pp. 61-63.

The unconstrained models are derived by parametric constraints on the full model specified in (4.8). The exclusion of the constrained prices Z_i in the reduced model is equivalent to setting the parameters $b_i = e_{ii} = g_{ii} = k_{ij} = 0$. From equations (4.7) that implies:

$$\frac{\frac{\partial \Pi}{\partial p_1}}{\frac{\partial \Pi}{\partial p_1} + \frac{\partial \Pi}{\partial Z_1}} = 1 \tag{4.9}$$

so that the unconstrained indirect profit function, output supply and input demand functions have the following quadratic specification:

$$\begin{aligned} \Pi &= a_o + \Sigma a_i p_i + \Sigma c_j r_j + \frac{1}{2}\Sigma d_{ii} p_i p_i + \frac{1}{2}\Sigma f_{jj} r_j r_j \\ &\quad + \Sigma h_{ij} p_i r_j + \Sigma \ell_t M_t \\ Y_i &= a_i + \Sigma d_{ii} p_i + \Sigma h_{ij} r_j \\ -X_j &= c_j + \Sigma h_{ij} p_i + \Sigma f_{jj} r_j \end{aligned} \tag{4.10}$$

for $i=1,\ldots,n-1$; $j=1,\ldots,m$; $t=1,\ldots,s$.

ESTIMATION AND TESTING PROCEDURES

The models were estimated using the iterated version of Zellner's seemingly unrelated regression (SUR) technique.[14] SUR is a joint

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[14] A. Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests For Aggregation Bias," Journal of the American Statistical Association Vol. 57(1962), pp. 585-612.

generalized least squares estimation procedure that takes into account the correlation of errors across equations. The results are asymptotically equivalent to maximum likelihood estimates.[15] The iterations were carried out using the Gauss-Newton method in which a generalized sum of squares is minimized at each iteration with starting values required for the initial iteration. A new set of coefficient estimates are then used in the next iteration to minimize the sum of squared residuals with the process continuing until the estimates converge according to one or more specified criteria. The starting values were taken to be 0.0001 although different starting values, arbitrarily selected, were also used in some cases to ensure that the final minimized sum of squares was global. The convergence criterion was set at 0.001.

The problem of assessing the profitability and pricing practices of branchline versus mainline elevators was approached in the following manner. First, the null hypothesis of equal profitability between both sets of elevators was tested in two ways. The constrained models were run on the full data sets including the dummy variable for type of rail line. The statistical significance of the dummy variable was used to determine if there was a difference in the level of profits between the two groups of elevators. The constrained models were also estimated

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[15] W. Oberhofer and J. Kmenta, "A General Procedure for Obtaining Maximum Likelihood Estimates in Generalized Regression Models," Econometrica Vol. 42 (1974) pp. 579-590.

separately, excluding the dummy variable for rail line status, for the two sub-samples comprising elevators located on grain-dependent lines and those on nongrain-dependent lines respectively. A test for structural differences between the grain-dependent and nongrain-dependent models was used with the appropriate test results fully described in Appendix C. Overall comparisons between the appropriate constrained and unconstrained models were carried out by taking the covariance matrix of the errors across equations from each of the constrained models and estimating each of the unconstrained models with the appropriate constrained covariance matrix. The change in the generalized minimum sum of squares can be used in a chi-square test between the two models that is both asymptotically valid and equivalent to a likelihood ratio test.[16]

DATA SOURCES

The database used in this study consists of the handling plus storage costs, revenues and concomitant data of 590 primary elevators/ operating units located across the three prairie provinces. The sample, for which descriptive statistics are provided in Appendix D, includes only wooden facilities that handled the six principal grain and oilseeds:

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[16]Gallant, A. R. and D. W. Jorgenson, "Statistical Inference for a System of Simultaneous, Nonlinear, Implicit Equations in the Context of Instrumental Variables Estimation," Journal of Econometrics, Vol.11 (1979), pp. 275-302.

wheat, oats, barley, rye, flaxseed and canola. The sample covers the majority of stations operated by three grain companies during the period August 1, 1982 to December 31, 1983. For two companies, the data pertains to crop year 1982-83 but for calendar year 1983 in the case of the third company.

One problem that can arise in estimating relationships using cross-section data from a single accounting period is whether the data corresponds to trend conditions or represents an aberration relative to the trend. The volumes of grain handled each crop year by primary elevators will depend primarily on production and export demand, both of which can affect the level and incidence of capacity utilization across the system. Table IV contains data on grain production, primary and terminal elevator receipts and exports for the ten years ending in 1986-87 crop year. Based on the ten year averages, 1982-83 appears to be a very good year indeed. Production, receipts and exports were 14.9, 18.6, 16.1 and 17.7 percent above the corresponding ten year averages. Beginning in the early 1980's, however, the level of Prairie grain production seems to have shifted upwards. From 1981-82 onwards, production averaged nearly 43 million tonnes, falling below 40 million tonnes only in 1984-85. Both exports and receipts at primary and terminal elevators also increased on average so that 1982-83 was only 6.5, 10.9, 7.1 and 7.7 percent above the respective six year averages ending in 1986-87. Put in this context, only primary elevator receipts in 1982-83 appear to be significantly above the six-year average, implying higher capacity utilization across the system relative to trend. It is likely, however, that higher rates of utilization would have occurred at elevators located on both grain-dependent and other rail lines. Therefore, the use of accounting data for one period only would not seem to be a problem.

The database was compiled from several sources. Costs represent the first year's observations contained in the data set used by Jeffrey[17] in his study on elevator industry performance on the Prairies. His sample consisted of 1472 observations for two consecutive years beginning at the start of crop year 1982-83 through to the end of calendar year 1984. CWB delivery point codes were assigned to Jeffrey's data set and used to link it with the cost and revenue database that the Hall Committee on Crow Benefit Payment had requested from six grain companies.[18] The Hall database, covering the same time period and including the three companies in Jeffrey's sample, contained data on 705 primary elevators/operating units. Jeffrey's costs were used because they were already edited and because the cost categories were specified in a form for which input prices could be derived.

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[17]J. Russell Jeffrey, op. cit., Chapter 6, Section 4.

[18]The Hall database became the property of Transport Canada once the Committee ceased to exist. Permission to use the database was granted by both Transport Canada and the three companies who also agreed to the use of Jeffrey's data so long as individual company data was kept confidential.

TABLE IV

CHARACTERISTICS OF PRAIRIE GRAIN PRODUCTION
HANDLING AND EXPORTS BY CROP YEAR*

CROP YEAR	PRODUCTION	ELEVATOR RECEIPTS PRIMARY	ELEVATOR RECEIPTS TERMINAL	EXPORTS
		- '000 tonnes -		
1977-78	36,853	26,761	22,287	20,214
1978-79	37,893	22,608	21,436	18,234
1979-80	31,067	27,337	24,451	21,733
1980-81	34,575	27,026	24,173	21,185
1981-82	42,453	29,396	28,383	26,049
1982-83	45,739	34,311	30,618	28,295
1983-84	40,834	31,744	32,024	29,441
1984-85	36,053	25,801	24,453	22,025
1985-86	41,212	29,918	24,760	23,221
1986-87	51,341	34,484	31,228	30,082
Averages:				
-1977-78 to 1986-87	39,802	28,939	26,381	24,048
-1981-82 to 1986-87	42,939	30,942	28,578	26,519

* Data includes only wheat, oats, barley, rye, flax and canola. Terminal elevator receipts cover Vancouver, Prince Rupert, Churchill and Thunder Bay. Exports may include small amounts produced in eastern Canada.

SOURCE: Canada Grains Council, Canadian Grains Industry Statistical Handbook 87, (Winnipeg: 1987).

Cost Data

Jeffrey has fully described his cost categories so that only a summary of his discussion needs to be presented here.[19] Total costs at each elevator/operating unit consists of eight categories.

Labour costs consist of salaries, wages and benefits paid to elevator managers, assistants and part-time employees. The data includes only the labour costs associated with handling and storing grain, being net of any remuneration employees receive for selling farm supplies.[20]

The category power includes the costs of energy consumed in lighting, heating and operating each elevator.

Repairs cover the cost of repairing and maintaining facilities.

Insurance costs are the annual premiums paid for insuring facilities and grain in-store.

Rentals/taxes consist of the costs of municipal property taxes and payments for the rental of land and/or facilities.

Depreciation ideally represents the costs of the invested capital that was consumed during the year's operation. The depreciation costs on the database were taken as reported by each company.

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[19] J. Russell Jeffrey, op. cit. Two of the three companies do not bother to calculate interest on undepreciated investment, even though in theory this represents the opportunity costs of retaining invested capital in its current use. Jeffrey excludes it from the third company's data on the grounds that it has more to do with the firm's expected rate of return than with expenditures actually incurred.

[20] The salaries, wages and benefits data were re-checked with each company to ensure this point.

The administration category is an allocation of head office expenditures related, for the most part, to handling and storing grain. Such costs cover many functions that either used to be performed in the elevator or are closely connected with elevator operations.

The miscellaneous cost category is comprised of expenditures on office supplies, telecommunications and so forth.

Revenue Data

The revenue information on the Hall database was supplemented and, where necessary, adjusted with additional data from the three companies. In editing the Hall data, it quickly became apparent that the revenue data was neither consistent nor complete across companies. Adjustments to the Hall data resulted in the following revenue categories.

Handling revenues at each elevator or station, representing the monies generated for elevating, removal of dockage and loading out grain, is the largest part of total income from handling and storing grain. The Hall data as reported by each company is an initial estimate based on the tonnage of grain handled at each elevator multiplied either by an average price or set of prices reflecting the tariffs filed with the Grain Commission. These data are simply a head office allocation that only loosely approximate the actual handling revenues generated at individual stations. Additional data on gains and losses attributable to differences in the primary and terminal elevator measurements of volumes, weights or grades based on the grain originating from each elevator on the Prairies was obtained for two companies.[21] Their allocated handling revenues were adjusted to reflect more accurately the actual revenue consequences from handling grain at each station.

The question that arises is whether the adjusted data can support the hypothesis testing given that a significant part of the handling revenues consist of amounts allocated as determined by using average prices. If a problem with allocated data exists, then it likely applies to the inclusion of data from the one firm that does not adjust its allocated revenues. There is an indirect indication at least that the problem may be minor in that these data are also used by each company not only in making decisions about current operations but also as an input in longer term investment and rationalization plans. As noted in Chapter II above, many of the major grain companies including the ones whose data is used in this study, had plans to close one-third to one-half of their elevators by 1990, thereby continuing the consolidation process that each firm had already undergone. It is difficult to see how elevator closure decisions could be made in any reliable way if the underlying financial data was inaccurate.

Storage revenues, representing the second revenue category, are derived from two sources. A small amount comes from the storage rates charged producers whose non-Board grain remains in the elevator for longer than ten days. Most storage revenue, however, comes from CWB interest and carrying charges on Board grain. The receipt of Board

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[21]The third company did not attribute grade/weight grains or losses to individual elevators/operating units.

grains at primary elevators imposes an additional cost on grain companies in that producers receive the appropriate CWB net initial price[22] from the companies on delivering their grain. The grain, however, will sit in the elevator until rail cars are allocated to the company in order to meet or fulfill a CWB sales commitment. The company incurs foregone interest on the funds it disburses to farmers in that the CWB only repays each company after taking possession of the grain; hence the need for the Board to reimburse the grain companies for their interest and carrying costs in implementing initial payments to producers. One company does not normally include CWB payments on either the revenue or expenditure side of their individual elevator accounts on the grounds that the payments simply balance the costs incurred. These data were made available by the company and added into the storage revenue and miscellaneous cost categories respectively.

Other revenues represents a catchall category that includes the value of crop sales to local users or other companies, revenues earned on the sale of dockage and income from renting property to employees.

SPECIFICATION OF VARIABLES

Total revenue at each elevator was defined as the sum of handling, storage and other revenues. Long run total cost was taken to be the sum

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[22]The net initial price is the initial price minus both the handling charge and the appropriate statutory freight rate to the nearest port.

of the cost categories described above whereas short run total cost was defined, for reasons discussed below, as the sum of labour plus power expenditures. Long and short run profits were calculated as the difference between total revenue and the appropriate total cost.

The following two output prices were defined for the purposes of this study. The average handling price represents handling revenues divided by the volume of grain shipped out of each elevator/operating unit.[23] The average price of storage was calculated as storage plus other revenues divided by the volume of Board grain delivered to each elevator on the reasonable grounds that CWB payments account for the major share of non-handling elevator revenues. The storage price was used to normalize the models and thus does not appear explicitly in them. The reason for normalizing on the storage price is that the handling charge is the one price that is under short term control of the grain companies. The price of storage on non-Board grains is fixed by the Grain Commission and there is little scope to alter the effective price charged to increase such revenues; besides, increased storage implies a lower turn rate and lower total revenues as a result. In addition, revenues from CWB interest and carrying charges are determined by the Board and the allocation of rail cars. The grain handling function

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[23]The grain companies do not keep track of either handling revenues or volumes shipped by type of grain so that it was not possible to estimate elevator-specific handling prices on a more disaggregated basis.

accounts for nearly 60 percent of country elevator revenues on average. More to the point, it is the handling price that can be changed via grade/ weight/volume discounts and premiums and it is one of the purposes of this research to test how strictly the filed handling tariffs are adhered to.

In addition, the constrained models include a constrained weighted average handling price based on each company's handling tariffs filed with the Grain Commission. During the period in question, the grain companies only changed their filed tariffs once. Moreover, the increases applied to all elevators in each company's network. Average tariffs by crop were first calculated for each company over its accounting year with the weights based on the number of months each set of filed tariffs was in effect. An elevator-specific composite weighted average filed handling tariff was then calculated for all six crops combined, with the weights being the respective tonnages of the six principal grains delivered to each elevator. This, in effect, gives a unique composite weighted average filed handling price for each elevator/operating unit.

The long run models include three input prices: labour, power and a residual price. The average prices of labour and energy were calculated by dividing person-years employed and estimated kilowatt-hours into labour and power costs respectively. Appendix B describes the estimation of total kilowatt-hours consumed at individual elevators. The residual input price was taken to be the remaining costs divided by elevator/ operating unit size, as measured by tonnage capacity, as many of these residual costs would likely vary more with plant capacity than with volumes handled. To the extent that the current value of capital invested varies with elevator size, then one would expect, for example, premiums to insure facilities, municipal property taxes and depreciation costs to increase with capacity.[24]

Table V contains simple correlations between the output and input prices. There is almost no linear correlation between the variables with one or two exceptions. As might be expected, the estimated handling price and the weighted average filed handling price have a correlation coefficient of 0.55, indicating that the two prices tend to move loosely together. The choice of the storage price on which to normalize the models seems justifiable in that it appears to be only slightly correlated in a negative way with the price of labour.

Data on the number of companies located at each delivery point was taken from published Grain Commission sources. Each observation in the sample was assigned a value of either one or zero depending on whether it was located on a grain-dependent branchline or not based on the 1982-83 crop year list of grain-dependent lines prepared by the (formerly) Canadian Transport Commission.

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[24]Aggregating residual costs is tantamount to assuming that the inputs represented by these costs are weakly separable in the unspecified cost and transformation functions. Cf. James M. Henderson, and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach, 3rd Edition, (McGraw-Hill Book Company, 1980), pp. 40. Moreover, the use of only one grain handling price, while done because of data limitations, implicitly assumes weak separability as well.

TABLE V

CORRELATIONS BETWEEN OUTPUT AND INPUT PRICES*

	P_1	P_2	V	I_1	I_2	I_3
P_1	1.000	-0.052	0.557	0.050	0.138	0.203
P_2	-0.052	1.000	0.117	-0.318	-0.026	0.006
V	0.557	0.117	1.000	-0.114	0.022	0.033
I_1	0.050	-0.318	-0.114	1.000	0.026	0.062
I_2	0.138	-0.026	0.022	0.026	1.000	0.025
I_3	0.203	0.006	0.033	0.062	0.025	1.000

* Based on the full sample of 590 observations where:

P_1 = handling price
P_2 = storage price
V = filed handling price
I_1 = labour price
I_2 = price of power
I_3 = residual input price

CHAPTER V

EMPIRICAL RESULTS

The results of the models discussed in the previous chapter are herein analyzed and compared. The first section contains parameter estimates and associated statistics of the long and short run models respectively. The second section presents the results of testing on the level and structure of profits and the relationship between filed and estimated handling revenues. Appendix C contains the complete set of parameter estimates as well as a discussion of, and results on, the procedures used to test relative branch/mainline profitability. Finally, Table VI lists and defines the variable pneumonics used in presenting the parameter estimates of each model.

MODELLING ESTIMATES

Long Run Models

The long run model estimated on the combined sample used a dummy variable to provide an initial assessment of whether elevators located on branchlines were significantly different from those located on nongrain-

TABLE VI

DEFINITION OF VARIABLE AND MODEL PNEUMONICS

VARIABLE	DEFINITION
PROF1	Long run profits = total revenue-total cost
PROF2	Short run profits = total revenue - (labour and power costs)
TS	Volume = total shipments from each elevator/operating unit
TCAP	Total capacity of each elevator/operating unit
X_1	Person-years of employment
X_2	Kilowatt-hours of electrical consumption
X_3	TCAP = proxy for the quantity of other inputs
p	Weighted average price of grain handling services
v	Weighted average filed price of grain handling services
r_1	Input price of labour = labour costs/X_1
r_2	Input price of power = power costs/X_2
r_3	Residual input price = residual costs/X_3
NUM	Number of companies located at each delivery point
J1	Dummy variable for Company I
J2	Dummy variable for Company II
J3	Dummy variable = 1 for observations on grain-dependent branchlines and 0 otherwise.
LRCI	Long run constrained pooled sample model
LRCII	Long run constrained grain-dependent model
LRCIII	Long run constrained nongrain-dependent model
SRCI	Short run constrained pooled sample model
SRCII	Short run constrained grain-dependent model
SRCIII	Short run constrained nongrain-dependent model

dependent lines. Long run profits, PROF1, were restricted to being nonnegative to conform with one of requirements of duality theory, resulting in a combined sample of 524 observations. The long run model, normalized on the output price of storage and including variables to account for differences in accounting periods and practices, can be written as:

$$
\begin{aligned}
(5.1)\ \text{PROF1} = {} & a_o + a_1p + a_2v + a_3r_1 + a_4r_2 + a_5r_3 + 0.5a_{11}p^2 \\
& + 0.5a_{22}v^2 + 0.5a_{33}r_1^2 + 0.5a_{44}r_2^2 + 0.5a_{55}r_3^2 \\
& + a_{12}pv + a_{13}pr_1 + a_{14}pr_2 + a_{15}pr_3 + a_{23}vr_1 \\
& + a_{24}vr_2 + a_{25}vr_3 + a_{34}r_1r_2 + a_{35}r_1r_3 + a_{45}r_2r_3 \\
& + b_1\text{NUM} + b_2J_1 + b_3J_2 + b_4J_3
\end{aligned}
$$

$$\text{TS} = Z_1 = a_1 + a_{11}p + a_{12}v + a_{13}r_1 + a_{14}r_2 + a_{15}r_3$$

$$-X_1 = \frac{Z_1\ (a_3 + a_{13}p + a_{23}v + a_{33}r_1 + a_{34}r_2 + a_{35}r_3)}{Z_1 + Z_2}$$

$$-X_2 = \frac{Z_1\ (a_4 + a_{14}p + a_{24}v + a_{34}r_1 + a_{44}r_2 + a_{45}r_3)}{Z_1 + Z_2}$$

$$-X_3 = \frac{Z_1\ (a_5 + a_{15}p + a_{25}v + a_{35}r_1 + a_{45}r_2 + a_{55}r_3)}{Z_1 + Z_2}$$

where: $Z_2 = a_2 + a_{12}p + a_{22}v + a_{23}r_1 + a_{24}r_2 + a_{25}r_3$

The parameter estimate for a_{11} indicates the magnitude of the slope of the output supply function whereas the negative of the parameter estimates for a_{33}, a_{44} and a_{55} measure the slopes of the demand functions for the three inputs X_1, X_2 and X_3 respectively. Equivalently, a_{11} and the negative of the parameters a_{33}, a_{44} and a_{55} are the result of taking the second paratial derivatives of PROF1 with respect to the output price p and the input prices r_1, r_2 and r_3. As such, estimates on these parameters measure the rate of change of the slope of the profit surface with respect to the appropriate prices. The coefficient a_{22}, on the other hand, indicates both the supply response to a change in the constrained price v and the rate of change of the slope of the profit function with respect to v.

Table VII contains the parameter estimates and associated t-statistics plus some equation and system statistics for the long run model (LRCI) estimated on the pooled sample. All of the models reported in this study converged as per the SAS default settings for convergence.[1] The OBJECTIVE represents the generalized sum of squares that the algorithm attempts to minimize.[2] The R^2 statistics and sum of squared errors for each equation are also given. The R^2's provide a

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[1]SAS Institute, SAS/ETS User's Guide, (Carey, North Carolina, 1984).

[2]*Ibid.*, pp. 508.

TABLE VII

LONG RUN CONSTRAINED MODEL I ESTIMATES: POOLED ELEVATOR SAMPLE

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
a_o	8477.14	6.48
a_1	177.52	0.97
a_2	- 1.62	- 5.72
a_3	1.59	5.60
a_4	1593.61	- 1.21
a_5	- 280.75	- 8.49
a_{11}	619.11	3.87
a_{12}	- 1.00	- 26.03
a_{13}	0.79	21.18
a_{14}	- 15483.01	- 7.96
a_{15}	- 202.5	- 6.12
a_{22}	- 0.11	- 3.62
a_{23}	2.10 E-04	8.71
a_{24}	- 5.80	- 1.21
a_{25}	0.21	28.76
a_{33}	- 2.10 E-04	- 8.34
a_{34}	- 8.37	- 16.15
a_{35}	- 0.19	- 27.73
a_{44}	7439173.00	17.11
a_{45}	- 43.17	- 0.11
a_{55}	149.28	15.47
b_1 (NUM)	163.51	0.54
b_2 (J1)	1283.18	1.47
b_3 (J2)	979.39	1.21
b_4 (J3)	353.77	0.80

EQUATION	SSE	R^2
I	8.65 E + 10	0.209
II	3.21 E + 09	0.622
III	29.11438	0.682
IV	1.48 E + 11	0.552
V	102983561	0.619

N = 524 observations
OBJECTIVE = 4.95298
OBJECTIVE*N = 2595.36

UNCONSTRAINED MODEL: OBJECTIVE*N = 2601.23

SOURCE: Appendix C.

rough measure of goodness of fit and are defined as:[3]

(5.2) $R^2 = \frac{1 - (\text{predicted variable} - \text{actual variable})}{\text{corrected SS of the actual variable}}$

The negative of the parameter estimates for a_{44} and a_{55} indicate that the input demand functions for power and other inputs are downward sloping. On the other hand, the negative of the coefficient estimate for a_{33} suggests the demand function for labour is upward sloping. There are two possible explanations for this latter result. First, there may be a causality problem in that a higher average input price of labour does not lead to or cause an increased demand for labour. Rather, an increased utilization of labour, ceteris paribus, might result in an increased average price of labour. It is likely that an increase in person-years employed would come about mainly from the hiring of more casual labour or, perhaps, one or more additional assistant managers. For the average input price of labour to increase with an increase in labour demand, the manager's share of total wages and benefits would have to increase. Unfortunately, data on labour costs by labour category was insufficient to investigate this possibility further. The second

[3]Ibid., pp. 532. The intercepts of the output supply and input demand functions are individual parameters, or combinations thereof, from the profit function; hence, the R^2's are not valid for statistical tests given the cross-equation restrictions of the intercept terms but are reported only to indicate goodness of fit.

possible explanation for the somewhat perverse sign of the a_{33} estimate, a result which is consistent across all models estimated in this study, may be due to normalizing the data. One indication is that the correlation coefficient between the normalized labour price r_1 and normalized person-years X_1 is 0.730. The correlation coefficient between the corresponding non-normalized variables is -0.397.

The partial derivate of PROFI with respect to p is the output supply function in (5.1); hence, PROFI is an increasing function of p. Moreover, PROFI is increasing at an increasing rate given that the estimate of the coefficient a_{11} is positive and statistically significant. The partial derivative of PROFI with respect to the benchmark filed handling tariffs is given by Z_2 from equations (5.1):

$$(5.3)\ Z_2 = a_2 + a_{12}p + a_{22}v + a_{23}r_1 + a_{24}r_2 + a_{25}r_3$$

At first glance, it would seem that the filed handling prices v in the model are of some statistical significance in that only the estimate of a_{24} is statistically insignificant as measured by its calculated t-value in Table VII. To the extent that this result holds, then actual handling charges would be a good reflection of the filed handling rates. This would apply especially to the two companies that attribute grade/weight gains or losses back to their individual elevators.

The parameter estimates for the concomitant variables for LRCI are all statistically insignificant. In particular, profit levels would seem to be affected neither by the number of companies operating at each delivery point nor to which company each observation in the sample belongs. The insignificance of the latter suggests that different accounting periods and practices across firms are unimportant. Finally, the statistical insignificance of the parameter estimate for J3 indicates there is no difference in the level of profitability, and therefore, no pattern of cross-subsidization, between grain-dependent branchline and mainline elevators/operating units.

Equations (5.1) without the dummy variable J3 were re-estimated on the subsamples comprising observations located on grain-dependent lines and observations located on other rail lines. The parameter estimates and other statistics for these two models, hereafter referred to as LRCII and LRCIII respectively, are given in Tables VIII and IX. In the case of LRCII, profits increase at a constant rate with respect to p, as demonstrated by the highly insignificant estimate for a_{11}. The estimates for a_{33}, a_{44} and a_{55}, giving the slopes of the input demand functions, follow a pattern similar to the corresponding estimates of model LRCI, both in signs and magnitudes. The number of companies operating at each grain-dependent delivery point is statistically insignificant but the dummy variable J2, significant at 10 percent, indicates that one company generates higher long run profits from its branchline elevators than do the other two firms.

Parameter estimates for the nongrain-dependent model LRCIII, given in Table IX, are similar but not identical to the estimates of LRCI and LRCII. The coefficient a_{11} is positive and significant at 10 percent, suggesting that the profit function is increasing at an increasing rate in the handling price ratio p. Estimates of the parameters a_{33}, a_{44}

TABLE VIII

LONG RUN CONSTRAINED MODEL II ESTIMATES:

GRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_0	11738.12	7.06
a_1	388.35	1.60
a_2	- 0.70	- 1.98
a_3	0.65	1.84
a_4	- 2059.98	- 1.10
a_5	- 282.12	- 5.82
a_{11}	138.31	0.73
a_{12}	- 0.94	- 18.76
a_{13}	0.82	17.79
a_{14}	- 12101.51	- 4.61
a_{15}	- 138.13	- 3.37
a_{22}	- 0.14	- 3.41
a_{23}	8.00 E-05	2.75
a_{24}	- 8.32	- 1.46
a_{25}	0.24	22.58
a_{33}	- 8.00 E-05	- 2.76
a_{34}	- 10.15	- 14.53
a_{35}	- 0.22	- 24.49
a_{44}	7789007.00	13.33
a_{45}	385.73	0.77
a_{55}	162.82	12.14
b_1	- 254.33	- 0.61
b_2	2074.57	1.91
b_3	143.48	0.14

EQUATION	SSE	R^2
I	4.36 E + 10	0.108
II	1.56 E + 09	0.625
III	13.60717	0.669
IV	7.63 E + 10	0.617
V	60752350	0.614

N = 279 observations
OBJECTIVE = 4.91631
OBJECTIVE*N = 1371.65

UNCONSTRAINED MODEL: OBJECTIVE*N = 1377.34

SOURCE: Appendix C.

TABLE IX

LONG RUN CONSTRAINED MODEL III ESTIMATES:

NONGRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_0	1417.08	0.73
a_1	- 491.10	- 1.77
a_2	- 4.17	- 9.04
a_3	4.19	8.99
a_4	- 757.01	- 0.39
a_5	- 235.29	- 4.95
a_{11}	494.60	1.84
a_{12}	- 1.26	- 21.09
a_{13}	1.00	15.65
a_{14}	- 18210.18	- 5.95
a_{15}	- 200.85	- 3.62
a_{22}	- 0.08	- 1.72
a_{23}	4.98 E-04	12.42
a_{24}	0.58	0.07
a_{25}	0.21	19.90
a_{33}	- 5.09 E-05	- 12.20
a_{34}	- 6.86	- 8.93
a_{35}	- 0.19	- 16.38
a_{44}	6934041.00	11.95
a_{45}	- 209.38	- 0.34
a_{55}	138.31	9.74
b_1	391.08	1.02
b_2	- 1949.27	- 1.56
b_3	710.16	0.66

EQUATION	SSE	R^2
I	4.16 E + 10	0.310
II	1.52 E + 09	0.648
III	15.38897	0.693
IV	6.92 E + 10	0.463
V	42898941	0.611

N = 524
OBJECTIVE = 4.90541
OBJECTIVE*N = 1201.83

UNCONSTRAINED MODEL: OBJECTIVE*N = 1207.54

SOURCE: Appendix C.

and a_{55} indicate that the input demand curve for labour with respect to the normalized labour price is upward sloping whereas the corresponding curves for power and residual inputs with respect to own-prices are downward sloping. Coefficient estimates of the three concomitant variables are all insignificant. The estimate of a_{22} is only significant at 10 percent compared with the a_{22} estimates in the models LRCI and LRCII. Furthermore, the intercept on the profit equation in LRCIII is insignificant in contrast to LRCI and LRCII.

Diagram VI graphs normalized profits against p for each model, thereby showing a cross-section slice of the profit surface estimated by each model. All other variables were valued at their mean values from each sample respectively. The equation for each curve is:

$$\text{LRCI:} \quad PROF1 = 8775 + 3268p + 619p^2$$

$$\text{LRCII:} \quad PROF1 = 8984 + 4163p$$

$$\text{LRCIII:} \quad PROF1 = 9323 + 3341p + 495p^2$$

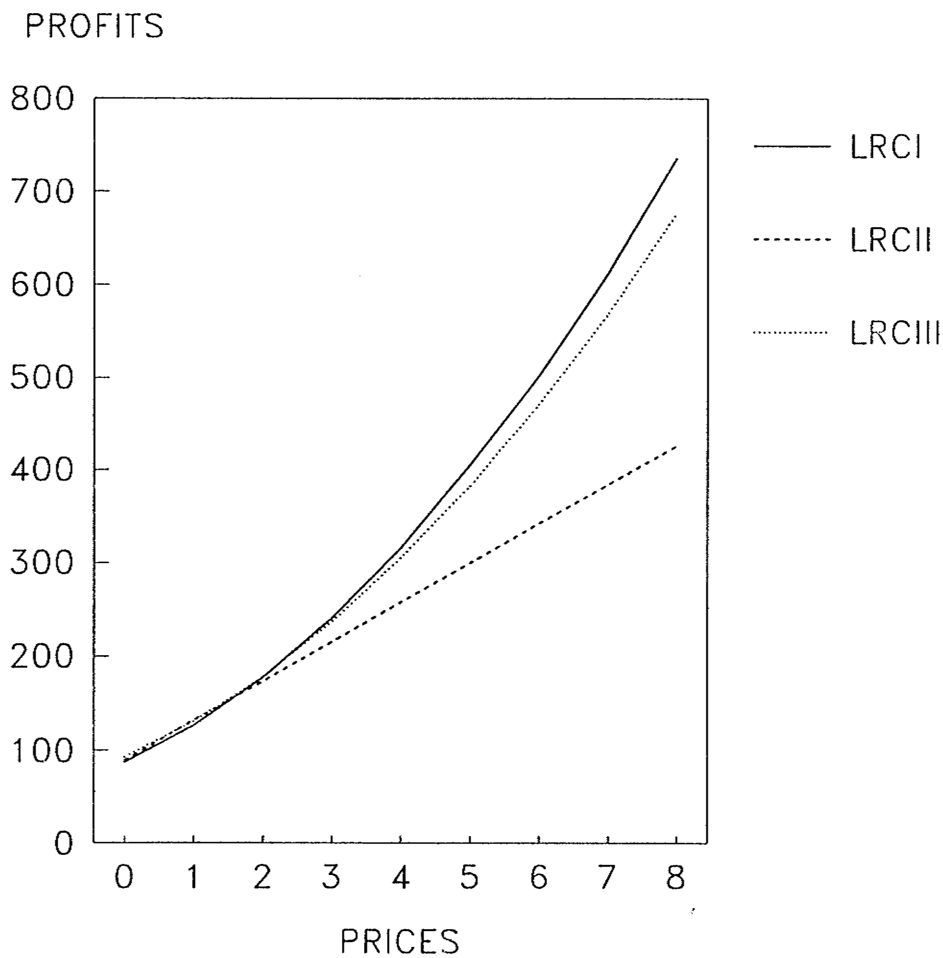
For a normalized price of under \$2 per tonne, normalized profit estimates from the three models are reasonably similar. Above p=2, however, branchline profits are far less responsive to price than those generated from elevators on nongrain-dependent lines.

Short Run Models

Corresponding to the long run models, three short run or gross profits models were estimated on the pooled sample and the subsamples of

DIAGRAM VI

RELATIONSHIP OF NORMALIZED PROFITS TO NORMALIZED PRICES FROM MODELS LRCI, LRCII, LRCIII



grain-dependent and nongrain-dependent observations. The parameter estimates, t-statistics and equation and system statistics for these models, labelled SRCI, SRCII and SRCIII respectively, are given in Tables XI, XII and XIII. Profits for each model were re-defined as total revenues minus labour and power costs so that the respective sample sizes were 590, 318 and 272 observations. In addition, a concomitant variable for elevator/operating unit size (TCAP) was included in each model. This obviously removes any effects due to economies of scale. The short run model SRCI estimated on the pooled sample is:

$$
\begin{aligned}
(5.4)\ \text{PROF1} = {} & a_o + a_1p + a_2v + a_3r_1 + a_4r_2 + 0.5a_{11}p^2 + 0.5a_{22}v^2 \\
& + 0.5a_{33}r_1^2 + 0.5a_{44}r_2^2 + a_{12}pv + a_{13}pr_1 + a_{14}pr_2 \\
& + a_{23}vr_1 + a_{24}vr_2 + a_{34}r_1r_2 + + b_1\text{NUM} + b_2\text{TCAP} \\
& + b_3\text{J1} + b_4\text{J2} + b_5\text{J3}
\end{aligned}
$$

$$
\text{TS} = Z_1 = a_1 + a_{11}p + a_{12}v + a_{13}r_1 + a_{14}r_2
$$

$$
-X_1 = Z_1 \frac{(a_3 + a_{13}p + a_{23}v + a_{33}r_1 + a_{34}r_2)}{Z_1 + Z_2}
$$

$$
-X_2 = \frac{Z_1 \ (a_4 + a_{14}p + a_{24}v + a_{34}r_1 + a_{44}r_2)}{Z_1 + Z_2}
$$

where: $Z_2 = a_2 + a_{12}p + a_{22}v + a_{23}r_1 + a_{24}r_2$

The models SRCII and SRCIII have the same formats except for the exclusion of the dummy variable J3.

TABLE X

SHORT RUN CONSTRAINED MODEL I ESTIMATES:

POOLED ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_o	10067.40	6.03
a_1	514.77	2.84
a_2	- 2.76	- 8.47
a_3	2.73	8.58
a_4	42.21	0.03
a_{11}	1267.45	11.07
a_{12}	- 0.64	- 18.48
a_{13}	0.31	9.02
a_{14}	- 27001.87	- 13.58
a_{22}	- 0.08	- 2.47
a_{23}	3.21 E-04	13.46
a_{24}	9.83	1.89
a_{33}	2.88 E-04	- 11.63
a_{34}	- 5.28	- 10.42
a_{44}	7535187.00	15.66
b_1 (NUM)	- 406.92	- 1.20
b_2 (TCAP)	1.62	8.95
b_3 (J1)	4350.30	4.47
b_4 (J2)	3034.21	- 3.39
b_5 (J3)	64.91	0.13

EQUATION	SSE	R^2
I	1.83 E + 11	0.401
II	3.94 E + 09	0.563
III	34.72164	0.680
IV	2.23 E + 11	0.500

N = 590
OBJECTIVE = 3.9667
OBJECTIVE*N = 2340.35

UNCONSTRAINED MODEL: OBJECTIVE*N = 2345.15

SOURCE: Appendix C.

TABLE XI

SHORT RUN CONSTRAINED MODEL II ESTIMATES:

GRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_o	11923.74	5.62
a_1	613.09	2.51
a_2	- 2.56	- 6.68
a_3	2.51	6.47
a_4	2064.84	0.92
a_{11}	971.64	6.87
a_{12}	- 0.64	- 14.97
a_{13}	0.36	8.39
a_{14}	- 26735.75	- 9.09
a_{22}	- 0.07	- 1.87
a_{23}	3.02 E-04	10.97
a_{24}	11.12	1.91
a_{33}	- 2.78 E-04	- 9.67
a_{34}	7.12	- 9.91
a_{44}	8616078.00	13.28
b_1 (NUM)	- 932.62	- 2.12
b_2 (TCAP)	1.54	7.38
b_3 (J1)	2859.92	2.53
b_4 (J2)	- 3866.00	- 3.58

EQUATION	SSE	R^2
I	9.65 E + 10	0.365
II	2.01 E + 09	0.552
III	16.01883	0.671
IV	1.39 E + 11	0.529

N = 318
OBJECTIVE = 3.94253
OBJECTIVE*N = 1253.72

UNCONSTRAINED MODEL: OBJECTIVE*N = 1258.27

SOURCE: Appendix C.

TABLE XII

SHORT RUN CONSTRAINED MODEL III ESTIMATES:

NONGRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_o	7071.28	2.76
a_1	240.39	0.90
a_2	- 3.62	- 6.98
a_3	3.62	6.93
a_4	- 2643.53	- 1.45
a_{11}	1668.22	9.16
a_{12}	- 0.70	- 12.60
a_{13}	0.27	4.92
a_{14}	- 30820.33	- 12.13
a_{22}	- 3.01 E-04	- 0.06
a_{23}	3.89 E-04	9.48
a_{24}	3.69	0.36
a_{33}	- 3.51 E-04	- 8.27
a_{34}	- 2.81	- 4.19
a_{44}	7038360.00	11.11
b_1 (NUM)	- 14.84	- 0.03
b_2 (TCAP)	1.56	5.09
b_3 (J1)	4865.50	2.98
b_4 (J2)	- 2612.73	- 1.84

EQUATION	SSE	R^2
I	8.54 E + 10	0.446
II	1.85 E + 09	0.592
III	18.91935	0.682
IV	7.73 E + 10	0.471

N = 272
OBJECTIVE = 3.93205
OBJECTIVE*N = 1069.52

UNCONSTRAINED MODEL: OBJECTIVE*N = 1074.22

SOURCE: Appendix C.

The estimates for all three models indicate that normalized profits are increasing at an increasing rate in the handling price ratio p. The responsiveness of profits to price is much greater for mainline elevators. Moreover, as one would except, the estimated magnitude of a_{11} in the short run models are substantially larger compared with the corresponding long run estimates. Diagram VII graphs short run normalized profits against p for each model, based on the following equations with other variables valued at their respective means:

(5.5) SRCI: PROF2 = 22,040 + 2084p + 1267p^2

SRCII: PROF2 = 42,002 + 2600p + 972p^2

SRCIII: PROF2 = 22,473 + 1, 467p + 1668p^2

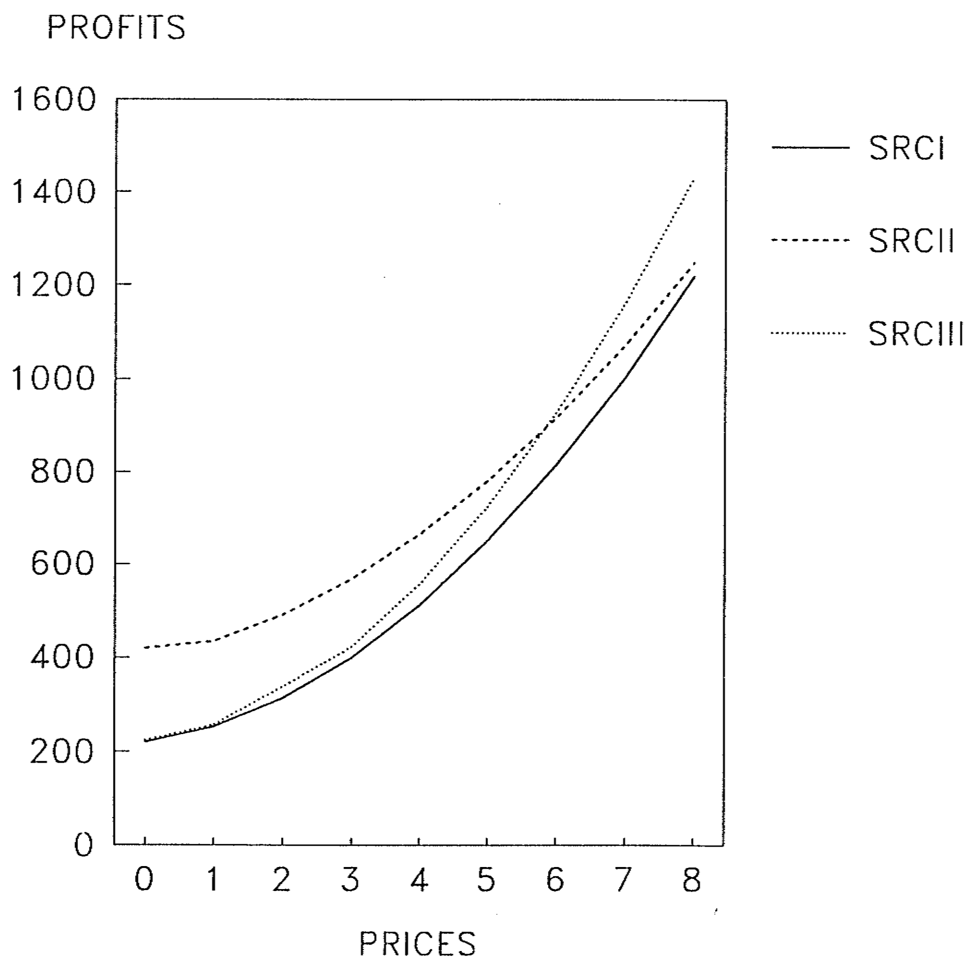
Unlike the profit-price relationships for the long run models, the short run grain-dependent relationship dominates the nongrain-dependent line at normalized prices up to about $6 per tonne.

The parameter estimates a_{33} and a_{44}, giving the slopes of the two input functions with respect to own-price, have the same signs and similar magnitudes as found in the long run models. The slope of the input demand for labour is upward sloping whereas the slope of the power demand curve is downward sloping.

The parameter estimates on the concomitant variables are somewhat different in the short run models. While the parameter estimate for the dummy variable J3 on rail line status is insignificant in the SRCI model, the estimated coefficient on the number of companies operating at each delivery point is negative and significant at 5 percent in SRCII, the

DIAGRAM VII

RELATIONSHIP OF NORMALIZED PROFITS TO NORMALIZED PRICES FROM MODELS SRCI, SRCII, SRCIII



grain-dependent branchline model. Elevator capacity is significant in all three models, indicating that larger elevators generate larger profits, all other things being equal. The two company dummy variables are significant in all three models but they have opposite signs. This suggests that one company generates higher short run profits in both their main and branchline elevators relative to the third company whereas the second company generates smaller short run profits relative to both other firms.

HYPOTHESIS TESTS

Pricing

The influence of the filed handling tariffs on profits can be seen by taking the partial derivatives of PROF1 and PROF2 with respect to v:

$$(5.6)\quad \frac{\partial(\text{PROF1})}{\partial v} = a_2 + a_{12}p + a_{22}v + a_{23}r_1 + a_{24}r_2 + a_{25}r_3$$

$$\frac{\partial(\text{PROF2})}{\partial v} = a_2 + a_{12}p + a_{22}v + a_{23}r_1 + a_{24}r_2$$

With the exception of the estimate of a_{22} in SRCIII and a_{24} in LRCIII and SRCIII, the remaining estimates of the coefficients in (5.6) from Tables VII to XII are significant, albeit some of them only at 10 percent.

As described in the previous chapter, it is possible to test the overall significance of the filed handling price v. The null hypotheses for this test are:

$$(5.7)\ H_o: a_2 = a_{12} = a_{22} = a_{23} = a_{24} = a_{25} = 0$$

in the long run models and:

$$(5.8)\ H_o: a_2 = a_{12} = a_{22} = a_{23} = a_{24} = 0$$

in the short run models. For each of these six models, an unconstrained version was estimated assuming the appropriate null hypothesis (5.7) or (5.8). The unconstrained models were nonetheless restricted by inputting the covariance matrix across equations from the appropriate constrained model. The resulting generalized sum of squares for each (restricted) unconstrained model is given at the bottom of Tables VII-XII. Table XIV contains the sum of squares of both the constrained and unconstrained version of the six models, their differences, the degrees of freedom and the theoretical Chi-square values at 5 and 1 percent levels of significance. It is quite apparent that the differences in the constrained and unconstrained generalized sum of squares is less than the Chi-square values so that it is not possible to reject the null hypothesis for any of the six models. Hence, one can conclude that the weighted average elevator-specific handling price is statistically different from the corresponding weighted average elevator-specific filed tariff price.

The question that arises from these results is whether the vector of handling prices differs by rail line status. The appropriate t and F-tests can be carried out to determine if there are differences in the

TABLE XIII

SIGNIFICANCE TESTS ON THE HANDLING PRICE CONSTRAINT

MODEL	CONSTR. SS	UNCONSTR. SS	DIFFERENCE	D.F.	CHI-SQUARE VALUES 5%	1%
LRCI	2601.23	2595.36	5.87	6	12.592	14.449
LRCII	1377.34	1371.65	5.69	6	12.592	14.449
LRCIII	1207.54	1201.83	5.71	6	12.592	14.449
SRCI	2345.15	2340.35	4.80	5	11.070	12.832
SRCII	1258.27	1253.72	4.55	5	11.070	12.832
SRCIII	1074.22	1069.52	4.70	5	11.070	12.832

SOURCE: Tables VII to XII and Jan Kmenta, Elements of Econometrics, (New York: MacMillan Company, 1971), Table D-3, pp. 622.

mean and/or variances between the grain-dependent and nongrain-dependent handling prices given the following null hypotheses:[4]

(5.9) H_o: mean(NGD) - mean(GD) = 0

(5.10) H_o: $\frac{\text{variance (NGD)}}{\text{variance (GD)}} = 1$

[4]Ronald E. Walpole, Introduction to Statistics, (New York: MacMillan Company, 1968), pp. 225 and 250.

where GD and NGD represent the grain-dependent and nongrain-dependent subsets respectively of the full sample of 590 observations. Table XIV contains the means and variances by rail line status within province, along with their appropriate calculated t and F-statistics. Sample sizes are given in Appendix D. As the data in Table XIV indicate only the

TABLE XIV

MEANS, VARIANCES AND CALCULATED t AND F-STATISTICS ON HANDLING PRICE DIFFERENCES BETWEEN GRAIN AND NONGRAIN-DEPENDENT SAMPLES BY PROVINCE

	MANITOBA	SASKATCHEWAN	ALBERTA	PRAIRIES
MEAN:				
- Grain-Dependent	1.90	1.96	1.31	1.62
- Nongrain-dependent	1.95	1.47	1.49	1.82
- t-statistics	0.01	-0.05	0.004	0.01
VARIANCES:				
- Grain-dependent	0.53593	1.69783	0.88755	1.25656
- Nongrain-dependent	0.59819	1.39253	1.58530	1.26670
- F-statistics	1.12	0.82	1.79*	1.01

*Significant at 5 percent.

difference in the variances of grain and nongrain-dependent sample handling prices in Alberta is statistically significant. Therefore, it would appear that there is little if any measurable difference between handling prices charged at elevators located on grain-dependent lines and prices charged at delivery points on other rail lines.

Profitability

As discussed in the previous chapter, a structural test was used to assess whether the appropriate long and short run models were the same: LRCII against LRCIII and SRCII against SRCIII. Appendix C describes the test procedures and results. It is identical to the test described above comparing the constrained with the unconstrained models. Moreover, it is analogous in some respects to the test for structural change in linear regression models. The null hypothesis for both the long and short run models was that the pooled models were not statistically different from the results obtained by estimating the identical models on the grain and nongrain-dependent subsamples respectively. The test thus involves a comparison of the minimized generalized sum of squares from the full unrestricted model with the corresponding sum of squares from the pooled models. The price constraint was retained in both models. The unrestricted model combines the grain and nongrain-dependent models into one model but allows for separate parameter estimates on the independent variables in each sub-model. The pooled model forces the parameter estimates for each independent variable to be the same in both subsamples. The results of these hypothesis tests are summarized in Table XV.

These results indicate that the null hypothesis can be rejected at neither the 5 percent nor the 1 percent level of significance so that one can conclude that models SRCII and LRCII are not significantly different from models SRCIII and LRCIII respectively. This implies that there is

TABLE XV

SIGNIFICANCE TESTS ON THE RELATIVE PROFITABILITY OF GRAIN AND NONGRAIN-DEPENDENT ELEVATORS

MODEL	UNRESTRICTED SS	POOLED SS	DIFFERENCE	D.F.	CHI-SQUARE VALUES	
					5%	1%
LONG RUN	4692.16	4671.07	21.09	21	32.67	38.932
SHORT RUN	4096.58	4112.11	15.53	16	26.30	32.00

SOURCE: Appendix C.

no difference in the profitability of elevators located on grain-dependent branchlines compared with those located on other rail lines. Combined with the results of the previous section, it would appear that there is very little evidence of any price discrimination in the primary elevator component of the GHTS that systematically favours producers who deliver to either branch or mainline elevators.

CHAPTER VI

CONCLUSIONS AND POLICY IMPLICATIONS

It is widely acknowledged that the costs associated with the grain handling and transportation system (GHTS) on the Prairies exceed those which would be incurred under a more consolidated system. The core of the problem is the retention of the extensive branchline network. Many of these lines have been upgraded at public expense and all but a very few have been protected against abandonment until the year 2,000. The pricing practices in both the rail and elevator components of the GHTS may, however, prevent a 'de facto' abandonment of the higher cost lines. There is clearly an element of price discrimination in the statutory freight rates in that the rate structure simply averages total grain rail costs across delivery points. Producers located the same distance from export position will pay the same freight rate, even though some may be patronizing delivery points located on branchlines while others deliver to lower cost mainline points. There is little, if any, financial incentive on the rail side to induce farmers to change their delivery patterns as a result.

It is worth noting that a reduction in the size of the grain-dependent branchline network would affect not only rail and elevator costs but would increase trucking costs to producers whose delivery points would be affected and, perhaps, provincial expenditures on road/highway maintenance. While this point is recognized, no attempt is made in this study to determine an optimal GHTS and who might gain or lose from it; rather, the focus is on whether primary elevator pricing is neutral with respect to the efficiency of the system.

The general purpose of this thesis was to determine if pricing at primary elevators tends to reinforce or offset the inefficiency found on the rail side of the GHTS. That is, GHTS inefficiency will depend, at least in part, on whether elevator price discrimination favours branchline delivery points. The grain companies nominally charge the same handling and storage rates, as tariffs filed with the Grain Commission reveal, at nearly all delivery points within each province. If branchline elevators were, on average, less profitable than those located on mainlines, then this would constitute evidence of price discrimination favouring producers who deliver to branchline elevators. Moreover, this would increase the inefficiency found in the rail component of the GHTS.

The specific objectives of this thesis were to: (1) determine whether the pricing of branchline grain handling services is neutral with respect to the issue of GHTS efficiency (2) determine whether effective grain handling prices are the same for producers who deliver to mainline elevators as for those who utilize branchline points (3) assess the relative profitability of branch versus mainline elevators (4) draw conclusions about the magnitude, direction and policy implications of elevator price discrimination and its impact on GHTS efficiency. The following two sections summarize the results and conclusions from the empirical analysis as well as drawing some potential policy implications resulting from the analysis. The final section discusses the limitations of the study and contains suggestions for further research.

CONCLUSIONS

Price discrimination occurs when the price of a good or service, relative to its cost, is higher for one or more buyers than it is for others. It can, under some circumstances, lead to a more efficient pattern of production and distribution, increasing total consumer welfare. In the case of the western grain handling and transport system, the lack of appropriate price signals concerning the costs of the services provided has led to a less than optimal use of resources.

There seems to be an obvious pattern of discrimination in primary elevator pricing based on primary elevator tariffs filed with the Grain Commission; however, its influence on resource use and inefficiency in the GHTS will depend on whether this pattern systematically favours producers who deliver either to branch or mainline delivery points. This problem was investigated as part of the overall profit structure analysis by embedding both the estimated actual handling price of grain at each elevator and the weighted average filed tariff price in the analysis. The filed tariff price represents a benchmark against which the actual price could be measured to determine whether it differs statistically from the filed rates. Some further statistical tests were then conducted to assess whether the level and dispersion of prices differed between elevators located on grain-dependent branchlines and those located on nongrain-dependent lines.

The core of the empirical work is contained in the parameter estimates and associated statistics of the six basic models, comprising three long run and three short run profit functions and corresponding output supply and input demand equations. The models all produced reasonable estimates with the exception of the slope of the labour input demand function, a result which may be due only to normalizing the data. As expected, normalized profits increased with the normalized handling price. The level of profits was approximately equal up to a price of $2 per tonne for the three long run models based on the sample of pooled observations and the two subsamples comprising observations located on grain-dependent branchlines and those located on other rail lines. Above a price of $2, however, the profitability of branchline elevators, as a group, seems to decrease relative to elevators on nongrain-dependent lines. This result is due to the fact that estimated profits are increasing at a constant rate in the grain-dependent model but are increasing at an increasing rate in the other two models. The short run models, on the other hand, display somewhat different profit-price relationships. Estimated profits for the grain-dependent model dominate for prices up to nearly $6 per tonne, thereafter falling below the level of profits generated by the mainline model. This price, however, lies about three standard deviations away from the mean price of $1.72 so that it would appear that for most elevators, short run profits are higher for branch relative to mainline delivery points.

One possible explanation for the difference in results between the long and short run model comparisons is the exclusion of residual costs from the latter models. This might suggest that many branchline elevators are relatively less financially viable in the longer term, a result which is not inconsistent with the on-going consolidation of the primary elevator network on the Prairies. In addition, the short run models include a size variable in the form of total elevator capacity. This effectively removes the influence of capacity on profits so that the estimated relationships pertain to an average elevator size. Mean residual costs are $3,627 less, or about 6% lower, for elevators located on grain-dependent lines so that it is not surprising that short run profits are higher for this group as a result. The short run model comparisons are reasonably consistent, then, with the long run results in that the rate of change in profits with respect to price is higher for mainline relative to branchline elevators.

The statistical tests performed on the model results indicate that realized average handling prices differ from the filed tariffs, although there is no evidence that the differences are greater or lesser for grain versus the nongrain-dependent elevators. Moreover, there is no evidence that both the long and short run grain-dependent models are statistically different from the corresponding mainline models. The dummy variable for rail line status was insignificant in both the long and short run pooled sample models. Furthermore, the test for structural differences between the pooled and subsample models indicates that combining the subsamples in both the long and short run cases is statistically appropriate.

The pricing and relative profitability analyses taken together suggest that there is no systematic pattern of price discrimination favouring producers utilizing either branch or mainline delivery points. This result holds for both the long and short run analyses. Therefore, one can conclude that primary elevator pricing on the Prairies is neutral with respect to the problem of efficiency in the western grain handling and transport system.

POLICY IMPLICATIONS

The policy implications of any research are always normative, being dependent on the underlying objective function. The implications for grain transportation policy will differ, for example, depending on whether the objective is either to minimize the total costs of moving grain from farmgate to export position or to minimize costs subject to an income distribution constraint. It is clear from the recent history of Prairie grain transport policy that cost minimization alone has not been the major policy objective, that concerns over both the level and distribution of producer incomes has played an important role as well.

Notwithstanding this, there are three reasons for focusing on the goal of minimizing total GHTS costs. First, it provides a yardstick against which to measure the additional costs associated with income distribution constraints. Second, the pressure of events over time may change the relative importance that are attached to individual goals. During the 1960's and 1970's, for example, successive governments seemed to view grain transportation policy as one of maintaining a viable grain-gathering system without changing the Crow rate. Subsequent financial pressures on the railways, amongst other factors, ultimately necessitated replacing the Crow rate with a rate-setting mechanism so that producers would share in future grain rail cost increases. Third, the possibility exists for minimizing GHTS costs while paying compensation in a way that meets income distribution targets but without the corresponding resource misallocation effects that have been prevalent in the GHTS.

There are, therefore, solid grounds for looking at the problem of minimizing GHTS costs by itself. Reducing inefficiency on the rail side likely means a reduction in the size of the grain-dependent branchline network, implying both a decrease in the number of branchline delivery points and a concomitant increase in the proportion of grain moving through mainline delivery points. The results of this study indicate that the handling prices and profitability of branch versus mainline primary elevators are statistically the same. That is, elevator pricing corresponding to the existing grain rail network is, in itself, neutral with respect to total GHTS inefficiency.

It is worth noting that the tariffs filed with the Grain Commission were used as a benchmark to help in measuring whether price discrimination was related to rail line status. The conclusion that effective handling rates can vary from the filed tariffs says very little about the efficiency of Commission regulation of elevator pricing. Moreover, it says nothing at all about an optimal level of tariff regulation. The evidence does point to a lack of transparency in effective handling rates in that grain companies obviously have better information about the potential for grade/weight gains. Competition for market share, however, likely results in these savings being passed down to producers so that, on balance, there does not seem to be a policy problem in this regard.

What the pricing and profitability analysis does suggest is that cost-based elevator handling rates would not help to speed up the consolidation of the elevator network, even if these were combined with cost-based freight rates.

LIMITATIONS OF THE STUDY

A general caveat of most empirical studies is the reliability of the data. The cost and revenue data used in this study comes primarily from accounting records of three grain companies. Additional data, most of which was submitted by these companies, came from various government agencies. How robust the estimates are, and the conclusions drawn from them, depends in part on the accuracy of the data in at least two ways. First, it is assumed that the data was recorded without errors. In editing the database and in some cases going back to the companies' primary files, there was no evidence of any large or even small scale transcription problem. Second, it is crucial that the revenue and cost categories actually measure what they suggest. There may in fact be a problem with allocated data, although the affected categories were adjusted with additional company data for the obvious cases.

A more important criticism of the data is that it comes from only one accounting period during the early 1980's. There is no evidence that this period was unusual in terms of production, handling and exports since then; however, the elevator network has continued to consolidate since the period to which the data pertains. This, of course, tends to weaken the conclusions and policy implications based on the empirical estimates.

The difference between the long and short run models is in the exclusion of residual costs from the latter. The aggregating of these costs is due to data limitations relating to the specification of physical quantities which could be used to derive separate input prices for the individual residual cost categories. Nonetheless, such a procedure is arbitrary and may affect the reliability of the short run model estimates.

Finally, the quadratic function was used in the modelling exercise. It has certain advantages over other flexible functional forms but it also constrains the estimated output supply and input demand functions to be linear. This makes the parameter estimates for these equations, especially the output supply function, less interesting than they might otherwise have been.

SUGGESTIONS FOR FURTHER RESEARCH

One very obvious direction in which this study could be extended is to incorporate capacity utilization into the analysis as a first step in analyzing whether a more consolidated elevator system might be more efficient overall than the existing network for the time period to which this study pertains. While branchline versus mainline elevator pricing might be neutral with respect to system efficiency, this does not imply that the existing number of elevators/operating units is optimal. Second, the study should be repeated with more up-to-date data from a larger number of companies in order to ensure that the results of the analysis still pertain.

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APPENDIX A

THE CONSTRAINED MULTIPLE OUTPUT INDIRECT PROFIT FUNCTION MODEL[1]

Let $F(Y_i, X_j) = 0$ be a standard neoclassical transformation function for grain-handling services where Y_i represents n outputs and X_j represents m inputs in grain handling. The long run is assumed so that all inputs are variable. The corresponding output and input prices are P_i and r_j respectively with Z_i representing the n output price constraints. The Lagrange profit maximization function is:

$$(A.1)\ L = \Sigma P_i Y_i - \Sigma r_j X_j + uF(Y_i, X_j) - w[\Sigma Z_i Y_i - \Sigma r_j X_j + uF(Y_i, X_j)]$$

where u and w are the Lagrange multipliers. The first order conditions are then:

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[1]This model is an extension of the one developed by Cowing. Cf. Cowing, Thomas G. "The Effectiveness of Rate-of-Return Regulation: An Empirical Test Using Profit Functions", in M. Fuss and D. McFadden, Production Economics: A Dual Approach to Theory and Applications, Vol. II (Amsterdam: North-Holland Publishing Co., 1978), Chapter IV. 5.

(A.2) $P_i = wZ_i - (1-w)\, u \frac{\partial F}{\partial Y_i}$

(A.3) $r_j = u \frac{\partial F}{\partial X_j}$

(A.4) $F(Y_i, X_j) = 0$

(A.5) $\sum Z_i Y_i - \sum r_j X_j + uF\,(Y_i, X_j) = 0$

Equations (A.2)-(A.5) can be solved simultaneously to obtain the long run profit-maximizing output supply and factor demand schedules, denoted by lower-case letters i and j respectively, as well as the profit-maximizing values for the Lagrange multipliers, denoted as u*, w*[2]:

(A.6) $Y_i{*} = Y_i{*}(P_i, r_j, Z_i)$ for i = 1, ..., n; j = 1, ..., m

(A.7) $X_j{*} = X_j{*}(P_i, r_j, Z_i)$ for i = 1, ..., n; j = 1, ..., m

(A.8) $w{*} = w{*}(P_i, r_j, Z_i)$ for i = 1, ..., n; j = 1, ..., m

(A.9) $u{*} = u{*}(P_i, r_j, Z_i)$ for i = 1, ..., n; j = 1, ..., m

Substituting equations (A-6)-(A-9) into (A-1), and dropping the (*) superscript because all values are assumed to be optimal, gives the constrained indirect profit function:

(A.10) $L = \Pi(P_i, r_j, Z_i)$

$$= \sum P_i Y_i - \sum r_j X_j + uF(Y_i X_j) - w[\sum Z_i Y_i - \sum r_j X_j + uF(Y_i, X_j)]$$

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[2]The Lagrange multiplier u has no ready economic interpretation. J.R. Beattie and C.R. Taylor, The Economics of Production, (New York: John Wiley, 1985), pp. 208.

where the last two expressions are both zero by the first-order conditions (A.2)-(A.5) when evaluated at optimal values.

An important feature of the indirect profit function that makes it so useful for econometric work is that, by Hotelling's Lemma, the input demand and output supply functions can be derived by taking the partial derivatives of the profit function with respect to input and output prices respectively. For the unconstrained case, these are:[3]

(A.11) $$\frac{\partial \Pi}{\partial r_k} = -X_k(P_i, r_j) \text{ and } \frac{\partial \Pi}{\partial P_k} = Y_k(P_i, r_j)$$

The revised version of Hotelling's Lemma for the constrained case can be derived by taking the partial derivatives of equation (A.10) with respect to r_j, P_i, Z_i:

(A.12) $$\frac{\partial \Pi}{\partial r_k} = \Sigma P_i \frac{\partial Y_i}{\partial r_k} - X_k - \Sigma r_j \frac{\partial X_j}{\partial r_k} + \frac{\partial u}{\partial r_k}[F(Y_i, X_j)] + u\left(\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} + \Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k}\right)$$
$$- \frac{\partial w}{\partial r_k}[\Sigma Z_i Y_i - \Sigma r_j X_j + uF(Y_i, X_j)] + wX_k - w\,\Sigma Z_i \frac{\partial Y_i}{\partial r_k} + w\,\Sigma r_j \frac{\partial X_j}{\partial r_k}$$
$$- w\frac{\partial u}{\partial r_k}[F(Y_i, X_j)] - wu\left(\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} + \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k}\right)$$

where the expressions in square brackets equal zero by the first-order conditions (A.4) and (A.5). Substituting the other two first-order

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[3]H.R. Varian, Microeconomic Analysis, 2nd ed. (New York: W.W. Norton, 1984), pp. 52.

conditions, equations (A.2) and (A.3), for P_i and r_j and rearranging terms gives:

$$(A.13)\quad \frac{\partial \Pi}{\partial r_k} = -(1-w)X_k - u(1-w)\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} - u(\Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k} - w\,\Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k})$$

$$+ u[\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} + \Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k}] - wu[\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} + \Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k}]$$

The terms in square brackets in (A-13) can be shown to be zero by substituting the optimal values Y_i, X_j into the transformation function and differentiating it with respect to r_k:

$$(A.14)\quad F[Y_i(P_i,r_j,Z_i),X_j(P_i,r_j,Z_i)] = 0$$

$$(A.15)\quad \Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} + \Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k} = 0$$

Rearranging terms in (A.13) in order to make further use of (A.15) gives:

$$(A.16)\quad \frac{\partial \Pi}{\partial r_k} = -(1-w)X_k - u(1-w)\,\Sigma \frac{\partial F}{\partial Y_i}\frac{\partial Y_i}{\partial r_k} - u[\Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k} - w\,\Sigma \frac{\partial F}{\partial X_j}\frac{\partial X_j}{\partial r_k})$$

$$= -(1-w)X_k$$

so that:

$$(A.17)\quad \frac{\partial \Pi}{\partial r_k} = -(1-w)X_k(P_i,r_j,Z_i) \text{ for } k = 1,\ldots,m$$

By an identical process, it can be shown that:

(A.18) $\frac{\partial \Pi}{\partial P_t} = Y_t(P_i, r_j, Z_i)$ for $t = 1, \ldots, n$

and

(A.19) $\frac{\partial \Pi}{\partial Z_h} = wY_h(P_i, r_j, Z_i)$ for $h = 1, \ldots, n$

Denoting $\partial \Pi/\partial r_k$, $\partial \Pi/\partial P_t$, and $\partial \Pi/\partial Z_h$ as Π_k^r, Π_t^P and Π_h^z respectively, (17)-(19) comrpise 2n + m equations and can be rewritten as:

(A.20) $\Pi_k^r = -(1 - w)X_k$ for $k = 1, \ldots, m;$

(A.21) $\Pi_t^P = Y_t$ for $t = 1, \ldots, n;$

(A.22) $\Pi_h^Z = -wY_h$ for $h = 1, \ldots, n;$

Equations (A.20) - (A.22) can be used to eliminate w which is an unobserved variable. From (A.21) and (A.22):

(A.22) $$-w = \frac{\Pi_1^Z}{\Pi_1^P} = \ldots = \frac{\Pi_n^Z}{\Pi_n^P}$$

Substituting any one of these ratios, say Π_1^Z/Π_1^P, for w in equation (A.20), together with (A.10), gives the following system of equations:

(A.23) $\Pi = \Pi(P_i, r_j, Z_i)$

(A.22) $-X_j = \dfrac{\Pi_1^P * \Pi_j^r}{\Pi_1^P + \Pi_1^Z}$ $\quad j = 1, \ldots, m$

(A.24) $Y_i = \Pi_i^P$ $\quad i = 1, \ldots, n$

APPENDIX B

ESTIMATION OF KILOWATT-HOURS

Manitoba

Manitoba Hydro has a three-part tariff for commercial electricity users. For calendar years 1982 and 1983, these rates were:

1982: \$8.35 per month + 4.7¢ per kwhr up to 1,200 kwhrs per month
\$8.35 per month + 2.97¢ per kwhr for the next 10,500 kwhrs per month
\$8.35 per month + 1.12¢ per kwhr per month on the balance

1983: \$9.15 per month + 5.14¢ per kwhr up to 1,200 kwhrs per month
\$9.15 per month + 3.25¢ per kwhr for the next 10,500 kwhrs per month
\$9.15 per month + 1.23¢ per kwhr per month on the balance

For electrical consumption less than 11,701 kwhrs, 1982-83 crop year power costs P were calculated as:

kwhrs 1,201: P = 5[8.35 + 1,200*4.7¢] + 7[9.15 + 1,200 *5.14]
= $819.56

kwhrs 11,701: P = 819.56 + 5(10,500*2.97¢) + 7(10,500*3.25¢)
= $4,767.56

Total 1983-83 electrical consumption at each elevator/operating unit located in Manitoba were based on the following equations:

1. If power costs P_1 at each elevator < $820, then:

$$\text{kwhrs} = \frac{P_1 - 5 * 8.35 - 7 * 9.15}{[5 * 4.7¢ + 7 * 5.14¢]/12} = \frac{P_1 - 105.8}{4.96¢}$$

2. If $\$819 < P_1 < \$4,768$, then:

$$\text{kwhrs} = \frac{P_1 - 105.8}{4.96¢} + \frac{P_1 - 820}{[5 * 2.97¢ + 7 * 3.25¢]/12}$$

$$= 52.11P_1 - 28,331$$

3. If $P_1 > \$4,767$, then

$$\text{kwhrs} = 52.11P_1 - 28,3331 + \frac{P_1 - 4,767}{[5 * 1.12¢ + 7 * 1.23¢]/12}$$

$$= 106.4P_1 - 287,126$$

Similar calculations for 1983 calendar to estimate kwhrs at each Manitoba elevator belonging to the company that operated on a calendar year accounting basis.

Saskatchewan

Saskatchewan Power Corporation uses a two-part tariff for commercial electrical users. Their rates were unchanged between February 1, 1982 and December 31, 1983. The rates charged were:

6.75¢ per kwhr up to 6,000 kwhrs

3.04¢ per kwhr on the balance

If elevator power costs P_1 were < 6,000*6.74¢ = $405, then:

$$\text{kwhrs} = \frac{P_1}{6.75¢}$$

If elevator power costs P_1 > $405, then

$$\text{kwhrs} = \frac{P_1}{6.75¢} + \frac{P_1 - 450}{3.04¢}$$

$$= 47.71P_1 - 13{,}323$$

Alberta

Trans Alberta Utilities uses a multi-part tariff comprising both a demand and an energy charge. It was not possible to estimate elevator electrical consumption from their tariffs. Estimated kwhrs at each

Manitoba and Saskatchewan elevator was regressed on elevator power costs to obtain the following equation on which the Alberta estimates were based:

$$\text{kwhrs} = -\ 21152.2 + 50.47_{*}P_1 \qquad \bar{R}^2 = 0.98$$
$$(-27.14) \quad (154.03)$$

where the t-statistics are given in brackets below the coefficient estimates.

APPENDIX C

TEST FOR STRUCTURAL DIFFERENCES BETWEEN GRAIN-DEPENDENT AND NONGRAIN-DEPENDENT MODELS

The Chow[1] test is used for testing the equality of coefficients in two single equation linear regression models estimated on two different samples. It involves testing one model whereby the two samples have been pooled and only one set of coefficients need be estimated. As such, it is a particular case of the more general test that the parameter vector b is subject to a set of restrictions given with the null hypothesis:

(C.1) H_o:Rb = r

If H_o is rejected then the linear restrictions implied by C.1 do not apply and hence pooling the two samples is inappropriate. Put another way, the two models are statistically different if H_o is rejected.

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[1]G.C. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," Econometrica, Vol. 28 (1960), pp. 591-605.

The pooled or restricted model is nested within the two models and is derived by parametric constraints. As Gallant and Jorgenson[2] have demonstrated, parametric restrictions in a nonlinear system of equations can be tested in an analogous fashion using the difference in the generalized minimized sum of squares for the complete and restricted system, each multiplied by the respective number of observations. Their test statistic is distributed asymptotically as a Chi-square[3].

Table CI to CVIII give the parameter estimates for the four long run models, labelled LRCI, IA, II, III and the corresponding short run models, labelled SRCI, IA, II, III. The models LRCII and LRCIII represent the grain and nongrain-dependent long run models with SRCII and SRCIII the short run equivalents. Models LRCIA and SRCIA, estimated on the combined grain and nongrain-dependent samples respectively, differ from the models discussed in Chapter VI in that they explicitly incorporate both the grain and nongrain-dependent models but with different parameters for each independent variable corresponding to the two subsamples. The pooled models restrict the parameter estimates to be the same on each subsample. Hence, the pooled models are nested within the unrestricted models.

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[2]A.R. Gallant and D.W. Jorgenson, "Statistical Inference for a System of Simultaneous, Non-Linear, Implicit Equations in the Context of Instrumental Variable Estimation", Journal of Econometrics, Vol. II (1979), pp. 275-302.

[3]Ibid., pp. 279.

Let the equations C.2 and C.3 represent the grain and nongrain-dependent models respectively:

$$(C.2)\ Y_1 = F[X,A] + E_1$$

$$(C.3)\ Y_2 = F[X,C] + E_2$$

The unrestricted constrained model, written in vector form, becomes:

$$(C.4)\ Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} F(X,A) \\ F(X,B) \end{bmatrix} + \begin{bmatrix} E_1 \\ E_2 \end{bmatrix}$$

The pooled model, however, restricts the parameters on F_1 and F_2 to be equal so that the restricted constrained model can be represented as:

$$(C.5) \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} F(X,D) \\ F(X_1D) \end{bmatrix} + \begin{bmatrix} E_3 \\ E_3 \end{bmatrix}$$

or:

$$(C.6)\ Y = F(X,D) + E_3$$

Tables CII and CVI give the parameter estimates for the long and short run unrestricted constrained models LRCIA and SRCIA respectively. The a- parameter estimates correspond to observations on grain-dependent elevators whereas the c- parameter estimtes correspond to observations on nongrain-dependent elevators. Because a multicollinearity problem arose by including a separate intercept term c_o, a dummy variable for grain-dependent observations was used in each model.

The generalized minimized sum of squares multiplied by the appropriate sample size is labelled OBJECTIVE*N and is given at the bottom of each table. The covariance matrix from the unrestricted but constrained models LRCIA and SRCIA were used to estimate the corresponding sum of squares in the pooled models respectively. The difference in the restricted and unrestricted OBJECTIVE*N can be compared with the theoretical Chi-square values at the appropriate degrees of freedom to conclude that the models are statistically the same at both the 5 and 1 percent levels of statistical significance.[4] These results indicate that the pooled models LRCI and SRCI are statistically the same as the long and short run grain and nongrain-dependent models estimated separately. All other things being equal, this does tend to indicate that the profitability of branch versus mainline elevators is the same.

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[4]For an example of this method of testing for structural change in a nonlinear system of equations, cf. Christopher J. Nichol, "Estimation of Higher-Order Flexible Functional Form Demand Systems with Canadian Data", (Ph.D. Thesis, Queen's University, 1986).

TABLE CI

LONG RUN CONSTRAINED MODEL I ESTIMATES: POOLED ELEVATOR SAMPLE

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
a_0	8477.14	6.48
a_1	177.52	0.97
a_2	- 1.62	- 5.72
a_3	1.59	5.60
a_4	- 1593.61	- 1.21
a_5	- 280.75	- 8.49
a_{11}	619.11	3.87
a_{12}	- 1.00	- 26.03
a_{13}	0.79	21.18
a_{14}	- 15483.01	- 7.96
a_{15}	- 202.5	- 6.12
a_{22}	- 0.11	- 3.62
a_{23}	2.10 E-04	8.71
a_{24}	- 5.80	- 1.21
a_{25}	0.21	28.76
a_{33}	- 2.10 E-04	- 8.34
a_{34}	- 8.37	- 16.15
a_{35}	- 0.19	- 27.73
a_{44}	7439173.00	17.11
a_{45}	- 43.17	- 0.11
a_{55}	149.28	15.47
b_1 (NUM)	163.51	0.54
b_2 (J1)	1283.18	1.47
b_3 (J2)	979.39	1.21
b_4 (J3)	353.77	0.80

EQUATION	SSE	R^2
I	8.65 E + 10	0.209
II	3.21 E + 09	0.622
III	29.11438	0.682
IV	1.48 E + 11	0.552
V	102983561	0.619

N = 524 observations
OBJECTIVE = 4.95298
OBJECTIVE*N = 2595.36

UNCONSTRAINED MODEL: OBJECTIVE*N = 2601.23

TABLE CII

LONG RUN UNRESTRICTED CONSTRAINED MODEL IA ESTIMATES

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
a_o	5314.02	3.51
a_1	89.77	0.94
a_2	- 0.55	- 1.91
a_3	0.54	1.87
a_4	- 530.76	- 0.79
a_5	- 78.73	- 4.11
a_{11}	124.90	0.79
a_{12}	- 0.96	- 27.27
a_{13}	0.89	25.21
a_{14}	- 10512.96	- 5.78
a_{15}	- 167.68	- 5.24
a_{22}	- 0.18	- 6.03
a_{23}	6.63 E-05	2.51
a_{24}	- 12.16	- 2.77
a_{25}	0.27	35.48
a_{33}	- 6.69 E-05	- 2.66
a_{34}	- 10.24	- 20.07
a_{35}	- 0.25	- 35.94
a_{44}	7144874.00	16.18
a_{45}	604.82	1.68
a_{55}	169.11	16.81
c_1	- 153.90	- 1.70
c_2	- 3.09	- 8.99
c_3	3.10	8.99
c_4	62.42	0.10
c_5	- 42.06	- 2.76
c_{11}	647.82	3.25
c_{12}	- 1.13	- 28.60
c_{13}	0.91	21.07
c_{14}	- 15224.95	- 7.25
c_{15}	- 198.84	- 5.04
c_{22}	- 0.11	- 3.54
c_{23}	4.24 E-04	12.47
c_{24}	- 13.67	- 2.10
c_{25}	0.23	30.20
c_{33}	- 4.24 E-04	- 12.23
c_{34}	- 6.25	- 11.19
c_{35}	- 0.20	- 25.81
c_{44}	5381887.00	11.70
c_{45}	16.04	0.04
c_{55}	118.13	11.45

TABLE CII (continued)

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
b_1 (NUM-GD)*	- 480.27	- 1.12
b_2 (NUM-NGD)*	679.39	1.77
b_3 (J1)	1191.63	1.41
b_4 (J2)	291.09	0.37
b_5 (J3)	5829.82	3.16

EQUATION	SSE	R^2
I	8.66 E + 10	0.207
II	1.59 E + 09	0.762
III	1.53 E + 09	0.765
IV	13.59160	0.820
V	14.93813	0.813
VI	7.69 E + 10	0.722
VII	6.64 E + 10	0.639
VIII	64238860	0.779
IX	42811220	0.794

	UNRESTRICTED MODEL	RESTRICTED MODEL
N	524	524
OBJECTIVE	8.91425	8.95450
OBJECTIVE*N	4671.07	4692.16
PARAMETERS	46	25

*GD = Grain-dependent

*NGD = Nongrain-dependent

TABLE CIII

LONG RUN CONSTRAINED MODEL II ESTIMATES:

GRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_0	11738.12	7.06
a_1	388.35	1.60
a_2	- 0.70	- 1.98
a_3	0.65	1.84
a_4	- 2059.98	- 1.10
a_5	- 282.12	- 5.82
a_{11}	138.31	0.73
a_{12}	- 0.94	- 18.76
a_{13}	0.82	17.79
a_{14}	- 12101.51	- 4.61
a_{15}	- 138.13	- 3.37
a_{22}	- 0.14	- 3.41
a_{23}	8.00 E-05	2.75
a_{24}	- 8.32	- 1.46
a_{25}	0.24	22.58
a_{33}	- 8.00 E-05	- 2.76
a_{34}	- 10.15	- 14.53
a_{35}	- 0.22	- 24.49
a_{44}	7789007.00	13.33
a_{45}	385.73	0.77
a_{55}	162.82	12.14
b_1 (NUM)	- 254.33	- 0.61
b_2 (J1)	2074.57	1.91
b_3 (J2)	143.48	0.14

EQUATION	SSE	R^2
I	4.36 E + 10	0.108
II	1.56 E + 09	0.625
III	13.60717	0.669
IV	7.63 E + 10	0.617
V	60752350	0.614

N = 279 observations
OBJECTIVE = 4.91631
OBJECTIVE*N = 1371.65

UNCONSTRAINED MODEL: OBJECTIVE*N = 1377.34

TABLE CIV

LONG RUN CONSTRAINED MODEL III ESTIMATES:

NONGRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_0	1417.08	0.73
a_1	- 491.10	- 1.77
a_2	- 4.17	- 9.04
a_3	4.19	8.99
a_4	- 757.01	- 0.39
a_5	- 235.29	- 4.95
a_{11}	494.60	1.84
a_{12}	- 1.26	- 21.09
a_{13}	1.00	15.65
a_{14}	- 18210.18	- 5.95
a_{15}	- 200.85	- 3.62
a_{22}	- 0.08	- 1.72
a_{23}	4.98 E-04	12.42
a_{24}	0.58	0.07
a_{25}	0.21	19.90
a_{33}	- 5.09 E-05	- 12.20
a_{34}	- 6.86	- 8.93
a_{35}	- 0.19	- 16.38
a_{44}	6934041.00	11.95
a_{45}	- 209.38	- 0.34
a_{55}	138.31	9.74
b_1 (NUM)	391.08	1.02
b_2 (J1)	- 1949.27	- 1.56
b_3 (J2)	710.16	0.66

EQUATION	SSE	R^2
I	4.16 E + 10	0.310
II	1.52 E + 09	0.648
III	15.38897	0.693
IV	6.92 E + 10	0.463
V	42898941	0.611

N = 524
OBJECTIVE = 4.90541
OBJECTIVE*N = 1201.83

UNCONSTRAINED MODEL: OBJECTIVE*N = 1207.54

TABLE CV

SHORT RUN CONSTRAINED MODEL I ESTIMATES:

POOLED ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_o	10067.40	6.03
a_1	514.77	2.84
a_2	- 2.76	- 8.47
a_3	2.73	8.58
a_4	42.21	0.03
a_{11}	1267.45	11.07
a_{12}	- 0.64	- 18.48
a_{13}	0.31	9.02
a_{14}	- 27001.87	- 13.58
a_{22}	- 0.08	- 2.47
a_{23}	3.21 E-04	13.46
a_{24}	9.83	1.89
a_{33}	- 2.88 E-04	- 11.63
a_{34}	- 5.28	- 10.42
a_{44}	7535187.00	15.66
b_1 (NUM)	- 406.92	- 1.20
b_2 (TCAP)	1.62	8.95
b_3 (J1)	4350.30	4.47
b_4 (J2)	- 3034.21	- 3.39
b_5 (J3)	64.91	0.13

EQUATION	SSE	R^2
I	1.83 E + 11	0.401
II	3.94 E + 09	0.563
III	34.72164	0.680
IV	2.23 E + 11	0.500

N = 590
OBJECTIVE = 3.9667
OBJECTIVE*N = 2340.35

UNCONSTRAINED MODEL: OBJECTIVE*N = 2345.15

TABLE CVI

SHORT RUN UNRESTRICTED CONSTRAINED MODEL IA ESTIMATES

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
a_o	11722.84	6.19
a_1	62.61	0.67
a_2	- 2.76	- 7.54
a_3	2.75	7.51
a_4	771.93	0.96
a_{11}	1295.94	10.72
a_{12}	- 0.50	- 14.40
a_{13}	0.33	9.72
a_{14}	- 21616.61	- 10.56
a_{22}	- 0.23	- 7.46
a_{23}	3.08 E-04	9.98
a_{24}	- 0.99	- 0.21
a_{33}	- 2.68 E-04	- 8.57
a_{34}	- 6.23	- 11.76
a_{44}	6693077.00	13.01
C_1	- 25.19	- 0.29
C_2	- 3.92	- 9.61
C_3	3.92	9.60
C_4	- 145.64	- 0.27
C_{11}	1906.41	14.53
C_{12}	- 0.59	- 15.00
C_{13}	0.24	6.16
C_{14}	- 25275.93	- 14.84
C_{22}	- 7.71 E-03	- 0.23
C_{23}	4.12 E-04	11.23
C_{24}	- 26.29	- 3.48
C_{33}	- 3.64 E-04	- 9.80
C_{34}	- 2.07	- 4.64
C_{44}	4695994.00	10.02

TABLE CVI (continued)

COEFFICIENT	PARAMETER ESTIMATES	t- STATISTICS
b_1 (NUM-GD)*	- 770.57	- 1.36
b_2 (NUM-NGD)*	396.72	0.80
b_3 (J1)	6404.72	5.76
b_4 (J2)	- 3763.10	- 3.64
b_5 (J3)	3213.16	1.37

EQUATION	SSE	R^2
I	1.91 E + 11	0.375
II	1.94 E + 09	0.730
III	1.79 E + 09	0.743
IV	13.86115	0.844
V	17.71245	0.815
VI	1.35 E + 11	0.662
VII	7.05 E + 10	0.673

	UNRESTRICTED MODEL	RESTRICTED MODEL
N	590	590
OBJECTIVE	6.94336	6.96968
OBJECTIVE*N	4096.58	4112.11
PARAMETERS	34	16

*GD = Grain-dependent

*NGD = Nongrain-dependent

TABLE CVII

SHORT RUN CONSTRAINED MODEL II ESTIMATES:

GRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_o	11923.74	5.62
a_1	613.09	2.51
a_2	- 2.56	- 6.68
a_3	2.51	6.47
a_4	2064.84	0.92
a_{11}	971.64	6.87
a_{12}	- 0.64	- 14.97
a_{13}	0.36	8.39
a_{14}	- 26735.75	- 9.09
a_{22}	- 0.07	- 1.87
a_{23}	3.02 E-04	10.97
a_{24}	11.12	1.91
a_{33}	- 2.78 E-04	- 9.67
a_{34}	- 7.12	- 9.91
a_{44}	8616078.00	13.28
b_1 (NUM)	- 932.62	- 2.12
b_2 (TCAP)	1.54	7.38
b_3 (J1)	2859.92	2.53
b_4 (J2)	- 3866.00	- 3.58

EQUATION	SSE	R^2
I	9.65 E + 10	0.365
II	2.01 E + 09	0.552
III	16.01883	0.671
IV	1.39 E + 11	0.529

N = 318
OBJECTIVE = 3.94253
OBJECTIVE*N = 1253.72

UNCONSTRAINED MODEL: OBJECTIVE*N = 1258.27

TABLE CVIII

SHORT RUN CONSTRAINED MODEL III ESTIMATES:

NONGRAIN-DEPENDENT ELEVATOR SAMPLE

COEFFICIENT	ESTIMATES	t- STATISTICS
a_0	7071.28	2.76
a_1	240.39	0.90
a_2	- 3.62	- 6.98
a_3	3.62	6.93
a_4	- 2643.53	- 1.45
a_{11}	1668.22	9.16
a_{12}	- 0.70	- 12.60
a_{13}	0.27	4.92
a_{14}	- 30820.33	- 12.13
a_{22}	- 3.01 E-04	- 0.06
a_{23}	3.89 E-04	9.48
a_{24}	3.69	0.36
a_{33}	- 3.51 E-04	- 8.27
a_{34}	- 2.81	- 4.19
a_{44}	7038360.00	11.11
b_1 (NUM)	- 14.84	- 0.03
b_2 (TCAP)	1.56	5.09
b_3 (J1)	4865.50	2.98
b_4 (J2)	- 2612.73	- 1.84

EQUATION	SSE	R^2
I	8.54 E + 10	0.446
II	1.85 E + 09	0.592
III	18.91935	0.682
IV	7.73 E + 10	0.471

N = 272
OBJECTIVE = 3.93205
OBJECTIVE*N = 1069.52

UNCONSTRAINED MODEL: OBJECTIVE*N = 1074.22

APPENDIX D

SAMPLE CHARACTERISTICS

TABLE DI

LONG RUN MODELS BY PROVINCE AND STATUS OF RAIL LINE

	MANITOBA		SASKATCHEWAN		ALBERTA	
	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER
Total Revenues($)						
- Mean	213,636	217,858	167,366	184,511	166,435	168,378
- Standard Dev.	75,038	84,383	83,073	99,458	77,815	79,398
- Coef. of Var.	35.12	38.73	49.64	53.90	46.75	47.15
Total Costs($)						
- Mean	125,745	123,867	100,026	102,424	99,303	105,193
- Standard Dev.	44,113	41,541	37,782	41,603	38,658	41,448
- Coef. of Var.	35.08	33.54	37.77	40.62	38.93	39.43
Profits($)						
- Mean	87,891	93,990	67,340	82,086	67,132	63,186
- Standard Dev.	42,708	56,539	54,256	66,069	44,672	44,464
- Coef. of Var.	48.59	60.15	80.57	80.49	66.54	70.37
Volume						
- Mean	18,222	18,760	15,595	16,471	13,657	13,876
- Standard Dev.	7,067	6,953	7,166	7,990	7,054	6,423
- Coef. of Var.	38.78	37.06	45.95	48.51	51.65	46.29
Handling Price ($)						
- Mean	7.81	7.48	6.17	5.69	6.28	6.38
- Standard Dev.	1.58	1.49	1.21	1.03	1.20	1.13
- Coef. of Var.	20.25	19.96	19.65	18.17	19.06	17.66
Filed Handling Price ($)						
- Mean	7.74	7.14	6.87	6.02	7.06	7.05
- Standard Dev.	3.14	1.39	3.96	1.31	2.36	2.58
- Coef. of Var.	40.63	19.45	57.59	21.83	33.43	36.57

	MANITOBA		SASKATCHEWAN		ALBERTA	
	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER
Storage Price($)						
- Mean	4.73	4.63	4.95	5.98	6.88	6.49
- Standard Dev.	2.21	2.54	2.71	2.68	2.88	2.78
- Coef. of Var.	46.79	54.86	54.69	44.77	41.87	42.76
Labour Price($)						
- Mean	21,411	21,076	20,210	20,073	19,567	19,864
- Standard Dev.	2,602	2,620	3,371	3,340	2,578	2,850
- Coef. of Var.	12.15	12.43	16.68	16.64	13.17	14.35
Power Prices($)						
- Mean	0.027	0.028	0.025	0.025	0.022	0.025
- Standard Dev.	0.004	0.004	0.002	0.003	0.002	0.002
- Coef. of Var.	14.60	14.24	9.94	10.35	9.20	8.20
Price of Other Inputs ($)						
- Mean	21.23	23.02	15.50	16.17	15.69	16.48
- Standard Dev.	7.47	6.85	5.16	6.63	5.22	4.96
- Coef. of Var.	35.19	29.75	33.30	40.99	33.29	30.11
Capacity (tonnes)						
- Mean	3,812	3,481	4,072	4,042	4,003	4,044
- Standard Dev.	1,295	1,197	1,583	1,484	1,461	1,480
- Coef. of Var.	33.98	34.37	38.87	36.72	36.50	36.59
Sample Size	87	81	137	88	55	76

TABLE DII

SHORT RUN MODELS BY PROVINCE AND STATUS OF RAIL LINE

	MANITOBA		SASKATCHEWAN		ALBERTA	
	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER
Total Revenues($)						
- Mean	209,072	217,357	149,537	174,937	152,444	150,882
- Standard Dev.	78,060	83,983	85,933	99,606	81,796	81,253
- Coef. of Var.	37.34	38.64	57.45	56.94	53.66	53.85
Total Costs($)						
- Mean	124,361	124,530	96,464	102,014	95,645	101,489
- Standard Dev.	44,566	41,,716	36,695	40,294	37,740	39,495
- Coef. of Var.	35.84	33.50	38.04	39.99	39.46	38.92
Profits($)						
- Mean	162,032	171,770	111,327	135,118	114,904	111,633
- Standard Dev.	67,828	75,186	77,672	89,795	71,090	71,842
- Coef. of Var.	41.86	43.77	69.77	66.46	61.87	64.36
Volume (tonnes)						
- Mean	17,935	18,783	14,267	15,907	12,721	12,705
- Standard Dev.	7,134	6,913	7,296	7,871	7,091	6,451
- Coef. of Var.	39.78	36.80	51.14	49.48	55.74	50.77
Handling Price ($)						
- Mean	7.71	7.46	6.09	5.70	6.25	6.29
- Standard Dev.	1.72	1.49	1.12	0.99	1.12	1.16
- Coef. of Var.	22.24	20.02	18.34	17.30	17.97	18.51
Filed Handling Price ($)						
- Mean	7.71	7.12	6.68	5.99	6.93	6.91
- Standard Dev.	3.09	1.39	3.63	1.25	2.23	2.36
- Coef. of Var.	40.15	19.46	54.34	20.93	32.17	34.21

	MANITOBA		SASKATCHEWAN		ALBERTA	
	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER	GRAIN-DEPEND.	OTHER
Storage Price($)						
- Mean	4.70	4.61	4.54	5.64	6.40	6.22
- Standard Dev.	2.19	2.53	2.69	2.77	3.00	3.06
- Coef. of Var.	46.53	54.85	59.21	49.18	46.81	49.16
Labour Price($)						
- Mean	21,464	21,204	20,812	20,584	19,890	19,959
- Standard Dev.	2,584	2,852	4,097	4,228	3,048	3,168
- Coef. of Var.	12.04	13.45	19.69	20.54	15.32	15.87
Power Prices($)						
- Mean	0.028	0.028	0.025	0.025	0.025	0.025
- Standard Dev.	0.004	0.004	0.003	0.003	0.002	0.003
- Coef. of Var.	15.21	14.38	10.01	10.29	8.92	11.47
Price of Other Inputs ($)						
- Mean	21.31	23.01	15.59	16.13	15.49	16.69
- Standard Dev.	7.58	6.81	5.40	6.85	5.20	5.45
- Coef. of Var.	35.59	29.58	34.64	42.49	33.54	32.66
Capacity (tonnes)						
- Mean	3,756	3,500	3,929	4,028	3,893	3,881
- Standard Dev.	1,312	1,200	1,544	1,435	1,445	1,456
- Coef. of Var.	34.92	34.29	39.30	35.64	37.12	37.52
Sample Size	90	82	165	97	63	93

TABLE DIII

CHARACTERISTICS OF THE ENTIRE LONG RUN SAMPLE

	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
REVENUES ($)			
- Handling	78,336	49,128	62.71
- Other	107,446	54,231	50.47
- Total	185,782	86,286	46.45
COSTS ($)			
- Labour	39,694	13,084	32.96
- Power	2,167	983	45.39
- Repair	8,358	7,286	87.18
- Insurance	4,215	2,164	51.35
- Rentals/Taxes	8,213	4,879	59.41
- Depreciation	7,435	8,734	117.48
- Administration & Miscellaneous	38,975	18,020	46.23
TOTAL	109,058	42,015	38.53
PROFITS ($)	76,724	53,862	70.20
VOLUME (tonnes)	16,215	7,341	45.28
BOARD GRAIN (tonnes)	15,188	6,728	44.30
CAPACITY (tonnes)	3,921	1,446	36.87
PERSON-YEARS	1.99	0.72	36.08
KILOWATT-HOURS	88,141	47,993	54.45

TABLE DIV

CHARACTERISTICS OF THE ENTIRE SHORT RUN SAMPLE

	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
REVENUES ($)			
- Handling	100,703	55,090	54.71
- Other	72,050	49,749	69.05
- Total	172,753	89,715	51.93
COSTS ($)			
- Labour	38,786	13,059	33.67
- Power	2,164	1,012	46.80
- Repair	8,333	7,619	91.44
- Insurance	4,066	2,164	53.23
- Rentals/Taxes	7,945	4,892	61.57
- Depreciation	7,326	9,367	127.87
- Administration & Miscellaneous	37,618	17,417	46.30
TOTAL	106,237	41,488	39.05
PROFITS ($)	131,804	79,879	60.61
VOLUME (tonnes)	15,313	7,474	48.81
BOARD GRAIN (tonnes)	14,362	6,846	47.67
CAPACITY (tonnes)	3,848	1,426	37.07
PERSON-YEARS	1.93	0.73	37.90
KILOWATT-HOURS	88,190	49,257	55.85