

THE UNIVERSITY OF MANITOBA

TRANSPORT SUBSIDIES AND REGIONAL DEVELOPMENT

by

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ABSTRACT

TRANSPORT SUBSIDIES AND REGIONAL DEVELOPMENT

by John Heads

Major Advisor: Dr. E. W. Tyrchniewicz

The objectives of this dissertation are:

- (i) To determine the extent to which allegations of regional economic disparities and freight rate inequities in the Atlantic Region and the Western Provinces of Canada are confirmed by the factual evidence;
- (ii) To examine the circumstances in which transport subsidies can be used to alleviate transport problems;
- (iii) To examine within a theoretical framework the effectiveness of freight rate subsidies, in comparison with non-transport subsidies, in achieving increased output from a firm located in a slow growth region.

The extent of economic disparities is described in respect of income, employment and economic growth. Specific allegations of rail freight rate inequities are documented, but it is concluded that a general reduction in rail freight rates towards closer conformity with variable costs would not necessarily benefit the Atlantic Region and the Western Provinces more than Central Canada.

The economic basis for transport subsidies is examined. Transport subsidies should generally be concentrated on those modes showing increasing returns to scale and this means that all modes should not necessarily receive equal subsidy treatment. Transport subsidies can also be used to offset the vestigial monopoly powers still enjoyed by carriers, but it is normally more efficient to offer such subsidies on a flat-rate basis rather than as percentage reductions to freight rates. Transport subsidies can also be used to secure non-transport public policy goals such as income redistribution and regional economic development.

A model is developed to examine the relative efficiency of transport subsidies in securing increased output from a firm located in a slow growth area, as against subsidy on output price or on a factor of production. This analytical frame can also include subsidy on other inputs such as raw material costs. The most efficient subsidy system is specified as that which minimizes net social cost, defined as subsidy payments by government minus the increased profit of the firm. However, government does not raise taxes without cost and it is also desirable to minimize the actual subsidy payments.

The model assumes perfect competition modified by the existence of transport charges, where any increase

in output must be shipped to more distant markets. The model is not constrained to constant returns to scale and data are assembled to allow as realistic calibration as possible. The geographical distribution of the firm's shipments are specified under two different assumptions, with the real world situation lying between these two alternatives.

Analysis and calibration of the model suggests that, on the criterion of minimizing net social cost, subsidy on transport charges and subsidy on output price are equally efficient, and less costly than subsidizing either the labour or the capital used by the firm. On the further criterion that the subsidy payments made by government should also be minimized, the subsidy on transport charges is the most efficient approach. If the subsidy scheme can be confined only to additional output, further substantial savings in government payments can be made.

The conclusions to this study are somewhat at variance with accepted wisdom which is skeptical of the role of transport in regional development. Yet, in spite of shortcomings, it is argued that the model is fairly robust when transport charges are the main hindrance to increasing a firm's output. Essentially, the transport subsidy meets only the costs necessary to overcome distance on each specific

unit of output, while the output price subsidy dissipates resources by paying the same rate of subsidy on product moving short distances as on product moving long distances. However, many regional development problems are not primarily attributable to transport difficulties and transport subsidies are, of course, no panacea.

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At risk of stating the obvious, the views expressed in this thesis do not necessarily coincide with the opinions of my previous employers, the Manitoba Department of Industry and Commerce, or my present employers, the Canadian Transport Commission. However, I would like to express my appreciation to the Hon. A. R. Paulley, Minister of Labour and formerly

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Finally, I dedicate the dissertation to my children and my wife. I appreciate the understanding shown by Jonathan and Melanie as father suffered from algebraic preoccupations during his years of study, while they were passing from childhood to adolescence. The contribution of my wife, Wendy, to this work has been enormous, ranging from textual criticism (with which my major advisor subsequently agreed) to earning the bulk of the family's finances for a year; moreover, to give me a true sense of proportion, she also completed a degree herself while I was studying!

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TRANSPORT SUBSIDIES AND REGIONAL DEVELOPMENT

CHAPTER I: INTRODUCTION

There is an apocryphal story of a Saskatchewan farmer watching his crops being destroyed by hail and raising his hands to the heavens to invoke "Goddamn the Canadian Pacific Railway!" This story catches the spirit of Western Canadian complaints over the years in respect of rail transport and the widely held western view that freight rate inequities are the prime hindrance to more rapid economic development in the West. This key role ascribed to the effect of freight rates on economic development is not exclusively a western phenomenon. For over one hundred years, it has been alleged that freight rates have been a major hindrance to the development of the Canadian Atlantic Provinces.

The present dissertation owes its origins to the concerns expressed in Western Canada and the Atlantic Region as to the effects of high freight rates on economic development and a tendency in some quarters to see freight rates not merely as one of a number of problem areas but rather as the embodiment of all factors inhibiting economic development. From these concerns, the study proceeds to consider the extent of general regional disparities and alleged freight rate inequities; the economic role of transport subsidies; and, in the specific

context of attempting to increase regional production, the efficiency of transport subsidies as against other forms of aid. The discussion commences with a strong orientation towards Western Canada and the Atlantic Region, as it was the transport problems of these areas which provided the initial *raison d'etre* for the study. As the analysis proceeds to the role of transport subsidies in general and their efficiency in regional development, inevitably the approach becomes broader and less confined to the problems of specific regions. The final chapter of the dissertation therefore includes a re-focus of conclusions of general applicability back to the specific geographical regions with which the study commenced.

1. THE TRANSPORT PROBLEM

The Canadian Pacific Railway completed its first trans-continental rail link in 1885. Western transportation complaints had been marked long before the completion of this trans-continental system and the construction of an all-Canadian railway did not remove the concerns.* In the debate on the Crow's Nest Pass contract in 1897, Frank Oliver, Member of Parliament for Edmonton, stated in terms very similar to those

* In debate on the freight rate issue, the terms "Western Canada" and "Prairie Provinces" are often used interchangeably; this inaccurate but hallowed tradition is followed in the present dissertation, even though it is unusual for British Columbia to complain in the same terms as the three Prairie Provinces.

used in the West today:

. . . it is because the railway rates have been distinctly against the west in particular and in general from the first that Manitoba and the Territories have shown so much less rapid progress than was expected when the Canadian Pacific Railway was first aided. (71, p. 536)

The concern with rail freight rate inequities has continued in Western Canada to the present day and is deeply embedded in the fabric of the western economic outlook. The concern has never been inactive, although its intensity has obviously fluctuated over the years--less intense during the period of economic prosperity that preceded the First World War; more intense in the 'twenties when Canadian National Railways was formed and the grain rates of the Crow's Nest Pass Agreement were given permanent statutory extension; less intense in the 'thirties against preoccupation with the general problem of economic depression; more intense after the Second World War, in the era of horizontal increases, the Turgeon and MacPherson Commissions and the 1967 National Transportation Act.

The 1967 Act relied primarily upon competition as a means of avoiding discrimination in freight rates, although there were also three provisions to protect shippers from excessive rate charges. It was hoped that the 1967 Act, together with the continued growth of highway transport, would allay the concerns of the West in respect of rail freight discrimination.

However, within two or three years of the passing of the Act, it became clear that these hopes were not to prove justified. Thus, in 1970 the late Ross Thatcher, then Liberal Premier of Saskatchewan, claimed that the railways

. . . charge Western Canadians substantially higher freight rates than they charge the people of Central Canada. The result has been that unfair and discriminatory rates have hurt Saskatchewan in a major way in attracting new industries. (34,p. 33)

In similar vein, a 1971 Manitoba submission to the Federal Minister of Transport argued that:

. . . the Prairie Provinces are more dependent upon rail transportation and the penalty of this captive status has been that the west has been called upon to make more than a proportionate contribution to the total railway overhead. This is the basic complaint of Manitoba on the question of freight rates. (78, p. 1)

Complaints in respect of freight rate inequities continued to become more intense in the Prairie Provinces during the early 'seventies and in July 1973 the Western Economic Opportunities Conference took place in Calgary between the Prime Minister of Canada and the Premiers of the four Western Provinces. Transport had pride of place on the agenda and the Premiers stated in their submission that "the development of the Western region of Canada is inhibited by the lack of positive policy direction and the discrimination inherent in our present system of freight rates" (92, p. 3).

The concern with transport problems in the Atlantic

Region goes back well over one hundred years. The promise of railway construction was an integral part of Confederation itself and the Intercolonial Railway was built at public expense with a rate structure that was not required to cover fully the interest on the investment. After a particularly large rise in rail freight rates during and following the First World War, in 1927 Parliament passed the Maritime Freight Rates Act which provided a twenty per cent subsidy on rail traffic movements within the Select Territory and on the Select Territory part of westbound rail movements.* As a result of further complaints from Maritime interests, the outbound western subsidy was increased to thirty per cent in 1957. In 1969, the freight rates subsidies were extended from rail to include highway transport; provisions were made to reduce the level of subsidy on movements within the Select Territory and this has now been lowered to fifteen per cent; and the savings from the reduction in the subsidy on intra-traffic were to be used for alternative forms of transport assistance in the Select Territory. This has since included additional subsidy to a total of fifty per cent on selected westbound products.

*The Select Territory consisted of New Brunswick, Nova Scotia, Prince Edward Island and Eastern Quebec; Newfoundland also became part of the Select Territory when it entered Confederation in 1949. For a history of transport subsidies in the Select Territory see (19, pp. 113-21) and (81, pp. 163-74).

In the light of the very considerable transport subsidies given to the Select Territory amounting to \$36 million in 1974, perhaps it could be expected that complaints in respect of freight rates would be much less pronounced in the Atlantic Region than in Western Canada. Such expectations would only be partially realized. The Atlantic Premiers asserted in 1975 that the reliance on competition in the 1967 Act "is not practical in the Atlantic Provinces where there is limited competition, lack of facilities, a low volume of traffic, and long distances which are sparsely populated" (2, p. 3). Atlantic concerns on transport issues have been expressed even more vividly in a recent issue of the Halifax Chronicle-Herald which refers to "freight rates that unfairly discourage industrial growth in developing regions of the nation--that is to say the west and Atlantic provinces" (42).

Turning to the provision of rail services in Canada, the railway companies claim that they compete in respect of service, but there is very little price competition as all freight rates are as filed with the Canadian Freight Association. The railways would admit to price differentiation in the sense that freight rates are related to value of service and not only to cost of service. As there is virtually no price competition, the railway companies can be considered in aggregate as approximating the economic behaviour of a price discriminating monopolist, with this behaviour pattern only slightly modified

by service competition arising from the actual existence of duopoly rather than monopoly.

Yet the railway companies do not make excessively large profits. In the two years 1971-72 Canadian National Railways operated at an annual average net income before interest on debt of \$46 million. This represented little more than a return of 1% on the consolidated assets of the corporation. After payment of debt interest, the corporation showed a deficit of \$21 million, giving a negative return of 1% on shareholders' equity held by the Government of Canada (12, calculations from pp. 38-41). The financial performance of Canadian Pacific Limited was more favourable, but hardly impressive. Income before tax from railway and "miscellaneous" sources averaged \$107 million per annum in 1971-72. Related to total assets, the return before tax was only 4½%; after tax the return fell to just over 3% (13, calculations from pp. 8-11). Although the argument is often advanced that Canadian Pacific Limited has "salted away" resources originally given for railway construction into Canadian Pacific Investments Limited, nevertheless the return on assets currently employed in Canadian Pacific Limited is certainly not high. In theory, the railways may still enjoy a residual element of monopoly power in spite of increased intermodal competition; in practice, the rewards from exploitation of this monopoly power are meagre.

To conclude this first section, the transport problem raised in the Prairie Provinces and the Atlantic Region is dissatisfaction with the Canadian rail freight rate structure. This dissatisfaction is often expressed in rather vague generalized terms, but the overall complaint is that, because of lack of competitive transport, the Prairie Provinces and the Atlantic Region have to bear more than their fair share of the railway overhead. Without admitting these charges of regional discrimination, the railways would admit to discrimination in the sense of obtaining greater contributions to fixed costs from some traffic movements than from others. The railway position is that this type of discrimination is essential if revenue is to cover fixed costs and that the financial position of the railway companies is in fact precarious, showing clearly that rate discrimination is not being used to reap excessive profits.

2. THE REGIONAL DISPARITY PROBLEM

Regional disparities are not very difficult to explain as short-run phenomena. Postulate a dynamic economy, with changing income, tastes and technology, and it is highly improbable that growth will proceed at precisely the same rate in each geographical region. During the period of time in which the economy is adjusting, incomes and employment opportunities should increase at a greater rate in the more rapidly expanding areas and unemployment should be less there. However, within a national economy, these disparities should only be temporary, if labour and capital can move freely within the national boundaries. Yet, it has become increasingly evident that in both advanced and underdeveloped economies interregional disparities can persist for very long periods of time. Typically, these disparities take the form of large differences in income per head between regions; high unemployment and under-employment in certain parts of the country; and population concentration in certain areas with reduced growth or depopulation elsewhere.

There is considerable evidence that a high degree of labour mobility can co-exist with only modest diminutions in income disparities between regions. For example, a large gap between farm and non-farm labour income has persisted in both the United States and Canada in spite of substantial migration from the land over a considerable number of decades. In his

1961 analysis of the Upper Midwest of the United States, Sjaastad suggested that since "a good part of what we consider human capital is an accumulation of skills and experience specific to an occupation . . . income differentials could persist over long time periods even in a market system with no lags or imperfections save lack of perfect foresight" (74, p. 262). From a general survey of empirical evidence, Okun and Richardson concluded that "no general proposition can be formulated concerning the effect of internal migration on regional inequality of per capita income" (76, p. 318). Some writers, for example Myrdal, have argued that internal migration can even widen regional inequalities because the migration is selective of the young and capable. Economic theory implies that migration will reduce interregional income disparities on the assumption that units of labour are homogeneous; this does not necessarily hold if the actual migration process is selective of the more productive labour units.

In Canada, there are two major areas faced with problems of regional disparities--the Atlantic Region and Manitoba/Saskatchewan. The Maritime Provinces have lagged behind Canada in terms of income and growth of employment opportunities for over one hundred years. Confederation itself was a disappointment to this region in respect of hopes for wider markets and increased industrial development; Macdonald's National Policy was felt to impose further costs; and the Maritimes did not even share in the economic expansion of the

Laurier years (73, pp. 409-10, 450). Following the Duncan Commission on Maritime Rights of 1926, attempts were made to alleviate economic depression through freight rate subsidies and these were further increased in subsequent years. However, as will be shown in the next chapter, incomes in the Atlantic region have remained far below the Canadian average, the growth in employment opportunities has been less and unemployment rates have been higher.

The second region of Canada suffering from regional disparities is Manitoba/Saskatchewan. For some forty years, the growth in employment and population has been much below the national average in these two provinces. The explanation has been the heavy dependence on agriculture, where employment opportunities have been declining. At the beginning of the twentieth century, the proportion of the Canadian labour force employed in agriculture approximated 42%; by 1951 this was down to 20% and the current figure is rather less than 7%. Alberta would have shared the same fate as the other two Prairie Provinces, but the discovery of petroleum and the accompanying development allowed the economic base employment there to increase very substantially in spite of declining employment opportunities in the large agricultural sector. Anticipating the results of the next chapter, the problem of regional disparities in the Prairies is confined to Manitoba and Saskatchewan; in Manitoba, the problem is seen only in

terms of low growth of employment opportunities; in Saskatchewan there is the lowest growth in employment opportunities and population in the whole of Canada, an income problem related primarily to fluctuations in agricultural prosperity, but unemployment far below the national average.

The Government of Canada has, of course, always had to be aware of the political importance of regional considerations, but direct action in respect of regional variations in economic growth is a more recent development. In 1940 the Rowell-Sirois Report recognized the need to reduce regional economic disparities in Canada and its proposals for revenue adjustment between provincial and federal governments were in effect achieved through wartime tax arrangements which were continued into the post-war period (73, p. 628). Nevertheless, it was not until the 'sixties that efforts to create employment opportunities in the slow growth areas of Canada became really pronounced with an impressive array of new legislation.

Concern with the plight of impoverished farmers was responsible for the Agricultural Rehabilitation and Development Act of 1961. In 1962 the Atlantic Development Board was established to provide special assistance to the Atlantic Provinces. In 1963 the Area Development Agency was set up to encourage industrial development in areas of chronic unemployment. In 1966 the Fund for Rural Economic Development appeared on the scene to permit implementation of comprehensive rural

development programs in problem areas considered to have development potential. Of these agencies--ADA, ARDA, and FRED--Rotstein remarked "New government agencies are launched and one acronym follows another into a state of suspended animation" (72, p. vii). In 1968, the Federal Government set up a new Department of Regional Economic Expansion and all the programs with the confusing initials were consolidated here. The new emphasis has been stated as the development of "growth centres," and the need for regional development has been kept consistently in the foreground of economic discussion and policy of Canada.*

The persistence of interregional economic disparities is now fully recognized; in fact, the Economic Council of Canada only slightly overstated the degree of persistence in the following passage from its 1968 Annual Review.

Differences in both the levels of economic and social well-being and in economic opportunity among the various regions and provinces of Canada are large, and have persisted with only modest change for over forty years. This persistence has been remarkable; neither strong national economic growth nor the strains and turbulence of depression and war have had lasting effects on the basic pattern of regional disparities. There is little reason to suppose that the historical mix of market forces and public policy is likely to lead in good time to a significant reduction in these disparities. (32, p. 141)

*Nevertheless, as recently as December 1975, Conservative Leader Stanfield charged that the "government has failed to develop a coherent, co-ordinated program to attack the deep-rooted problems of regional disparity," (77, p. 4).

3. A SYNTHESIS OF PROBLEMS

All advanced countries are concerned with the "geographical unevenness of their development . . . All try in one way or another to steer economic activity from their more prosperous to their less prosperous areas " (38, p. v). The concern at the national level is felt even more keenly by provincial jurisdictions which have not been content to rely on migration as a solution to interregional disparities. For example, the Manitoba Commission on Targets for Economic Development, reporting in 1969, established the objectives that by 1980 provincial income per head should equal the Canadian average and that Manitoba should regain its 1966 share of Canadian population (70, pp. 523-5). The North American preoccupation with growth for growth's sake was regarded with more askance in the 'seventies, yet the Manitoba objective in 1973 seemed only slightly modified with its stress on the stay option allowing natives of each area the opportunity to continue to live and work in their area of origin (69, pp. 14-5). These Manitoba objectives are not atypical.* Within most western economies, the objective of slow growth regions has been to

*For further discussion, see (74). An aspect of population migration from the slow-growth areas which has received far too little attention has been expressed by Leven as the need "to investigate whether the regret over induced migration is mainly expressed by individuals who have had to move to realize an improved economic position, or by individuals who are confronted with declining markets for local goods and services" (65, p. 587).

attain at least an "average" rate of growth, for "below average" is regarded not merely as a statistical description but also as an expression of moral disapprobation.

For many decades, the major growth area in employment in Canada has been the tertiary or service sector of the economy and this has, of course, been typical of economies with rising levels of real income per head. However, generally the service industries are located as a result of multiplier effects from the basic economic activities which exist in an area; in some instances, of which tourism is the most important example, service industries can provide the *raison d'être* for economic activity, but usually service employment is a function of other economic base employment. The economic base of a region is normally defined as consisting of agriculture, fishing, forestry, mining, manufacturing, and perhaps tourism; although the construction industry produces a tangible product, the level of employment here is responsive to other economic activities and, in terms of economic base theory, construction is best considered along with the tertiary sector.

The agricultural component of the economic base in the Prairie Provinces has been declining for many years, while fishing and forestry offer only a limited number of employment opportunities. The petroleum industry has, of course, had a marked effect on the development of Alberta, while in Manitoba and Saskatchewan mining employment has provided a welcome

addition to the provincial economies. Employment in the tourist industry has also increased. However, manufacturing industry has usually been regarded as the main contributor to increased base employment. In Manitoba, for example, this was apparent in provincial thinking before the publication of the report of the Commission on Manitoba's Economic Future of 1962; it continued in the Targets for Economic Development of 1969; and, although stating constraints and reservations, the 1973 Manitoba Guidelines recognized the stress that had been placed on "industrialization as a means of promoting, influencing or maintaining economic development" (69, p. 122). Similarly, after examining employment opportunities in agriculture, fishing, forestry, coal-mining, tourism, and defence expenditure, a recent study concluded that "Nova Scotia's hope lies in its manufacturing sector" (38, pp. 22-3).

Increased growth in employment opportunities requires a larger economic base and, in the slow growth regions, this is perceived as best achieved by an expansion of the manufacturing sector. Transport charges are alleged to be one of the main costs in developing manufacturing.* Vast distances separate the Prairies from the major markets of Central Canada and the distances are also considerable between the Atlantic Region and Central Canada. Moreover, it is alleged that transport costs are high not only because of the real costs

*Data on transport charges in relation to product selling prices are developed later in Chapter IV, Section 3.

of distance, but also because lack of competitive transport allows an inequitable rail freight structure to be imposed on the Prairies and the Atlantic Region. Hence, it is claimed, lower freight rates would help substantially towards relief of regional disparities, particularly inadequate growth of employment opportunities. This is the basis for a perceived integration of the transport problem and the regional disparities problem.

This synthesis of problems is made easier in that since Confederation itself the Federal Government has regarded transport as one of the means of securing national objectives. Government had relatively few tools available to influence development in the nineteenth century and railways, together with the tariff and western settlement, were the three main planks of Macdonald's national policy. Canadian railways were not primarily business enterprises but instruments of national purpose (20, p. 144). Up to the present time, the development of transport policy in Canada has been dominated by the need to reconcile policies which are appropriate for transport with the desire to use transport itself to promote other national goals. The MacPherson Commission, reporting in 1961, and the 1967 National Transportation Act allowed economic considerations to be the main criteria for transport policies, but the issue was certainly not dead.

When a problem has existed as long as the transport issue in Canada, complaints about transport and freight rates can become at times a useful catch-all for many forms of business woe. If inequities are widely believed to exist in the freight rate structure, it is very easy to generalize these inequities as the cause of a far wider range of economic problems. The term "freight rate inequities" becomes symbolic of a multitude of problems, not all of which are even in the transport field. Ruppenthal has recently summarized this attitude as follows:

In Canada there is an uncommon propensity to look to transport as the potential cure for all our ills. Probably in no other nation in the world is transport regarded as the universal nostrum. Just do something to transport and all will be well with the farmers, the miners, the loggers, and the native peoples. Transport is regarded as the key to economic expansion, equitable treatment, and a more abundant life. (85, p. 588)

While the synthesis of the transport problem and the regional development problem may not be complete, nevertheless it is clear that transport is ascribed a key role in respect of alleviating regional disparities. Thus, the Atlantic Provinces stress the need for policy recognition that "transportation is used as a positive instrument for regional economic development" (2, p. 10). The position of the Prairie Provinces is unchanged from 1973 when, joined by British Columbia in the interests of western unity, they asserted the need to solve the transport problem as a means towards a solution of regional disparities:

The Western Economic Opportunities Conference has been called by the Federal Government "specifically to consider concrete programs for stimulating and broadening the economic and industrial base of Western Canada." One of the most dramatic and effective ways to do this is for the Federal Government to commit itself to new transportation policies to overcome the aforementioned inequities and hence significantly stimulate and broaden the economic and industrial base of Western Canada. (92, p.2)

4. OBJECTIVES, SCOPE, AND ORGANIZATION OF THE PRESENT STUDY

The present study commenced by documenting two issues which are widely perceived as problems in the Prairie Provinces and the Atlantic Region. Firstly, there is the claim that the rail freight rate structure contains inequities which work against these regions and secondly there is the complaint that the regions suffer generally from economic disparities. Freight rate inequities are viewed as a major cause of regional disparities, especially in respect of the slow growth in employment opportunities. This study was initially inspired by these concerns and the dilemma that, while transport is generally believed to be crucial to regional development on the part of provincial governments and public opinion in the Prairie Provinces and the Atlantic Region, academic opinion tends to be skeptical as to the usefulness of transport as a regional development tool.*

The overall objective of this dissertation is therefore to make a contribution towards resolution of the role of transport in regional development. The specific objectives are as follow:

*See, for example, the conclusions to Straszheim's 1972 article (88, p. 219), and the writings of George Wilson, such as (95).

- (i) To document the extent to which perceived regional economic disparities and rail freight rate inequities are in fact justified by the evidence;
- (ii) To determine the extent to which transport subsidies can be used to solve transport problems;
- (iii) To examine within a theoretical framework the effectiveness of subsidies on transport freight rates*, in comparison with other types of non-transport subsidies, to achieve a required increase in output from a firm located in a slow growth region where it is specified that this increased output is desirable and can only be achieved by increased shipments to markets outside the region.

The organization of the individual chapters of this study is briefly outlined.

Chapter II examines the extent to which perceived disparities can be factually supported. In the first section, regional disparities are documented in respect of income, unemployment and the growth of employment opportunities. The second section examines freight rate disparities with reference to the Prairie Provinces and the Atlantic Region.

*Subsidization of increased infrastructure and services is not usually advanced as having a significant stimulus to regional development. The only mode in which more transport services are urged for purposes of regional development is local air services; for a critical review see (14, pp. 22-4). As far as increased surface transport is concerned, the hope for increased regional development from increased infrastructure is almost reminiscent of Adam Smith's famous parody of attempting "to increase the good cheer of private families by obliging them to keep an unnecessary number of kitchen utensils" (87, p. 386).

The examination commences with examples of specific disparities and then assesses the evidence for the existence of overall discrimination across the freight rate structure. The final section deals with the difficult problem of equity in freight rates and explores the question of whether the Prairie Provinces and the Atlantic Region are seeking the correction of injustice or subsidy in the sense of freight rates which do not cover the costs of providing transport services.

Chapter III is concerned with the general economic basis for transport subsidies and is an essential prelude to the later discussion of subsidies in the more narrow regional development context. Pareto-optimality conditions are specified and it is argued that the transport industry does not satisfy the conditions necessary to ensure an efficient allocation of resources without government intervention. The theoretical case for subsidy under increasing returns to scale is examined, qualifications required by the theory of second best are considered, and the existence and consequences of increasing returns to scale in transport are assessed. Transport subsidies are considered as a means of counteracting monopolistic power, transport is examined as a strategic factor in economic growth, and the non-economic benefits of transport are discussed. Finally, income distribution and regional development aspects of transport subsidies are briefly introduced.

Chapter IV outlines a model to examine the efficiency of transport subsidies as a means of securing increased output from a single-plant firm. It is specified exogenously that the increased output is required for regional development purposes and that this can be achieved only by expanding the geographical area in which the firm sells. Three alternative subsidy approaches are examined--subsidy on output price, subsidy on the prices of factors employed by the firm, and subsidy on transport charges--and it is argued that these alternatives also provide a basic framework for examination of subsidy on other inputs such as raw materials. The most efficient subsidy system is defined as that which minimizes net social cost, which is specified as subsidy cost paid by government minus the increased profit of the firm. However, government does not raise taxes without expense and it is also desirable to minimize the actual subsidy cost paid by government. Empirical data necessary to calibrate the model are also presented.

Chapters V and VI develop and calibrate the model. Chapter V postulates that the demand for the firm's product is uniformly distributed in an unbounded plane; in other words, as the firm increases output, it has to tap more distant markets but these are available in every direction from where the firm is situated. Chapter VI postulates demand as uniformly distributed in a band of constant width;

ignoring exports to the U.S., this assumption could be applied as a rough approximation for those parts of Canada where population is distributed in a line along the U.S. boundary so that increased output cannot be delivered in all directions, but roughly only due east or due west. The real world situation is, of course, intermediate between these two alternative formulations of demand.

The model is developed in two versions in Chapters V and VI, corresponding to these two demand patterns. Output is established for equilibrium conditions without subsidy and the effects of the three forms of subsidy are examined. The model is developed on the alternative assumptions that subsidy is paid on all output and that subsidy is paid only on additional output. The practical feasibility of confining subsidies to incremental output is discussed. Constraints are introduced on the amount of subsidy payments that can be made and arithmetical simulations are presented.

Finally, Chapter VII summarizes the dissertation and makes suggestions for further research.

CHAPTER II: THE EXTENT OF DISPARITIES

The first chapter established the concerns expressed in Western Canada and the Atlantic Region in respect of regional disparities and transportation. The present chapter examines the extent to which these perceptions of inequities are justified by factual evidence. Section 1 describes regional economic disparities. Section 2 is a rather lengthy discussion of rail freight rate disparities, focussing initially on examples of specific disparities and then examining the evidence for the existence of general disparities against different commodities and different geographical regions of Canada. Section 3 considers the very difficult concept of equity in freight rates, and the question of whether the aspirations of the West and the Atlantic Region can be met in terms of correction of inequities, as distinct from transport subsidies.

1. THE EXTENT OF REGIONAL DISPARITIES

It is customary to describe regional disparities in terms of income, employment opportunities, and growth and this section proceeds to examine the extent of such disparities in Canada.*

*This section is based on the author's "Inter-regional Disparities in Canada: A Statistical Analysis" (47)

There are three main approaches used in defining economic regions. The first approach is to stress homogeneity in respect of significant characteristics such as income, unemployment, growth, and other physical and social factors. The second approach concentrates on nodal regions, where a central urban area is regarded as the pole around which the region concentrates. The third approach relies on administrative coherence and the institutions available for carrying out policy decisions. These approaches to regional delineation are not necessarily contradictory and in practice regional definitions are often established as a compromise between these three criteria.* However, decisions on regional boundaries can often be heavily influenced by the intractability of statisticians. In the words of Walter Isard, "Finally . . . the choice of a particular inter-regional framework depends upon the stock of existing data, and the manner in which existing data collecting and processing agencies are organized and their procedures subject to change" (58, pp. 323-4). The examination in the present section is in terms of the provinces of Canada, although this hides some substantial variations, for example the contrast between conditions in the Quebec Gaspé and the metropolitan area of Montreal.

*For useful discussion of regional definitions see (74, p. 243) and (5, pp. 46-51).

(a) *Variations in Personal Income per Head*

Table 2.1 below has been prepared from Statistics Canada data of personal income per person and from intercensal population estimates. The income statistics relate to money incomes and are not corrected for price changes. Personal income per person has been averaged over three year periods to reduce the effect of random fluctuations, of which the most important are variations in agricultural income. The starting period of 1949-51 is the earliest for which figures are available to include Newfoundland. The population distribution between the various provinces does not fluctuate from year to year and it was therefore not necessary to use three-year averages in this series.

Annual personal income per head by province is also shown in the table on an index basis. In each period, the overall Canadian average personal income is shown as an index of 100.0 with appropriate indexes estimated for each province. The coefficient of variation gives the standard deviation of the index of personal income per head expressed as a percentage of average personal income; this coefficient is calculated in two different ways. Firstly, the equi-weighted index gives all provinces an equal weight in the calculation. Secondly, the population weighted index gives each province a weight in the calculation in proportion to its share of Canadian population. This second method seems to be more realistic, as it is to some extent historical

TABLE 2.1 Annual Personal Income per Head by Province					
	Annual Personal Income per Head			% Increase per Annum	
	1949-51	1959-61	1969-71	49-51 to 59-61	59-61 to 69-71
	\$	\$	\$		
Newfoundland	539	916	2,002	5.4	8.1
P.E.I.	593	955	2,036	4.9	7.8
Nova Scotia	782	1,255	2,439	4.8	6.9
New Brunswick	742	1,108	2,268	4.1	7.4
Quebec	916	1,442	2,803	4.7	6.9
Ontario	1,289	1,939	3,710	4.2	6.7
Manitoba	1,098	1,599	2,956	3.9	6.4
Saskatchewan	1,039	1,324	2,469	2.4	6.4
Alberta	1,142	1,646	3,156	3.7	6.8
B.C.	1,294	1,896	3,442	3.9	6.1
Canada	1,078	1,638	3,157	4.2	6.8

	Personal Income per Head			Population Distribution - %		
	Index Canada = 100			1950	1960	1970
	1949-51	1959-61	1969-71			
Newfoundland	50.0	55.9	63.4	2.6	2.5	2.4
P.E.I.	55.0	58.3	64.5	0.7	0.6	0.5
Nova Scotia	72.5	76.6	77.3	4.7	4.1	3.7
New Brunswick	68.8	67.6	71.8	3.7	3.3	3.0
Quebec	85.0	88.0	88.8	29.0	28.8	28.3
Ontario	119.6	118.4	117.5	32.6	34.3	35.6
Manitoba	101.9	97.6	93.6	5.6	5.1	4.6
Saskatchewan	96.4	80.8	78.2	6.1	5.1	4.4
Alberta	105.9	100.5	100.0	6.7	7.2	7.5
B.C.	120.0	115.8	109.0	8.3	9.0	10.0
Canada	100.0	100.0	100.0	100.0	100.0	100.0

	Coefficient of Variation - %		
	1949-51	1959-61	1969-71
Equi-weighted	27.4	24.4	20.4
Population weighted	19.5	17.8	16.0

Source: Calculations from Statistics Canada data--no catalogue number.

accident that the ten per cent of Canadian population contained in the Atlantic Region should be split into four administrative entities, while Quebec with over 28 per cent of the total population should constitute only one administrative unit.

Interregional income disparities in Canada are very substantial. On the data for 1969-71, personal income per head was far below the national average in the Atlantic Region, ranging from a shortfall of 37% in Newfoundland to 23% in Nova Scotia. Other provinces below the national average were Quebec, Saskatchewan and Manitoba. Income per head in Manitoba was only 6% below the Canadian average, but in Saskatchewan the shortfall was 22% on 1969-71 figures. These were bad years for prairie agriculture and therefore particularly for Saskatchewan, which is the most heavily agricultural province of Canada. However, calculations for the more representative period of 1967-69 still showed a Saskatchewan shortfall of 13%. The third province of the Prairie Region, Alberta, has income per head identical with the Canadian average. The most prosperous provinces in Canada are Ontario and British Columbia.

The figures of personal income per head in Table 2.1 relate to money income and make no allowance for differences in price levels between the various regions. It is very difficult to make this type of adjustment, chiefly because of lack of data on variations in housing costs. Moreover, apart from this data problem, there are further difficulties

in trying to quantify costs imposed on a consumer by virtue of his residing in a specific area of Canada, such as the heavy costs in time and transportation in getting to work in Toronto and the higher fuel consumption in the more severe winter of the Prairies. An examination of an admittedly tentative nature suggested that allowance for regional price variations and differences in consumer costs would marginally reduce the degree of interregional disparity in terms of real income (47). However, the variations in personal income per head in money terms in Table 2.1 seem substantially to mirror the variations in real terms.

In spite of these substantial interregional income variations in Canada, there is at least some evidence that there has been a modest narrowing in the extent of differences. In the period 1959-61 to 1969-71 all four Atlantic Provinces had rates of increase in personal income per head greater than Canada as a whole and, with the exception of New Brunswick, this was also true of the earlier period 1949-51 to 1959-61. Quebec also enjoyed a greater rate of increase in personal income than Canada in each of these time periods. Of the provinces with personal income per head below the Canadian average, only Saskatchewan and Manitoba failed to reduce the shortfall. The coefficients of variation in Table 2.1 give a measure of the dispersion in personal income per head. On both sets of coefficients, the degree of disparity in personal income has been reduced in the last twenty years. This was

also the broad conclusion of Chernick's study of income disparities based on earlier data (18, p. 15).

(b) *Variations in the Unemployment Rate*

Table 2.2 shows Statistics Canada unemployment rates in the provinces of Canada averaged over 1970-72. Figures of provincial unemployment rates are not available prior to the mid-sixties. Unemployment is ranked by province, with the lowest unemployment rate ranked one and the highest ranked ten. Although overall levels of unemployment change from year to year, this rank order of provincial unemployment rates has been remarkably stable. The table also shows provincial rankings in terms of annual personal income per head in 1969-71, with these figures derived from Table 2.1 above.

TABLE 2.2			
Unemployment Rates by Province			
	Average Unemployment	Provincial Rankings	
	Rate (%) - 1970-72	Unemployment	Income per head
Newfoundland	11.5	10	10
P.E.I.	6.6	5	9
Nova Scotia	6.9	6	7
New Brunswick	7.9	8	8
Quebec	8.1	9	5
Ontario	4.8	4	1
Manitoba	4.7	3	4
Saskatchewan	4.1	1	6
Alberta	4.5	2	3
B.C.	7.4	7	2
Canada	6.2	-	-

Source: Statistics Canada 71-201. Unemployment rates for P.E.I. were not released after 1971. It has been assumed that the ratio of the P.E.I. unemployment rate to that of Canada was the same in 1972 as in 1970-71.

Unemployment in Canada is lowest in the Prairie Provinces and Ontario. Newfoundland and New Brunswick have high unemployment rates, but the other two Atlantic Provinces are not much above the Canadian average. Quebec and British Columbia have high unemployment.

In principle, there should be a positive correlation between provincial rankings on unemployment and on personal income per head, as given in Table 2.2. Wages and income per head should be high where there is a strong demand for labour and minimal unemployment. However, the Spearman rank correlation coefficient between these two variables is only .43. There are three factors which reduce the correlation. Firstly, British Columbia has high personal income per head, but also high unemployment. Although the province is growing fast, its attraction to migrants from other parts of Canada is such that the labour inflow appears to run ahead of the creation of employment opportunities. Secondly, Quebec has a more serious problem in respect of unemployment than in respect of income. Thirdly, unemployment rates are low in the more agricultural parts of the Canadian economy, namely the three Prairie Provinces and Prince Edward Island. Each of these provinces ranks better in respect of low unemployment than in personal income per head. The explanation may be partly in terms of disguised unemployment on the land and it can be argued that a statistical measure of unemployment which does not make allowance for under-employment is inadequate.

However, from Statistics Canada data, it would be difficult to establish regional disparities in the Prairie Provinces on the basis of unemployment.

(c) Variations in the Rate of Population Growth

Table 2.3 shows the Census populations of the provinces in 1971 and the percentage rates of increase in the decades 1951-61 and 1961-71. The rank order of provinces by population growth is shown for 1961-71, together with the provincial rankings by unemployment and income per head from Table 2.2.

TABLE 2.3

Population Increase by Province

				<u>Provincial Rankings</u>		
	<u>Population</u>	<u>Population increase - %</u>		<u>Population</u>	<u>Unemploy-</u>	<u>Income</u>
	<u>thousands</u>	<u>1951-61</u>	<u>1961-71</u>	<u>increase</u>		
	<u>1971</u>			<u>1961-71</u>	<u>ment</u>	<u>per</u>
						<u>head</u>
Newfoundland	522	27	14	5	10	10
P.E.I.	112	7	7	7	5	9
Nova Scotia	789	15	7	7	6	7
New Brunswick	635	16	6	9	8	8
Quebec	6,028	30	15	4	9	5
Ontario	7,703	36	24	2	4	1
Manitoba	988	19	7	7	3	4
Saskatchewan	926	11	-	10	1	6
Alberta	1,628	42	22	3	2	3
B.C.	2,185	40	34	1	7	2
Canada	21,569	30	18	-	-	-

Source: Statistics Canada 11.003E. Total Canadian population includes Yukon and N.W.T.

The Canadian population increased by 18% in the decade 1961-71. Three provinces had rates of increase appreciably above this -- British Columbia, Ontario, and Alberta. Quebec and Newfoundland showed increases slightly below the national average. The population increase of 7% in Manitoba was similar to Nova Scotia, Prince Edward Island, and New Brunswick. The Saskatchewan population showed virtually no change during the decade.

The Canadian increase in population of 18% in 1961-71 was much below the 30% increase in 1951-61, mainly because of the very large fall in the birth rate in the 'sixties. However, the geographical pattern of growth had not changed much between the two decades. The provinces which grew most in the 'fifties also grew most in the 'sixties. The Spearman correlation coefficient between provincial rankings on percentage population increase in 1951-61 and 1961-71 was a high of .87.

The use of population growth as a proxy for the increase in employment opportunities would be indefensible in international comparisons, but examination of the relevant statistical series for the Canadian economy suggests that this is not quite so unreasonable for comparisons between the provinces. In view of population migration, one would hypothesize positive correlation between population increase and income per head and between population increase and low unemployment rates. The rank correlation between population increase in 1961-71 and average income per head in 1969-71 was +.65,

thus showing the expected positive sign. Two factors prevented the association from being higher. Firstly, there was relatively high population increase in Newfoundland but very low income per head. Secondly, the effect of low employment growth on income per head in Saskatchewan was modified by heavy out-migration of population.

The data did not support the hypothesis of positive correlation between population increase and low unemployment. The rankings of these two series in the table produced a correlation coefficient of virtually zero (-.18). This is explained by three factors. Firstly, Newfoundland and Quebec had fairly high rates of population increase in spite of heavy unemployment. Secondly, British Columbia had high growth, but also high unemployment. Thirdly, population increase was modest in Manitoba and non-existent in Saskatchewan, while the unemployment rates were also low in these two provinces as a result of high out-migration and the failure to measure underemployment on the land.

To conclude this section on regional disparities, the major problem area in Canada is, of course, the Atlantic Region. Personal income per head is substantially below the Canadian average, ranging from shortfalls of 23% in Nova Scotia to 37% in Newfoundland. The growth in population and employment opportunities has been much less than in the rest of Canada and unemployment is above the national average, especially in Newfoundland and New Brunswick. The Atlantic

Region suffers from regional disparities on all three counts of income, unemployment, and lack of growth.

The nature of the problem of regional disparities in the Prairie Provinces is very different. In spite of the common front often shown by the three Prairie Provinces, regional disparities really affect only Saskatchewan and Manitoba; Alberta is not a problem area on any of the three measures examined. Unemployment is less in the Prairie Provinces than in any other region of Canada, although this may be slightly misleading in view of the possibilities of disguised unemployment in agriculture. In terms of personal income per head, Manitoba is only slightly below the Canadian average, but Saskatchewan has more of an income problem and particularly a problem of income instability due to fluctuations in agricultural prosperity. The main disparity problem is low growth in employment opportunities and population; on this measure, growth in Saskatchewan in 1961-71 was the lowest in Canada and Manitoba also showed a low rate of growth, comparable to that in New Brunswick, Nova Scotia, and Prince Edward Island. If large variations in the rate of growth between different parts of Canada were not a public concern, the regional development problem in the Prairies would be mainly a question of income instability caused by agricultural fluctuations. However, given the concern for growth described in the previous chapter, it is not possible to dismiss regional disparity problems so easily.

2. THE EXTENT OF RAIL FREIGHT RATE DISPARITIES

Prior to the Canadian National Transportation Act of 1967, railway freight rates were regulated by the Board of Transport Commissioners. This regulation covered all freight rates except for the statutory Crow's Nest Rates on grain and grain products and rates were not allowed to be unjustly discriminatory or unduly preferential. The 1967 Act substituted competition for regulation and particularly competition on an inter-modal basis. With the exception of the statutory grain rates, the railway companies were left free to fix freight rates without regulatory approval; tariffs had merely to be filed with the Canadian Transport Commission with the required statutory notice given.

The 1967 National Transportation Act contained three provisions to protect shippers from excessive rate charges - where the act or omission or establishment of a rate of a carrier or any two or more carriers may prejudicially affect the public interest (9, Section 23); where a shipper is deemed captive to rail in the carriage of goods in less than carload quantities under 5,000 lbs. (11, Section 264); and where a shipper deemed captive to rail applies to the Canadian Transport Commission to fix a rate, which will be equal to variable cost of the carriage of the goods at loadings of 30,000 lbs. plus an amount equal to one hundred and fifty

per cent of the variable cost, with a specified deduction from this rate for loadings of 50,000 lbs. or more (11, Section 278). Since the 1967 Act came into effect, no action has been taken under Section 264 of the Railway Act and the only captive shipper appeal under Section 278 was withdrawn by the shipper before the case was concluded. There have been Section 23 appeals in respect of rapeseed oil and rapeseed meal, and pulp and paper. However, in spite of this limited utilization of legal forms of redress for freight rate problems, the complaints in respect of specific and general disparities have continued.

(a) Specific Disparities

The complaints of the Western Provinces in respect of specific rail freight rates fall into three broad categories. The first category relates to raw materials versus finished products, where it is alleged that further processing and manufacturing are hindered in the West because finished goods are charged higher freight rates than raw materials. The second category is long-haul short-haul discrimination, where short-haul movements to non-competitive points are assessed higher freight rates than long-haul movements of the same product. The third category is rail rate groups, where it is argued that the West is denied the advantage given in Central Canada of having several communities considered as one location for rate-making purposes and hence encouraging development

in the smaller population centres. Allegations of this type were made, for example, in the Transportation Statement of the four Western Premiers at the Western Economic Opportunities Conference in July 1973 (92, p. 2). They also formed the basis of complaints investigated in a Canadian Transport Commission Report to the Minister of Transport in late 1973, and subsequently released as a public document (16).

It is more difficult to document complaints on specific freight rates, as against the general inequity argument, in respect of the Atlantic Region. The transport of potatoes is always an active issue but the complaints often relate more to equipment problems than to freight rates. There are also complaints in respect of freight rates levied on small shipments, but this may be substantially because small-scale industry generates an unduly large proportion of small shipments rather than a result of any basic discrimination in the freight rate structure.

Westbound shipments from the Select Territory of the Atlantic Region and Eastern Quebec receive a 30% subsidy on that proportion of the rail or truck rate which applies to the Select Territory part of the journey. In 1974, these rail and truck subsidies amounted to \$10 million.* Effective April 1974, the westbound subsidy could be increased to 50% on a selective basis for industries with heavy transport

*However, subsidies on shipments between points in the Select Territory, the so-called intra-subsidies, amounted to \$25 million.

costs and good prospects of competing outside the Select Territory. During the last nine months of 1974, additional payments under this incremental 20% selective subsidy amounted to \$1.4 million and this was expected to double for the full year of 1975. Perhaps, the general westbound subsidy plus the additional selective subsidy has the effect of defusing complaints about individual rates in the Atlantic Region. In any event, the Atlantic Provinces Transportation Policy Statement of the four Atlantic Premiers, dated April 1975, states with apparent approval that "In recent years, both levels of government have agreed that selective subsidies are more effective than blanket subsidies in fostering regional economic development" (2, p. 11).

The issue of higher freight rates on finished products than on raw materials has been raised by the Western Provinces in recent years mainly in respect of rapeseed oil and meal and meat and livestock. A Section 23 application was made in 1970 to the Railway Transport Committee of the Canadian Transport Commission by the western rapeseed crushers for redress of freight rates on rapeseed oil and meal and this was supported by the Prairie Provinces. The application argued that it was cheaper to ship rapeseed from Western Canada for crushing in Eastern Canada than to ship the oil and meal obtained from crushing in the West. Rapeseed moved at the Crow's Nest Rates from Western Canada to Thunder Bay and then at an Agreed

Charge to Montreal. These rates were less than for rapeseed meal, which enjoyed the statutory rates to Thunder Bay but had to meet a much higher freight rate for transport beyond to Montreal, and less than for rapeseed oil, which moved at Agreed Charges from Western Canada to the East. The Railway Transport Committee found that this rate structure gave a bias in favour of crushing in Eastern Canada and the 1973 Decision of the Committee gave relief in respect of the domestic rates on rapeseed meal and ordered the railways to develop a complete export rate structure on rapeseed meal and oil (15, pp. 54-8).

Of the eleven freight rate disparities referred by the Minister of Transport to the Canadian Transport Commission for investigation in 1973 (see 16, Appendix A), four related to meat and livestock. A recent analysis by the Research Branch of the Canadian Transport Commission concluded that the evidence did not suggest that the freight rate structure discriminates in favour of shipping cattle rather than beef or that beef made a greater relative contribution to railway fixed costs than livestock. However, the statutory grain rates to Thunder Bay and feed freight assistance onward to eastern points could certainly make it economic to use western grain to feed hogs in Eastern Canada rather than to transport pork from the West (17, pp. 38-9).

Freight rate disparities where short haul movements are

charged at higher rates than long haul movements have been cited mainly in respect of iron and steel products and canned foodstuffs. Of the eleven freight rate differences cited by the Minister of Transport in 1973, four related to differentials of this type (16, Appendix A). A typical example was the freight rate on structural steel from Hamilton to Calgary, which was higher than the rate for the considerably longer haul from Hamilton to Vancouver. The long haul rate was originally lower than the intermediate rate because the railways had to face water competition through the Panama Canal. More recently, this differential has been justified on the grounds that higher rates from Hamilton to Vancouver would mean loss of traffic, as Hamilton structural steel would be unable to compete with off-shore imports.

The long-haul short-haul problem was documented at some length so far as it affected Manitoba in a 1971 submission to the Federal Minister of Transport (78, Exhibits III and IV). In respect of iron and steel, Manitoba complained that freight rates per ton-mile, operative in April 1971, were almost twice as high from Selkirk to Gillam as from Sault St. Marie to Ottawa in spite of the similarity of length of haul. On the transcontinental route, rates from Selkirk to Vancouver were identical to rates from Montreal to Vancouver, even though the haul was virtually twice as far from Montreal. A recent unpublished update of this material to December 1975 has shown a continuation of this first disparity; however,



Selkirk to Vancouver rates are now only two-thirds of the Montreal to Vancouver rates.

In respect of canned foodstuffs, Manitoba complained that the distance from Toronto to Vancouver was more than double the distance from Toronto to Winnipeg, yet the carload rate for 100,000 lbs. minimum was only 15% higher in April 1971. This differential had increased to 43% by December 1975. The freight rate structure was also claimed to discriminate against the Portage la Prairie producer of canned foodstuffs. The distance from Toronto to Vancouver was almost double the distance from Portage la Prairie to Vancouver. In April 1971, the carload rate for 100,000 lbs. minimum was only 16% higher on the longer run and by December 1975 this differential had only increased to 19%.

The third major category of specific freight rate complaints advanced by the West relates to rail rate groups. The argument is broadly that, if the smaller centres surrounding each major city were given the same freight rates as the larger city, this would encourage industrial expansion in the smaller centres. There is no disputing that the West does not enjoy rate groups of the size of that embracing Toronto and Montreal used in respect of freight rates for movements between Eastern and Western Canada. However, preliminary evaluation by the Canadian Transport Commission has questioned the amount of diffusion of industrial activities that would result from the establishment of rate groups (16, p. 25).

(b) General Disparities

In addition to specific disparities, there are also allegations of overall freight rate discrimination. Thus, the Western Premiers claimed that "The lack of competition in certain regions of the West places railways in a position of significant monopoly, leading to rail rates and pricing policies which are a major barrier to economic development and diversification", (92, p. 1). Similarly, the Atlantic Premiers have claimed that competition

is only effective and equitable in those regions of Canada which have a well developed, mature transportation system with a high level of modal and inter-modal competition. This policy works effectively in certain areas such as parts of Ontario and Quebec, but it is not practical in the Atlantic Provinces where there is limited competition, lack of facilities, a low volume of traffic and long distances which are sparsely populated. (2, p. 3).

There has been little substantiation of these claims of general discrimination partly because comparisons raise substantial difficulties in standardizing for differences in types of traffic, car loadabilities, length of haul and handling characteristics. The remaining part of this section attempts, very imperfectly, to throw some light on the problem of general discrimination.

Table 2.4 below shows rail average revenue, average haul and average carload for Major Commodity Groups in 1973. Compared to 1972, there had been slight increases in average

length of haul, average carload, and average revenue per car-mile and a marginal increase in average revenue per ton-mile; however, there had been no change in the relationships between the various commodity groups and 1972 data are therefore not shown below. Table 2.4 and all subsequent tables in this section are based on complete computer tape records of Canadian National Railways and CP Rail for all domestic carload revenue traffic, while the major exclusions are Canada-United States traffic, traffic moving over the lines of two or more railways, container traffic, piggyback movements other than Plan 1, joint water and rail movements, and less than carload traffic.

TABLE 2.4

Rail Average Revenue, Average Haul and Average Carload:

Major Commodity Groups - 1973

	<u>Average Revenue</u> <u>¢ per</u>		<u>Average</u> <u>Haul</u>	<u>Average</u> <u>Carload</u>
	<u>ton-mile</u>	<u>car-mile</u>	<u>miles</u>	<u>tons</u>
Statutory Grain	0.49	31.0	889	63.3
Agriculture	1.35	62.4	752	47.6
Animal	3.09	65.7	1,502	21.7
Mine	0.94	81.9	388	77.4
Forest	1.71	74.7	354	47.3
Manufacturing & Miscellaneous	2.38	75.7	673	37.9
Piggyback (Plan 1)	1.77	37.7	1,062	20.4
Total (excl. Statutory Grain)	1.68	71.6	508	51.4

Source: Canadian Transport Commission, Traffic & Tariffs Branch Reference Paper No. 1.1, Commodity Flow Analysis 1973, Table 12. Piggyback Plan 1 covers transport of trailers of highway common carriers. Calculations in the following text are from this table and also Tables 1, 5-11.

Figures of average revenue allow only limited comment on which commodity groups are most profitable to the railways. In general, costs per ton-mile would tend to fall as average length of haul increases and as average carload increases, but these tendencies can be swamped by such factors as variations in handling characteristics between different commodity groups.

The lowest revenue per ton-mile is earned from grain and grain products carried at the statutory Crow's Nest Rates. It has been widely argued that these rates are not compensatory and do not cover even the variable costs of moving grain.* Earnings per ton-mile are also low in the mine products group at only 0.94¢ per ton-mile. The average carload is naturally very high in this group, but on the other hand the length of haul is low. Freight rates for this group presumably covered variable costs in 1973, but there cannot have been much left over as a contribution to railway fixed costs.

Statutory grain and mine products accounted respectively for 17½% and 41% of total tons moved by rail in 1973. Statutory grain did not cover variable costs so that the contribution to fixed costs was negative; mine products can only have made a very modest contribution to overhead; consequently, the railways had to make up the shortfall of revenue on grain

*See, for example, the analysis carried out by the Canada Grains Council on data for 1970 and 1971 (8, pp. 112-25). The grain rates have, of course, remained unchanged since that time while costs have continued to rise steeply.

and coverage of fixed costs from the remaining two-fifths of the traffic carried. In general, variable costs account for some 75% of total railway costs so that the burden of fixed costs is a substantial 25% of railway costs.

The commodity group yielding the highest revenue per ton-mile was animals and animal products. This consists principally of meat moving in refrigerated cars and cattle moving in single and double deck cars. Although the railways obtain a contribution to fixed costs from this traffic, nevertheless the variable costs are quite substantial in the transport of meat because of the need for expensive refrigerated equipment and the heavy non-revenue yielding tare weight of the refrigerated cars. In any event, the traffic movement in this group is not very large and accounts for only $\frac{1}{2}\%$ of total tons moved by rail. The agriculture products group yields only a modest return of 1.35¢ per ton-mile and this group only accounts for $3\frac{1}{2}\%$ of total tons moved.

The piggyback (Plan 1) group is also small, accounting for only 2% of all traffic moved; the rate per ton-mile is only slightly above the average for all traffic excluding statutory grain and, while the length of haul is high, average carload is very low. The forest products group also produces ton-mile revenue at about the average level and this accounts for $10\frac{1}{2}\%$ of all tonnage moved. However, car loadings are slightly below average, and length of haul is very low.

From this superficial consideration of freight rates, traffic characteristics and traffic volume, it is unlikely that the contribution to fixed costs from these four groups - animal, agriculture, forest and piggyback - would do much to meet the shortfall from grain and mine products.

This leaves manufacturing and miscellaneous products to meet the major part of the burden of railway fixed costs. Average revenue per ton-mile in this group was 2.38¢ in 1973, more than 40% higher than the average for all traffic excluding statutory grain. The average carload at 38 tons was rather low, but the length of haul was appreciably higher than that recorded for all traffic. Manufacturing and miscellaneous products accounted for 25% of all tonnage moved by rail in 1973, but this group yielded 51% of freight traffic revenue from domestic Canadian traffic. As a broad generalization, the freight rate picture is therefore one where manufacturing and miscellaneous goods are meeting the greater part of the railway overhead, while there is a negative contribution to fixed costs from statutory grain and only a modest contribution from mine products.

The next table shows the distribution of rail tons moved

in 1973 by province of origin. The total column excludes statutory grain, but includes the agriculture, animal, forest and piggyback groups which are not shown separately in the table.

TABLE 2.5

Rail Tons Moved by Province of Origin - 1973% distribution

	<u>Statutory grain</u>	<u>Mine</u>	<u>Manufacturing & miscellaneous</u>	<u>Total</u>
Maritimes	-	15.4	13.2	13.7
Quebec	-	5.6	26.0	14.2
Ontario	1.7	33.5	33.3	32.2
Manitoba	14.6	4.9	4.7	4.7
Saskatchewan	64.1	6.5	5.3	5.8
Alberta	19.6	16.3	10.9	12.9
B.C.	-	17.8	6.6	16.5
Total - %	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
Total - thousand tons	22,997	53,467	32,332	107,317

Source: Calculations from Canadian Transport Commission, Traffic and Tariffs Branch Reference Paper No. 1.1, Commodity Flow Analysis 1973, Tables 2, 5-11.

The beneficiaries from low freight rates on statutory grain are, of course, the Prairie Provinces and especially Saskatchewan. In the mine products group, the Prairie Provinces account for 27.7% of total shipments, which was slightly in excess of their 23.4% share of all traffic excluding statutory grain. The Maritimes also accounted

for slightly more of the traffic in mine products (15.4%) than their share of all traffic excluding statutory grain (13.7%). Turning to the manufacturing and miscellaneous group which meets most of the railway overhead costs, the Maritimes share (13.2%) was slightly less than their share of all traffic and this was also true of the Prairies with a 20.9% share of originating traffic. As expected, Ontario originated more manufacturing and miscellaneous traffic than any other province, but Quebec had the greatest gap between its share of manufacturing and miscellaneous (26.0%) and its share of all traffic excluding statutory grain (14.2%). (The major part of this gap was offset in British Columbia. This province had a much lower share of manufacturing and miscellaneous loadings than of total traffic, because of heavy shipments of forest products which have not been shown separately in the table.)

Table 2.6 shows rail average revenue, average haul and average carload by province of origin for all traffic excluding statutory grain. (The inclusion of grain would, of course, reduce revenue per ton-mile and per car-mile very substantially in the three Prairie Provinces.)

This table is difficult to interpret because of variations in type of traffic, average haul and average carload. In terms of revenue per ton-mile, the railways obtained their highest earnings from traffic originating in Quebec and Ontario.

TABLE 2.6

Rail Average Revenue, Average Haul and Average Carload:Total Traffic excluding Statutory Grain - 1973

<u>Province of Origin</u>	<u>Average Revenue ¢ per</u>		<u>Average Haul</u>	<u>Average Carload</u>
	<u>ton-mile</u>	<u>car-mile</u>	<u>miles</u>	<u>tons</u>
Maritimes	1.96	65.9	220	51.5
Quebec	2.25	73.1	459	40.6
Ontario	2.24	75.5	433	47.4
Manitoba	1.85	74.3	567	46.4
Saskatchewan	1.13	79.9	842	64.2
Alberta	1.14	69.5	693	65.6
B.C.	1.22	63.6	655	63.3
Total	1.68	71.6	508	51.4

Source: Canadian Transport Commission, Traffic and Tariffs Branch Reference Paper No. 1.1, Commodity Flow Analysis 1973, Table 12. Freight assistance paid on shipments from the Select Territory is not included in the revenue figures above.

However, in addition to the freight rates charged to shippers from the Maritimes, the railways also received payments under the Maritime Freight Rates Act. On the structure of traffic destinations in 1973, it would appear that these subsidy payments were worth an additional 22% to the railways. If the figure of 1.96¢ per ton-mile recorded in the table were increased to this extent, revenue per ton-mile on traffic originating in the Maritimes would increase to 2.39¢ or approximately to the Quebec/Ontario level. Although average

carload was less in Quebec and Ontario than for Canada as a whole, average revenue per car-mile was also above the national average from these two provinces. Similarly, the addition of the transport subsidy would place average revenue per car-mile in the Maritimes above the national average. However, length of haul was below average from Quebec and Ontario and very low indeed from the Maritimes.

Turning to Western Canada, railway revenue per ton-mile was substantially below the national average on traffic originating in all provinces except Manitoba. However, both Saskatchewan and Manitoba yielded a revenue per car-mile above the national average. Length of haul was above the national average from all four Western Provinces and so was average carload except in the case of Manitoba.

The conclusion from the earlier examination was that manufacturing and miscellaneous products were meeting the bulk of railway fixed costs and that contribution to overhead was negative from grain and very modest from mine products. This commodity pattern takes the geographical form of high railway revenue per ton-mile on freight originating from the most heavily industrialized provinces, Ontario and Quebec. A similar revenue per ton-mile is obtained on traffic from the Maritimes when subsidy payments are included, while the lowest revenue per ton-mile is found on traffic originating from Saskatchewan, Alberta and British Columbia.

The examination now proceeds to consider only the manufacturing and miscellaneous products group. In Table 2.7 below, the figures of revenue per ton-mile fall into three broad classes. Firstly, there are the high revenue yields from Ontario and Quebec traffic. Secondly, there are intermediate yields from British Columbia and Manitoba traffic, with the Maritimes also included in this group if allowance is made for MFRA subsidy payments. Finally, there are the much lower figures of revenue per ton-mile from Saskatchewan and Alberta. However, average carload was much higher from these last two provinces, suggesting a greater proportion of lower valued products. Average length of haul was greatest for traffic originating from British Columbia, but traffic originating in Ontario moved further than that from the three Prairie Provinces. Average length of haul was lower from traffic originating in Quebec and the Maritimes.

On balance, the data in Table 2.7 may not support allegations of across-the-board discrimination in freight rates against manufacturing and miscellaneous traffic originating in one part of the country rather than another; at the same time it is not possible to allow refutation of such charges. An attempt was made to explore this further through regression analysis with the dependent variable revenue per ton-mile y and the independent variables average length of haul x_1 and average carload x_2 . These data are given as

TABLE 2.7

Rail Average Revenue, Average Haul and Average Carload:
Manufacturing and Miscellaneous Products - 1973

<u>Province of Origin</u>	<u>Average Revenue</u>		<u>Average Haul miles</u>	<u>Average Carload tons</u>
	<u>ton-mile</u>	<u>¢ per car-mile</u>		
Maritimes	1.87	57.8	505	37.6
Quebec	2.52	74.1	537	36.9
Ontario	2.78	77.6	784	33.2
Manitoba	2.14	87.2	674	39.3
Saskatchewan	1.60	100.3	670	53.5
Alberta	1.79	101.7	695	57.3
B.C.	2.23	62.3	971	38.7
Total	2.38	75.7	673	37.9

Source: Canadian Transport Commission, Traffic and Tariffs Branch Reference Paper No. 1.1, Commodity Flow Analysis 1973, Table 12. Freight assistance paid on shipments from the Select Territory is not included in the revenue figures above.

provincial origin/destination matrixes in the Commodity Flow Analysis 1973, Tables 13-19. As in the earlier discussion, the four Atlantic Provinces are treated as one region and the matrix is therefore on a seven-by-seven basis. Table 2.8 gives 1973 observations of the dependent and independent variables. However, earnings from traffic originating in the Maritimes are supplemented by MFRA subsidy payments and it was therefore decided to exclude all traffic originating in

the Maritimes from the regression calculations*. This reduced the size of the matrix to six-by-seven with 42 observations.

From a theoretical standpoint, a freight rate can be considered in two components, terminal charges which do not vary with distance travelled and line haul charges which vary directly with distance travelled. Hence, the freight rate per ton over a distance x_1 would be of the form $b + cx_1$, and revenue per ton-mile y would be $bx_1^{-1} + c$. A similar argument can be advanced in respect of the relationship between revenue per ton-mile and average carload x_2 and this explains the form of equation (2.1) below. However, a graphical examination of the data in Table 2.8 suggested that an ordinary linear relationship would be more appropriate and this is estimated in (2.2). There was also a slight suggestion from the graph of curvilinearity with respect to x_2 and this is estimated in (2.3). Finally, an interaction term was included in (2.4). The graphs did not suggest any logarithmic or semi-logarithmic relationships.

*Shipments to the Maritimes are, of course, not subsidized. It could be argued that subsidies on the east-west movement would have the effect of reducing rates from the west to the Maritimes. However, this effect would be weak because there is more rail traffic in total and for manufacturing and miscellaneous products in the west-east direction than in the east-west (Commodity Flow Analysis 1973, Tables 1 and 10.)

TABLE 2.8

Manufacturing & Miscellaneous Products 1973: Link-by-Link Data

<u>Link</u>	<u>Observation number</u>	<u>Revenue per ton mile(c)</u>	<u>Aver. length of haul(miles)</u>	<u>Aver. car load(tons)</u>	<u>Observed (y) minus Calculated (y) as % of Observed (y)</u>	
					<u>Equation 2.5</u>	<u>Equation 2.6</u>
		<u>Y</u>	<u>X₁</u>	<u>X₂</u>		
Mar - Mar	10	2.87	202	47.7		
Que	11	1.45	742	28.9		
Ont	12	1.39	1,047	28.7		
Man	13	2.78	2,169	22.2		
Sask	14	2.49	2,615	22.2		
Alta	15	3.05	2,841	22.8		
B.C.	16	2.28	3,569	25.7		
Que - Mar	20	2.20	686	28.7	-34.3	-20.3
Que	21	2.44	249	50.9	3.0	13.0
Ont	22	2.45	415	37.4	-12.8	- 0.9
Man	23	2.97	1,417	22.5	3.3	- 1.7
Sask	24	3.20	1,821	20.6	13.4	7.6
Alta	25	3.05	2,239	20.5	14.5	7.0
B.C.	26	2.53	2,892	21.5	8.8	12.9
Ont - Mar	30	2.50	1,089	26.1	-15.2	- 4.1
Que	31	2.82	463	33.6	- 2.0	8.9
Ont	32	2.99	253	47.4	16.8	25.6
Man	33	3.24	1,190	23.4	9.5	5.5
Sask	34	3.47	1,450	23.7	18.8	14.3
Alta	35	2.99	2,117	25.6	17.0	9.0
B.C.	36	2.29	2,761	25.5	2.9	7.2
Man - Mar	40	2.32	2,372	20.8	- 9.6	- 2.5
Que	41	1.45	1,771	50.1	-22.7	-16.8
Ont	42	1.80	763	53.7	-14.6	- 4.9
Man	43	2.87	317	37.5	2.4	- 1.2
Sask	44	2.72	470	32.9	- 6.5	-10.1
Alta	45	2.58	841	31.3	- 8.6	-13.7
B.C.	46	2.04	1,474	28.5	-29.5	-18.6
Sask - Mar	50	0.97	2,430	70.7	17.2	8.1
Que	51	1.32	1,167	61.9	-22.6	-15.6
Ont	52	1.41	1,195	68.5	2.2	6.2
Man	53	2.41	387	54.2	8.8	0.7
Sask	54	2.53	188	39.9	- 9.5	-13.6
Alta	55	1.98	533	57.4	- 2.5	-13.9
B.C.	56	1.24	1,216	73.7	3.8	6.1
Alta - Mar	60	1.73	2,993	35.9	- 2.4	- 1.1
Que	61	1.21	2,286	58.7	- 5.3	- 6.5
Ont	62	1.30	1,958	50.9	-28.9	-24.2
Man	63	2.27	848	46.5	- 0.3	- 9.4
Sask	64	2.56	525	52.6	14.2	6.3
Alta	65	2.90	203	57.4	25.4	18.9
B.C.	66	1.76	600	63.0	- 2.8	5.6
B.C. - Mar	70	1.32	3,376	41.6	- 7.6	-11.2
Que	71	2.24	2,843	19.0	- 7.7	- 2.3
Ont	72	2.26	2,602	22.4	- 5.9	- 0.2
Man	73	2.67	1,417	30.6	2.9	- 4.2
Sask	74	2.68	1,078	30.2	- 2.4	- 8.0
Alta	75	2.48	731	39.1	- 4.0	-10.3
B.C.	76	1.29	393	56.1	n/a	n/a

Source: Canadian Transport Commission, Traffic and Tariffs Branch Reference Paper No. 1.1, Commodity Flow Analysis 1973, Tables 10, 13 - 19, and regression calculations.

The equations below were estimated from 42 observations. The mean values were 2.27¢ for average revenue per ton-mile y , 1,334 miles for average length of haul x_1 and 40.3 tons for average carload x_2 . The estimates of y and x_2 are not too far distant from the figures shown for manufacturing and miscellaneous products in Table 2.7 above; average length of haul is almost twice as high, because the regression gives equal weight to a long-distance movement, such as B.C. to Quebec where the traffic is light, as it does to a short-distance movement, such as the very heavy traffic from Ontario to Quebec. In each equation, the first line of figures in parentheses gives the standard errors and the second line t -statistics.

$$y = 0.474 + 301.8x_1^{-1} + 47.3x_2^{-1} \quad (2.1)$$

$$(.213) \quad (51.6) \quad (5.7)$$

$$(2.22) \quad (5.85) \quad (8.34)$$

$$\bar{R}^2 = 0.647$$

$$y = 4.212 - .000388x_1 - .0353x_2 \quad (2.2)$$

$$(.200) \quad (.000063) \quad (.0036)$$

$$(21.09) \quad (6.13) \quad (9.70)$$

$$\bar{R}^2 = 0.712$$

$$y = 4.906 - .000430x_1 - .0684x_2 + .000372x_2^2 \quad (2.3)$$

$$(.537) \quad (.000069) \quad (.0241) \quad (.000268)$$

$$(9.13) \quad (6.19) \quad (2.84) \quad (1.39)$$

$$\bar{R}^2 = 0.719$$

$$y = 3.852 - .000170x_1 - .0269x_2 - .00000553x_1x_2 \quad (2.4)$$

(.359)	(.000192)	(.0079)	(.0000046)
(10.73)	(0.89)	(3.41)	(1.20)

$$\bar{R}^2 = 0.715$$

At this stage, (2.3) and (2.4) can be abandoned. They explain very little more of the variation than (2.2) and significance is low on the squared term in (2.3) and on the interaction term in (2.4). In spite of an *a priori* preference for (2.1), a better fit is provided in (2.2) in terms of significance of the regression coefficients, the square of the multiple correlation coefficient, and negligible skewness and kurtosis. The discussion therefore proceeds in terms of (2.2).

Of the two explanatory variables used, average carload x_2 explained more of the variation than average length of haul x_1 ; the simple correlation coefficients were -0.68 between the dependent variable and x_2 and -0.25 between the dependent variable and x_1 . The equation explained a remarkably large 71% of the total variation. This is surprising in view of the heterogeneity of the broad group of manufacturing and miscellaneous products, the tendency for freight rates also to be a function of the value of product carried, the relationship of rail freight rates to the availability of competitive modes of transport, the question of backhaul versus fronthaul rates, and the multi-

plicity of other considerations which influence freight rates. However, to some extent, the effects of these factors may have been partially caught in the variables used; average carload for example may also have been an imperfect inverse proxy for product value.

An examination of the residuals from (2.2) showed that the expected revenue per ton-mile on movements within British Columbia was 61% higher than the figure actually observed (observation 76 in Table 2.8). The next highest deviation of calculated from observed amounted to 33%. It was therefore decided to omit the observation for movements within British Columbia on the grounds that this was dominated by low-rated and presumably low-valued products. The re-estimated equation is shown as (2.5).^{*} The total number of observations used in the regression is now 41 with mean values of 2.30¢ for revenue per ton-mile y , 1,357 miles for average length of haul x_1 , and 39.9 tons for average carload x_2 .

$$y = 4.218 - .000405x_1 - 0.344x_2 \quad (2.5)$$

(.188)	(.000060)	(.0034)
(22.47)	(6.77)	(10.00)

$$\bar{R}^2 = 0.737$$

As expected, (2.5) shows an improvement in terms of goodness of fit and 74% of the total variation is now explained.

^{*}(2.1) was also re-estimated in this way; goodness of fit was still considerably inferior to (2.5).

The residuals have been expressed in percentage form in Table 2.8. The next table summarizes these residuals on a geographical basis. The clearest pattern in this table is the high revenue per ton-mile on traffic destined for the Prairie Provinces.

TABLE 2.9

Average Deviation (%) of Revenue per Ton-Mile Calculated
from Equation (2.5) from Observed Value

	<u>Origin</u>	<u>Destination</u>
Maritimes	n/a	-8.6
Quebec	-0.6	-9.5
Ontario	6.8	-7.2
Manitoba	-12.7	-4.4
Saskatchewan	-0.4	4.7
Alberta	-	7.0
B.C.	-4.1	-3.4
Total	-1.8	-1.8

The next step is to re-estimate (2.5) introducing a dummy variable x_3 which takes the value of one for destinations in the three Prairie Provinces and zero for other destinations.* Sample size continues to be 41 and mean values for the dependent and independent variables the same as in (2.5).

*A form of (2.1) was also re-estimated in this way. The square of the multiple correlation coefficient was slightly higher at 0.819 and t-statistics were also slightly more significant. However, there was a problem with a kurtosis value of 2.02 and it was therefore decided not to return to this formulation. In addition to the dummy variable approach used in cont'd....

$$y = 3.696 - .000297x_1 - .0295x_2 + .408x_3 \quad (2.6)$$

(.205) (.000057) (.0032) (.102)

(18.00) (5.17) (9.33) (4.00)

$$\bar{R}^2 = 0.812$$

Equation (2.6) suggests that, if the destination of a shipment of manufacturing and miscellaneous products is the Prairie Region, the average revenue per ton-mile earned by the railways is increased by 0.4¢ as compared with other destinations in Canada. This equation explains 81% of the variation, as against 74% in (2.5). The regression coefficients on all the independent variables are highly significant. However, the residuals to (2.6) were distributed with greater skewness than in (2.5) (0.68 as against 0.23) and kurtosis was also a greater problem (0.31 as against 0.06).

The residuals between observed values and calculations from (2.6) are shown in Table 2.8. In seven cases, the calculated value diverges from the actual observation by more than 15%, but there is no obvious pattern in these divergences. The two instances of observed value in excess of calculated value were the movements within Ontario and within Alberta.

(2.6), regressions were also calculated omitting x_3 and using an alternative variable of distance of destination from the centre of the Prairies (taken as the mean of Regina and Saskatoon) minus 500 miles. This gave zero values for destinations in Manitoba, Saskatchewan and Alberta and positive values for other destinations. However, these regression equations did not show any improvement in terms of goodness of fit and are therefore not shown.

The five cases where average revenue per ton-mile was appreciably less than expected from the equation were, in descending order of magnitude, Alberta to Ontario, Quebec to the Maritimes, Manitoba to B.C., Manitoba to Quebec, and Saskatchewan to Quebec. The table below shows the deviations of calculated revenue from observed values on a geographical basis. With the inclusion of the dummy variable, there is now very little variation in the column by destination. With respect to origin, traffic moving from Ontario continues to be shown with actual revenue per ton-mile appreciably in excess of the figures calculated from the equation, while the reverse is true in respect of Manitoba.

TABLE 2.10

Average Deviation (%) of Revenue per
Ton-Mile Calculated from Equation (2.6) from

	<u>Observed Value</u>	
	<u>Origin</u>	<u>Destination</u>
Maritimes	n/a	-5.2
Quebec	2.5	-3.2
Ontario	9.5	0.3
Manitoba	-9.7	-1.7
Saskatchewan	-3.1	-0.6
Alberta	-1.5	-0.5
B.C.	-6.0	2.6
Total	-1.3	-1.3

To conclude this section on general freight rate disparities, manufacturing and miscellaneous products meet most of the railway fixed costs. In terms of the geographical

origin of different commodity groups, railway revenue per ton-mile is highest on traffic originating in Quebec and Ontario and lowest on traffic from Saskatchewan and Alberta. Considering only traffic in the manufacturing and miscellaneous group, it would appear that over 70% of the variation in revenue per ton-mile between different movements can be explained in terms of differences in carload weights and differences in the length of haul. From the regression analysis, there does not seem to be evidence of unduly high freight rates on traffic originating in the Prairie Provinces. However there is evidence to suggest that average revenue per ton-mile tends to be higher on products destined for the Prairie Provinces and this would be the expected result of short-haul long-haul discrimination.

3. EQUITY AND SUBSIDY

(a) *Equity and the Disparities*

The discussion in the first section of this chapter established the existence of regional disparities. Income levels in the Maritimes are substantially below the Canadian average, employment opportunities are growing less rapidly and unemployment rates are above the national average. In the Prairie Provinces, there is a problem of slow growth of employment opportunities in Saskatchewan and Manitoba and an income instability problem in Saskatchewan. Fortunately, the present study does not require consideration of these disparities in terms of equity or answers to such teleological problems as determining the extent of income short-fall that would be equitable in the Maritimes or the short-fall in employment growth that would be equitable in Saskatchewan.

The conclusions as to the existence of rail freight rate disparities in Section 2 are much less clear and the concept of equity is also very difficult in this area. As long ago as the 1914 Western Rates Case, the Board of Railway Commissioners recognized that "it is practically impossible to formulate any hard and fast principle which would determine when and where discrimination ceases to be harmless and becomes undue" (quoted in 19, p. 229).

In a recent article, Studnicki-Gizbert has assigned two sets of meanings to the concept of equity, equity in outcome

and equity as a process. In respect of equity in outcome, the interpretation has ranged from a goal of equality in all outcomes to the more modest neutral concept of equal treatment of equals without discrimination. In the freight rate context, this neutrality concept would mean that given equivalent distances, volume of traffic and handling characteristics, rates per unit-distance should be equal, regardless of whether competitive conditions exist or not (89, pp. 648-51). On this neutral concept, equity would be satisfied for most movements on a cost-based rail rate system.

A major problem in establishing a cost-based rail rate system relates to cost allocation. Indivisible costs, which are common to all traffic, are typical of railway operations and in Canada only some 75% of total railway costs are classified as variable in the long period. Section 276 of the Railway Act (11) requires that freight rates must be compensatory but, if freight rates covered no more than long-term variable costs, there would remain the problem of meeting railway fixed costs.

While it may be in accordance with equity to suggest that each product should pay a freight rate equivalent to long-run variable costs plus a uniform percentage addition to cover overhead costs, this is not a practical solution.*

*George Wilson has suggested, outspokenly but justifiably, that "average cost pricing is economic nonsense" and also pointed out that long-run marginal cost represents a rate floor that can be too high for specific movements in some transport sub-markets (94, pp. 8-9)

If lower rated traffic were required to pay an average contribution to overhead, some of the traffic would be lost to other modes, or, unable to absorb a higher freight charge, it would cease to move. Consequently, the railways have been forced to practice price discrimination in the sense of obtaining greater contributions to overhead costs from some traffic movements than from others.*

A solution could be found to this dilemma by making freight rates equivalent only to long-run variable costs, but this would leave a deficit of some \$500 million per annum to be met by government. Increased taxation to provide a subsidy of this extent would involve allocative inefficiencies of

*Making highly simplified assumptions on homogeneity of output, the suggestion has been made that the average cost curve is always above the demand curve for rail traffic in Canada and this explains why it is necessary to practice price discrimination in order to achieve a determinate output. See my article (49), summarized in Chapter III, Section 4(b). An alternative hypothesis to explain the need for price discrimination could be advanced in terms of inefficiencies of having two national railway systems rather than one. On the assumption of increasing returns to scale, the existence of two firms where one would be more efficient would increase costs. However, it is not the intention to examine evidence for this hypothesis in the present study. In any event, it is possible that a consolidation of two railway systems could mean the provision of railway services on a higher cost curve as a result of removal of competitive stimulus, even if this competition is confined to service as distinct from price. This problem of ineffective utilization of resources and consequently higher costs of production has been christened X-inefficiency by Leibenstein; this tends to be more of a problem under monopoly where the pressure to minimize costs is less. For a discussion of X-inefficiency see (64).

resources between transport and other economic activities and income redistribution effects of uncertain direction. The problem in rail freight rates is to reach a compromise between equity in the sense of similar contributions to overhead from different traffic movements and commercial viability which requires some degree of price discrimination. There is no ready solution and the considerations below, although relevant towards a trade-off between equity and railway revenue requirements, are not original.

(i) The freight rate structure should not *in toto* discriminate against any of the geographical regions of Canada.

(ii) For movements of similar quantities of a given product over similar distances in different parts of Canada, freight rates should not discriminate over and beyond any discrimination based upon differences in variable costs. In practice, it can be difficult to establish where such cases of discrimination exist; for example, one does not normally find a major flow of a product from the Prairies to Ontario accompanied by a similarly large reverse flow of the same product from Ontario to the Prairies. Nevertheless, the long-haul and short-haul freight rate discrimination problem is of this broad genus.

(iii) Because of railway revenue considerations, some products must continue to make a higher than average contribution to railway fixed costs. In general, these are high

value products where freight rates are a very small part of the cost of production. Nevertheless, there should be limits to the extent to which any category of goods is obliged to make an above-average contribution to railway fixed costs, but Section 278 of the Railway Act only gives this protection if the shipper is captive to rail.

(iv) There is evidence that departure from the principle of equity in one area of freight rates can automatically cause problems in other areas. Low freight rates on statutory grain have played a fundamental part in allegations of discrimination in favour of raw materials as against finished products, for example in the rapeseed case and in the debate on the transport of meat versus livestock and grain.

(b) Justice and Subsidy

The demands for redress of transport problems in the Prairie Provinces and the Atlantic Region normally take the form of requiring the correction of inequities rather than requesting transport subsidies to facilitate reaching distant markets. The following quotation from a 1970 Manitoba ministerial address is reasonably typical.

Manitoba seeks equity, not subsidy, and to secure adequate economic growth in the Province we must ensure that freight rates reflect only the costs inherent in our distances from markets, and not an additional impost based on having to pay because of lack of alternative transportation. (79, p. 83).

The demand for equity rather than subsidy has obvious emotional appeal. Superficially, a correction of inequity would result in a superior economic allocation of resources, while subsidy would lead to an inferior allocation. However, in a world where "second best" considerations are pervasive and there is no logical way of interpreting allocative efficiency in respect of meeting the fixed costs incurred in railway operations, the distinction between equity and subsidy is very blurred.

Given that it is not feasible to cover railway fixed costs through equal proportionate contributions to overhead from all traffic movements, the only alternative equality criterion would seem to be zero or near-zero contribution to overhead from all traffic, with freight rates approximating to long-run variable costs. Apart from the substantial problem of meeting fixed costs through government subsidy, it is doubtful if this type of equity would meet the requirements of the Atlantic Region and the Western Provinces. This approach would eliminate freight discrimination on finished products as against raw materials and also the short-haul long-haul problem. On the other hand, freight rates would have to be increased on western grain and products of mines would enjoy only modest decreases in rates.

Considering manufacturing industry, the results of lower freight rates would be to reduce the burden of transport

charges in industrial costs and hence increase the relative importance of exploitation of economies of scale. Railway spokesmen have alleged that substantial reductions in freight rates on manufactured goods would destroy the manufacturing industry of the Atlantic Region and the West, because much of this industry flourishes on the basis of protection given by distance from Central Canada and the burden of freight rates. This complex problem is not pursued further in the present study, but it should be noted that there is no *a priori* reason for believing that a general reduction in freight rates on manufactured goods would necessarily benefit the Atlantic Region and the Western Provinces more than Central Canada.

If freight rate reductions were confined to shipments of manufactured goods from the Atlantic Region and the West (and possibly inbound shipments of raw materials), there would be more possibility of meeting regional aspirations for industrial development. While pursuit of equity in respect of some freight rates could have this result, it is unlikely that equity considerations by themselves would have this general effect on the rate structure. If the objective is to stimulate regional economic activity, it may be necessary to reduce outbound freight rates to a level below that dictated by equity considerations. However, in examining the effects of transport subsidies as a stimulus to regional out-

put, the present study does not need to be too concerned with whether subsidy is given to offset an inequity or to provide transport at rates which are below the costs of producing the required transport services. Regardless of whether previous freight rates were "too high", "about right", or even "too low" from the standpoint of equity, the effect of transport subsidies in promoting increased output can be compared with alternative methods of achieving this objective.

The next chapter examines the general role of transport subsidies and the study then proceeds to compare the efficiency of achieving output increases from transport subsidies as against subsidies on product price or factor prices.

CHAPTER III: THE ECONOMIC BASIS FOR TRANSPORT SUBSIDIES

This chapter is concerned with the general problem of the circumstances under which transport subsidies can be economically justified.* The term subsidy is interpreted in the usual sense as the excess of costs of providing transport over the amounts which are collected in the market place from users of transport services. There is no detailed discussion of cross-subsidization, where within a mode some commodities are charged at high rates and others at rates which barely cover out-of-pocket costs.

The Canadian National Transportation Act of 1967 relies more on market-place competition than on regulation or subsidy as policy tools. It declares the need for "an economic, efficient and adequate transportation system" and expresses faith in competition as the means by which this is "most likely to be achieved". Competitive conditions require *inter alia* that "each mode of transport, so far as practicable, bears a fair proportion of the real costs of the resources, facilities and services provided that mode of transport at public expense". However, the need for subsidized services under certain conditions is explicitly recognized and it is required that "each mode of transport, so far as practicable, receives

*An earlier version of this chapter was presented at the University of Manitoba Center for Transportation Studies in February 1975 (50).

compensation for the resources, facilities and services that it is required to provide as an imposed public duty" (9, Section 3).

The extent of Canadian transport subsidies paid to carriers is substantial. For 1972, payments to the Canadian railways under the National Transportation Act amounted to \$139 million, with a further \$13 million expended under the Maritime Freight Rates Act. Adding Darling's figures of government subscriptions to CN preferred stock, coverage of the CN deficit, and purchase of grain cars (22, p. 75), the assistance in 1972 increased to some \$260 million. Federal Government assistance to water carriers, primarily on the east coast, was \$47 million in the fiscal year 1972-3, and there were also modest subsidies of \$2 million to regional air carriers (23, pp. 51-3).

However, these figures related only to direct payments to carriers, while the bulk of transport subsidy in Canada is in the provision of infrastructure for which costs are only partially recovered through user charges. Assuming a required six per cent return on government investment in infrastructure, it has been calculated that the total deficit on the four major modes - rail, road, marine and air - incurred by all levels of government in respect of direct subsidies to carriers and non-recovered infrastructure costs totalled some \$1.5 billion in 1968 (43, p. 27).

Subsidization of transport in Canada is clearly substantial,

but the conceptual basis for this subsidization has received little attention in the literature. The economic case against subsidies rests primarily on the argument that competition can achieve an economically optimal allocation of resources and that subsidies therefore cause distortions from this optimal allocation. The chapter commences with a discussion of Pareto optimality and the main areas in which the real world diverges from the Pareto requirements. Subsequent sections consider the case for transport subsidies under increasing returns to scale; carrier monopoly power; social benefits not rewarded in the market-place; and the use of transport policy to secure non-transport public policy goals, such as income redistribution and regional development.

1. PARETO OPTIMALITY

A Pareto-optimal allocation of resources is one in which it would be impossible to reorganize production and distribution so that the utility of one or more individuals would be increased without decreasing the utility of others. Conversely, an allocation is Pareto-nonoptimal if the utility of at least one person could be increased without reducing the utility of anyone else. It can be demonstrated that Pareto-optimal conditions will be achieved under perfect competition if second order conditions are satisfied for each consumer and producer; no consumer is satiated; and there are no external effects

either in consumption or production (51, pp. 255-64).

Under Pareto-optimal conditions, it is impossible to secure a reallocation of goods that increases the utility of one or more consumers without reducing the utility of at least one other consumer. Product-product relationships require that consumers arrange their expenditure so that the marginal satisfaction from the last dollar spent on good X is exactly equivalent to the marginal satisfaction from the last dollar spent on good Y. Otherwise, the consumer will substitute between products until the equality condition is re-established. Similarly, goods X and Y are produced to the point where the last unit of resources used to produce X yields a return in the market exactly equivalent to the last unit of resources used to produce Y.

Factor-factor relationships are such that the producer employs factors, say labour and capital, to the point where the marginal product attributable to the last dollar of expenditure on labour is equal to the marginal product of the last dollar expended for the services of capital. (The converse can appear naive if suppliers of factors are considered as supplying each factor up to the point where the marginal disutilities of factor supply are equal, say for supplying capital and labour. The concept is somewhat more meaningful when it is applied to an individual worker able to provide different types of labour.) Finally, the factor-product

relationships require that each factor of production be employed to the point where its marginal value product is equal to its price. Each factor is supplied to the point where the return just compensates for the marginal disutility of factor supply.

Subsidies would be distorting in a Pareto-optimal world characterized by perfect competition, no externalities and unwillingness to decrease the utility of any one consumer in order to increase the utility of others. However, it has long been recognized that a complete *laissez faire* price mechanism does not function in practice with the smoothness specified for conditions of Pareto optimality. The competition of the real world is a very imperfect image of the perfect competition of the textbook. The seven main areas in which the real world diverges from the Pareto requirements are listed below, and then examined in the context of transportation.

(i) Increasing returns to scale have been advanced as justification for subsidy to the point where price is equal to marginal cost. Average cost pricing would be necessary if total costs were to be covered by the industry but, to maximize the excess of benefits over costs, price should be equal to marginal cost with the shortfall in total costs met by government subsidy.

(ii) Goods jointly consumed by the community as a whole cannot be produced merely by reliance on the operation

of a free price mechanism, even though the total benefits from these goods exceed the costs. In addition to public goods such as defence and law and order, public works such as highways and bridges are commonly classed under this head.

(iii) Monopoly, oligopoly and all the other varieties of imperfect competition prevent the achievement of a Pareto-optimal distribution of resources. A firm equates marginal revenue to marginal cost and, if a degree of monopolistic power allows it to influence price by varying output, price will be higher than marginal revenue and marginal cost. The Pareto product-product relationships are violated by differences in the extent of monopolistic power. Similarly, variations in monopsonistic power over factors of production violate Pareto factor-factor relationships. The possession of either monopolistic or monopsonistic power is sufficient to violate the Pareto factor-product relationships. Moreover, in an industry with continuously increasing returns to scale that are internal to the firm, the efficient form of organization is monopoly as this is the way in which internal economies of scale can be most fully exploited.

(iv) Social costs and benefits are not taken into account by the free market price mechanism. A firm may impose costs on the community at large, for example through lack of pollution controls. Alternatively, a firm may bestow benefits on society without private reward, for example through

facilitating increased productivity in other industries. The efficiency of perfect competition explicitly assumes that these external effects do not exist. It has long been an accepted tenet of economic theory that the state should tax firms that inflict social costs on society and compensate those that bestow social benefits.

(v) Income distribution is not considered in the context of Pareto optimality and is exogenous to the allocation of resources. The prevailing income distribution is taken as a datum and the problem of finding an optimal income distribution is not examined. The possibility of interpersonal utility comparisons is denied and the economist *per se* can say nothing about a change which increases the utility of some consumers only at the expense of decreasing the utility of others. This assumption has arid consequences, as most changes in the real world result in a reduction of someone's utility, and the use of compensation criteria has been suggested to overcome this problem. For example, the Scitovsky criterion states that allocation A is socially preferable to B if those who gain from A could compensate the losers into accepting the change, and simultaneously the losers could not compensate the gainers into not making the change (51, p. 279). Subsidies can be justified - on ethical rather than economic grounds - to promote a more "desirable" distribution of income or to compensate the victims of economic

change.

(vi) Market frictions in respect of inadequate knowledge and resource immobility can prevent the attainment of Pareto-optimal allocations. Government subsidies are therefore used to improve the operations of the market in such areas as consumer protection and labour mobility.

(vii) Full employment and stable level of prices are not guaranteed in a *laissez-faire* economy. There is general recognition in free enterprise societies that the state has a responsibility for stabilization policy and the measures used may include subsidies.

The transportation industry does not satisfy the conditions necessary to ensure an efficient allocation of resources without government intervention or subsidy. Pareto requirements are violated in all of the first five areas listed above and only the problems of market frictions and full employment with stable price levels - items (vi) and (vii) - do not fall within the terms of reference of the present study.

(i) Until fairly recent times, there was a general belief among economists that increasing returns to scale were characteristic of rail transport. The discussion below therefore commences with an examination of the conceptual case for transport subsidies on the grounds of diminishing supply price.

(ii) The provision of public goods has always been very important in transport, particularly in respect of infrastructure where costs are not recovered through user charges. The example of Dupuit's bridge (30, pp. 255 - 83) deserves its eminence in the literature, although to some extent this example of zero marginal cost may be regarded as only a special case of increasing returns to scale. The question of public works, where the marginal cost of an additional unit of consumption is nil, is therefore not examined further in the following pages.

(iii) Perfect competition does not exist between or within the various transport modes. Transport companies are not purely price-takers but also determine prices themselves to a very considerable extent. Competition within modes is reduced, for example by the activities of rate bureaus, and this inevitably has repercussions on competition between modes. The discussion below considers two cases - firstly, where price discrimination is not operative, the examination relates to the use of transport subsidies to persuade a company exercising monopolistic power to produce the output that would result without exercise of this power; secondly, where price discrimination is operative, the examination proceeds to the implications of abolition of such discrimination.

(iv) Under social costs and benefits, the role of transport subsidies is discussed in the context of transport as

a strategic factor in economic growth and from the standpoint of the non-economic benefits of transport.

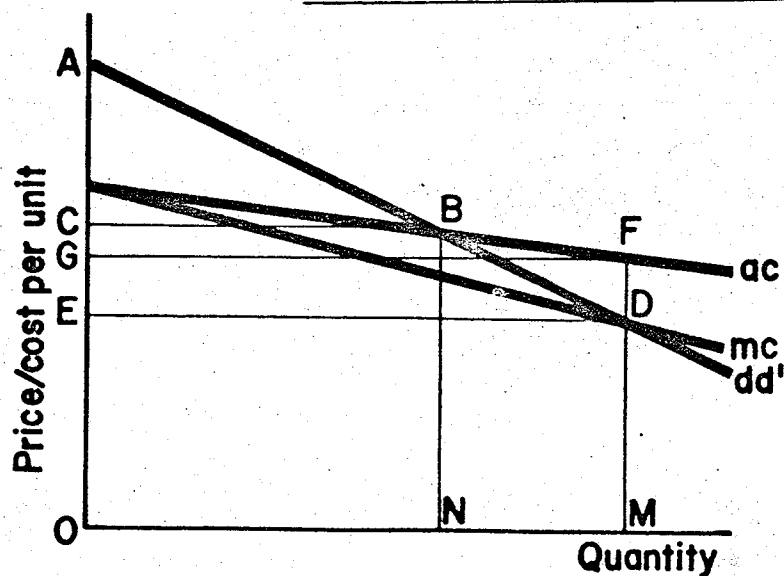
(v) Transport subsidies are considered finally in respect of their ability to achieve public policy goals in respect of income distribution and regional economic development.

(a) *The Theoretical Case for Subsidy under Increasing Returns to Scale*

In The Economics of Welfare, Pigou stated that there is "a presumption in favour of State bounties to industries in which conditions of decreasing supply price *simpliciter* are operating, and of State taxes upon industries in which conditions of increasing supply price from the standpoint of the community are operating" (80, p. 224). The argument in respect of increasing returns to scale is illustrated in the familiar diagram below.

FIGURE 3.1

Increasing Returns to Scale



The demand curve is dd' , the declining schedule of average costs per unit of output is ac , and the

marginal cost curve is mc . If the industry covers average total costs and there are no opportunities for price discrimination, output will be ON at a unit price of BN . The consumer surplus is ABC . Now let price fall to DM where the demand schedule intersects the marginal cost curve. Output increases to OM and the consumer surplus to ADE . Price now falls short of average cost by FD and a subsidy of $GFDE$ has to be paid to cover total costs. This subsidy is justified on the grounds that the payment is less than the increase in the consumer surplus of $CBDE$. This is the simple economic case for subsidization of industries with increasing returns to scale, but this leads immediately to the problem of second best.

(b) The Problem of Second Best

It has been suggested that economies which deviate from the marginal conditions necessary for Pareto optimality can usually be led to a Pareto world through the imposition of taxes and subsidies (51, p. 275). This is not necessarily correct. Tax receipts from those imposing social costs on society would not normally equal subsidy payments to those bestowing social benefits plus other expenditures of government, and additional taxation is usually required. Such taxation always involves a disturbance to the Pareto-optimal factor-product relationships and can involve a disturbance

to product-product relationships. Additionally, the imposition of taxes to finance subsidies implies an income redistribution and this is also a violation of Pareto conditions.

During the 'thirties, there was considerable discussion as to whether, in an otherwise Pareto-optimal situation, indirect taxes would cause a violation of the conditions of optimality. Obviously, the imposition of taxes at different rates on different products would destroy the product-product relationships. From a discussion of which the major participants were Kahn, Hotelling and Frisch, it was agreed that taxes proportional to marginal costs would not destroy the product-product relationships (59, pp. 1-35; 55, p. 151; 37, p. 145). However, a structure of proportionality in indirect taxes which preserves the product-product relationship does not maintain intact the factor-product relationship. If all prices were proportionately higher than marginal costs, then by working a little harder, everyone could be made better off since "the preferred terms at which they exchange leisure and goods are not equal to the true productivity terms at which they can be transformed into each other" (86, pp. 239-40). It is indeed correct that indirect taxation on a proportional basis still breaches the factor-product requirements and the writers in the 'thirties seem to have been aware of this. Kahn stated that "The interests of the national dividend demand that each factor shall be paid a price which is equal

to the value of its marginal product" (59, p. 18). Hotelling recognized quite clearly that both indirect taxes and direct taxes would violate the factor-product relationships (55, pp. 154-5).

Pareto-optimal conditions cannot normally be satisfied once taxation is imposed. At the same time, it is impossible to satisfy these conditions in increasing returns industries without subsidy. The theory of second best says that if one or more of the necessary conditions for Pareto optimality cannot be satisfied, in general it is neither necessary or desirable to satisfy the remaining conditions (51, p. 286). Yet, practical policy advice has to be given and there is value in the approach that violation of Pareto conditions for product X is not relevant to analysis of product Y if the two products are only distantly related.

The theory of second best serves a very useful purpose in showing that, when a subsidy is paid, the taxes are not raised without cost. The direct cost to government of collecting taxes rarely exceeds two cents in the dollar and the administrative cost of spending the tax money may be a similar amount. However, these direct costs may represent only the smaller part of the true loss in welfare through taxation in that the taxes themselves cause a misallocation often between products and always in factor-product relationships. The implicit assumption that tax revenue is raised

at the margin from activities which yield no consumer surplus is often unjustified.

(iii) *Increasing Returns to Scale in Transport*

In writings on railway economics before the Second World War, it was usually assumed that the railways showed increasing returns to scale. The high proportion of fixed costs in railway transport had been stressed by such writers as Wellington in 1893, Acworth in 1911, Ripley in 1927 and Eliot Jones in 1931 (4, p. 322).

In The Economics of Welfare, first published in 1920, Pigou stated the reasons for increasing returns to scale in the railway industry.

Among railways there is ground for believing that, at all events until considerable development has been reached, this condition is generally satisfied. The reason is that the fixed plant of a railway cannot, in practice, be so made as to be capable of effecting less than a certain considerable minimum of transportation. The aggregate costs of arranging for rail transportation for one ounce per week are very nearly as great as those of arranging for the transport of many thousand tons. For the same heavy expenditure must be undertaken for surveying and legal charges, bridging valleys and torrents, tunnelling through rock, erecting stations and platforms, and so on. This implies that the law of decreasing supply price acts strongly till a large investment has been made, and afterwards less strongly.

(80, p. 310)

Similarly, after discussion of the case of zero marginal cost in respect of highway bridges, Hotelling

claimed that the argument of making price equal to marginal cost applied "equally to railroads, except that in the latter case there is some slight additional cost resulting from an extra passenger or an extra shipper of freight" (54, p. 262). In 1953, Klein gave some quantitative support to increasing returns to scale in railway transport. He fitted a Cobb-Douglas type of production function to 1936 data for U.S. railways and obtained a production function homogeneous of degree 1.29 (91, p. 31). The claims of the theorists were apparently supported by the econometricians.

However, the argument of declining marginal cost in railway operations was not universally accepted. As early as 1916, Lorenz, the well-known statistician of the Interstate Commerce Commission, claimed that declining marginal cost was more typical of the early stages of railway development and that constant marginal cost was more realistic for high densities of traffic (24, p. 159). In 1940, Healy argued that:

Under present conditions of maturity, most main line railroad facilities and the operation thereon have had a chance to become closely adjusted to the density of traffic handled and the revenue derived therefrom, so that average unit costs tend to be nearly uniform over a wide range of densities and the cost of

handling additional increments of business are not likely to be much below the average costs.

(quoted in 24, p. 160).

Similarly in 1950 Nelson claimed that the growth in output of the railway industry had largely eliminated increasing returns (4, p. 318).

In an article published in 1952, De Melverda stated that fixed costs in railway operations were an illusion.* De Melverda argued that labour costs were fairly constant at about 60% of total costs in the operation of U.S. railways, regardless of whether one examined fluctuations in time over the 1933-47 period, regional variations on the basis of 1947 costs, or 1944 data on the labour cost share of total costs for different sizes of railway company (24, pp. 162-72). If labour costs form a larger proportion of variable costs than of total costs, this constancy of the labour share of total costs throws considerable doubt on the view that marginal cost is declining in railway operations.

With the rapid price increases of the early 1970's and the use of historic price costing, in many industries marginal cost measured in current dollars has tended to exceed average cost, measured partly in past dollars. This is an additional complication to an already complex problem

*I am grateful to Dr. K. W. Studnicki-Gizbert for bringing this article to my attention.

but, for purposes of evaluation of the existence of economies of scale, obviously the comparison between marginal cost and average cost must be in real terms and not in money terms. The measurement of economies of scale in the various transport modes is an under-researched area both in Canada and in other countries but some work in this field is currently underway in the Canadian Transport Commission. In the meantime, one can perhaps accept the conventional view that, with the exception of pipelines, where scale economies exist for other modes they are likely to be less than for rail.

At the 1972 University of Toronto - York University Conference on Canadian National Transport Policy, Dr. H. Mohring presented a most stimulating paper "Transport Subsidies and the Economic Development of the Atlantic Provinces." Dr. Mohring defined the marginal benefit of a subsidy dollar as the excess of benefit over subsidy cost. This marginal benefit is a function of economies of scale in the industry to be subsidized, the demand elasticity for the product of that industry, and the amount of subsidized output. Thus, in Mohring's table below, for $\alpha = 0.1$, $c = 0.6$, and elasticity of demand = 2.0, the expenditure of a subsidy dollar yields a total return of \$1.67 or \$0.67 in excess of the subsidy expenditure (75, pp. 275-6).

Marginal Benefits per Subsidy Dollar as a Function Scale
Economy Level, Demand Elasticity, and Amount of Subsidized Output*

$$\alpha = (W - W_0)/(W_1 - W_0)$$

Elasticity of Demand (1/b)	0.0	0.1	0.25	0.5	0.75	0.9
Scale Economy Index (c) = 0.6						
2.0	\$4.00	\$0.67	\$0.34	\$0.15	\$0.06	\$0.02
1.0	0.67	0.55	0.40	0.22	0.10	0.04
0.5	0.25	0.22	0.18	0.12	0.06	0.02
Scale Economy Index (c) = 0.8						
2.0	\$0.67	\$0.54	\$0.39	\$0.21	\$0.09	\$0.03
1.0	0.25	0.22	0.17	0.11	0.05	0.02
0.5	0.11	0.10	0.08	0.05	0.03	0.01

Where W = Actual output without subsidy.

W_0 = Output with price equal to average cost.

W_1 = Output with price equal to marginal cost.

c = Scale economy index where the cost of manufacturing an output W is of the form W^c . Increasing returns to scale mean that c is a fraction in the range zero to one; the greater the returns to scale, the lower is c .

$1/b$ = Price elasticity of demand obtained from a demand function of the form $P = aW^{-b}$.

Mohring advances this approach as indicative of orders of magnitude and not as a definitive measure of the benefit of subsidies. He considers the welfare

*As expected, marginal benefits are generally higher for $c = 0.6$ than for $c = 0.8$. The only exceptions are where $1/b = 2.0$ and $\alpha > 0.25$. In correspondence with the present writer, Dr. Mohring has agreed that these exceptions are intuitively surprising. However, the algebraic manipulations appear to be correct and the present writer confirms the accuracy of the arithmetical calculations.

costs of raising tax revenues, points out the lack of data, and speculates that "10-50 cents is a reasonable range for the social costs of tax revenues" (75, p. 277). There is merit in Mohring's argument that marginal benefits per subsidy dollar of ten cents and less are not worth their social costs. In particular, there is little net gain from subsidy when the elasticity of demand is only 0.5 or where $\alpha \geq 0.5$.

The following comments are relevant to the Mohring approach to transport subsidies.

(i) If a transport company is successfully exercising an element of monopolistic power, α must initially be negative, for actual output W is less than output W_0 where average total costs are just covered. Given that perfect competition cannot exist with increasing returns to scale that are internal to the firm, an α which is initially negative is quite likely. A transport company not exercising monopoly power and just covering average total costs would commence with $\alpha = 0$. A private transport company making a loss would commence with $\alpha > 0$, but without a state subsidy this is not a feasible long-run position.

(ii) In respect of the Canadian railways, the Costing Order of the Railway Transport Committee treats long-run marginal costs as equivalent to some 75% of average total costs, i.e., a value of $c = .75$ for Canadian rail transport. Interpolating from Mohring's table, the initial pay-off for subsidy dollars spent on rail transport would be reasonably high for $\alpha \leq 0.25$ and elasticity of demand of unity or above. As a further consideration, the pay-off should be higher in those parts of the country where c is below the system average, because traffic is less dense and the economies of scale further from exhaustion.

(iii) It is often argued that the demand for transport in total is inelastic on the grounds that transport forms only a small portion of the costs of a product and a large change in transport charges has therefore only a small effect on the price of the final product. For example, if transport costs constitute 10 per cent of the total costs of production of a good and transport rates fall by 20 per cent, then the cost of the final good will only decline by 2 per cent. However, this represents a partial approach to transport costs.

Transport must be regarded as a factor input in the production of a good and, to some extent, there can be possibilities for substituting transport for other factors of production. If a reduction in transport rates made it economic for a manufacturer to relocate his plant in an area where labour costs are low, this would mean that a transport input was being substituted for labour. It can only be argued *a priori* that the aggregate demand for transport is inelastic when there are no opportunities for substitution between transport and other factor inputs.

(iv) The demand for transport by a specific mode is, of course, more elastic than the demand for transport in total. If the Mohring table is applied to rail transport, it is legitimate to use the price elasticity of demand for rail without any adjustment only if there are constant returns to scale in competing modes. If competing modes show increasing returns to scale, the subsidy benefit from increased rail transport must be reduced to allow for the rise in costs in the competitive mode. Suppose that the marginal benefits of subsidy expenditure for a given commodity were 22¢ for rail and 10¢ for highway and that the aggregate

transport elasticity of demand was such that an increase in one unit travelling by rail in response to a dollar subsidy expenditure was accompanied by a reduction of four-fifths of a unit travelling by highway. In that case, the net marginal benefit from the subsidy dollar would be $22¢ - (4/5 \text{ of } 10¢) = 14¢$. Conversely, if the competing mode suffered from decreasing returns to scale, the benefit of the subsidy would be increased beyond the figures shown in the Mohring table.

As a general conclusion to this section, the greater are the economies of scale, the greater is the justification for transport subsidies. If the extent of increasing returns to scale is small, the scope for benefit from subsidization is small. The more elastic the demand for transport, the greater is the social pay-off from subsidy. There are diminishing returns to the application of subsidy dollars in that the net social benefit from increasing applications of subsidy declines as output increases towards the point where average revenue equals marginal cost. Elasticities of demand and, particularly, returns to scale are not identical for all transport modes. Hence, as Mohring has argued, "sound economic principles" do not dictate that "all modes receive equal treatment" in respect of transport subsidies (75, p. 298).

3. COUNTERACTING MONOPOLISTIC POWER

This section considers two situations. Firstly, on the assumption of no price discrimination, subsidies are examined as a means of persuading a transport company with some degree of monopoly power to produce the output that would result without exercise of this power. Secondly, where price discrimination is operative, the implications of the abolition of such discrimination are considered.

(a) Monopoly without Price Discrimination

The approach is algebraic and the results are summarized in the initial paragraphs.*

Output is less and price higher under monopoly than under perfect competition. A subsidy to the monopolist given as a fixed sum would not necessarily affect his behaviour. The examination proceeds to the case where a fixed percentage sum is added to the price obtained by the monopolist. An output equal to that of perfect competition can be achieved if the price elasticity of demand is greater than unity. If the demand curve becomes inelastic

*The monopolist is assumed to be a profit maximizer. Although discussion of alternative measures of the degree of monopoly power is beyond the scope of this thesis, different interpretations of monopoly power would of course have different interactions with subsidy requirements over time. For a useful discussion of monopoly power, see Eugene M. Singer. Antitrust Economics (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1968), pp. 63-72.

at some point between the monopoly and competitive outputs, this type of subsidy is unable to secure any increase in output beyond the point where demand ceases to be elastic.

Payment of a flat rate of subsidy per unit of output can ensure that the monopolist produces an output identical to perfect competition, but this implies subsidy in excess of the marginal cost of production if the demand curve becomes inelastic. Where the elasticity exceeds unity, the flat rate subsidy per unit of output is less expensive than the percentage addition to price as a means of obtaining the competitive output.

If a monopolist is subsidized to produce an output equivalent to the competitive level, in theory the total subsidy payments to the monopolist can be recovered by a fixed tax on the monopolist of equivalent amount, but not variable with the output. "Normal profit" is already included within costs and the complete taxation of the monopoly profit need not cause production to cease. Although there are obvious difficulties in implementing this approach and insufficient knowledge to allow recovery of all the monopoly profit, the possibilities of some recovery in this way are at least intriguing.

Algebraic Approach

A conventional demand curve is assumed where quantity demanded q increases as price p declines.

$$q = f(p)$$

The elasticity of demand is therefore always negative.

The case of perfect inelasticity with $e = 0$ is excluded from consideration.

$$e = \frac{dq}{q} / \frac{dp}{p}$$

Total cost is expressed as $C(q)$ and its derivative, marginal cost, is

$$\frac{dC}{dq} = C^1$$

The profit equation is $\Pi = pq - C$

and this is maximized when $\frac{d\Pi}{dq} = 0$

(i) *Perfect competition* (p_1 and q_1)

$$\frac{d\Pi}{dq_1} = p_1 - C_1^1 = 0$$

Substituting in the demand curve, $\therefore p_1 = C_1^1$

$$\text{and } q_1 = f(C_1^1)$$

(ii) *Exercise of monopolistic power* (p_2 and q_2)

$$\frac{d\Pi}{dq_2} = p_2 + q_2 \frac{dp_2}{dq_2} - C_2^1 = 0$$

$$\therefore p_2 \left(1 + \frac{1}{e}\right) = C_2^1$$

$$\text{and } p_2 = \frac{C_2^1}{\left(1 + \frac{1}{e}\right)}$$

Substituting in the demand curve,

$$q_2 = f\left(\frac{C_2^1}{\left(1 + \frac{1}{e}\right)}\right)$$

At the monopoly output, the demand curve must be elastic

($e < -1$), as otherwise marginal revenue would be negative

and the monopolist could increase receipts and profits by further restricting output.

Hence, $0 < (1 + \frac{1}{e}) < 1$ and the expression $(C_2^1 / 1 + \frac{1}{e})$ is positive.

$$\therefore p_2 > p_1$$

$$\text{and } q_2 < q_1$$

Price is higher and output less than under perfect competition. The payment to the monopolist of a fixed sum, independent of the scale of output, would cause no change in the profit maximization equation. By definition, this fixed sum would not affect marginal revenue or marginal cost.

(iii) *Exercise of monopolistic power with % subsidy addition to price (p_3 and q_3)*

Subsidy addition to price is ap_3 , where $a > 0$.

$$\frac{d\pi}{dq_3} = p_3 (1 + a) (1 + \frac{1}{e}) - C_3^1 = 0$$

$$\therefore p_3 = \frac{C_3^1}{(1+a) (1+\frac{1}{e})}$$

Substituting in the demand curve,

$$q_3 = f\left(\frac{C_3^1}{(1+a) (1+\frac{1}{e})}\right)$$

If the demand curve continues to be elastic ($e < -1$) between the monopoly output and the competitive output, $0 < (1 + \frac{1}{e}) < 1$ and the expressions for p_3 and q_3 are meaningful.

$$\text{As } 1+a > 1, p_3 < p_2$$

$$\text{and } q_3 > q_2$$

If q_3 is to equal q_1 , C_3^1 must equal C_1^1 , and p_3 must equal p_1 .

$$\therefore (1+a) (1+\frac{1}{e}) = 1$$

and $a = -\frac{1}{1+e}$, which is positive where $e < -1$.

If the demand curve continues to be elastic it is possible to achieve an output equivalent to that of perfect competition through a percentage subsidy addition to price. However, the cost can be high; for example, where the elasticity is $e = -2$, the subsidy ($a = 1$) must be equal to the price under perfect competition. If the demand curve becomes inelastic at some point between the monopoly output and the competitive output, it is not possible to secure an expansion of output beyond this point through application of a % subsidy addition to price. In algebraic terms, $(1 + \frac{1}{e})$ becomes negative and the expressions for p_3 and q_3 are not meaningful. In economic terms, a monopolist will not operate on the inelastic part of his demand curve and the addition of a % subsidy to price does not change the situation.

(iv) *Exercise of monopolistic power with flat rate subsidy addition to price (p_4 and q_4)*

Subsidy addition is b per unit of output, where $b > 0$.

$$\frac{d\Pi}{dq_4} = p_4 \left(1 + \frac{1}{e}\right) + b - c_4^1 = 0$$

$$p_4 = \frac{c_4^1 - b}{1 + \frac{1}{e}}$$

Substituting in the demand curve,

$$q_4 = f\left(\frac{c_4^1 - b}{1 + \frac{1}{e}}\right)$$

For an elastic demand curve, $0 < (1 + \frac{1}{e}) < 1$ and the expressions for p_4 and q_4 are meaningful.

As $b > 0$, $p_4 < p_2$

and $q_4 > q_2$

If q_4 is equal to q_1 , C_4^1 must equal C_1^1 , and p_4 must equal p_1 .

$$\therefore \frac{C_1^1 - b}{1 + \frac{1}{e}} = C_1^1$$

$$\text{and } b = - \frac{C_1^1}{e}$$

Under conditions of elastic demand, a flat rate subsidy addition to price can increase a monopolist's output to that of perfect competition. If demand becomes inelastic at some point between the monopoly output and the competitive output, the expression $(C_4^1 - b)/(1 + \frac{1}{e})$ is negative if $C_4^1 > b$ and output cannot be expanded further. However, if $b > C_4^1$, it is possible to secure the competitive output through a flat rate subsidy even under conditions of inelastic demand. In economic terms, the monopolist will increase output if the flat rate subsidy for an incremental unit of output exceeds the sum of the marginal cost of producing that unit plus the reduction in revenue implied by operation on the inelastic part of the demand curve. But this can be a very costly form of subsidy operation.

Under the % subsidy addition to price in sub-section (iii) above, the output of perfect competition could only be achieved with an elastic demand schedule. The rate of subsidy per unit of output is ap_3 , where $a = -(1/1+e)$.

$$ap_3 = \frac{aC_1^1}{(1+a)(1+\frac{1}{e})} = - \frac{C_1^1}{(1+e)}$$

For the flat rate subsidy, $b = -\frac{c_1^1}{e} < \frac{c_1^1}{(1+e)}$

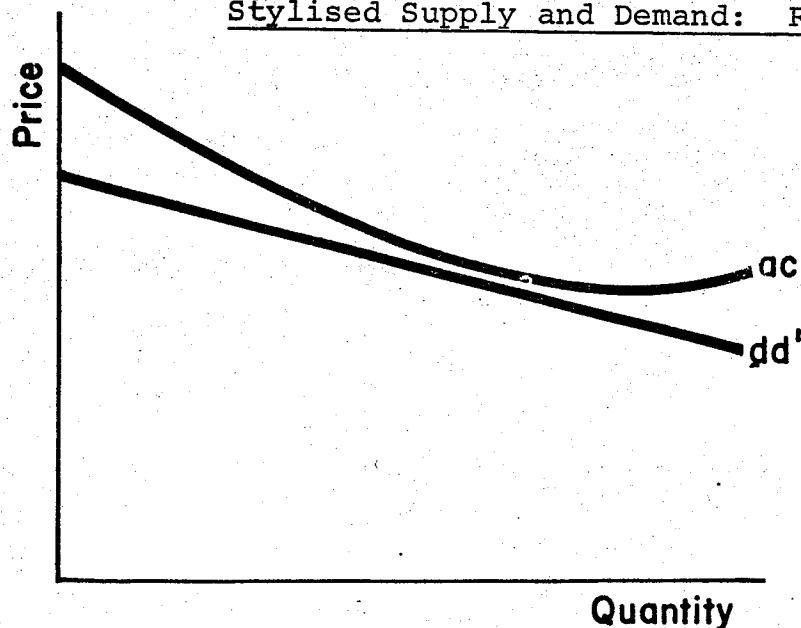
Therefore, the flat rate subsidy per unit of output is less costly than the % subsidy addition to price.

(b) *Monopoly with Price Discrimination**

In respect of the transport industries, analysis of monopolistic power supplemented by price discrimination is of much greater practical interest. From the very earliest days, railway companies have partially followed the principle of value of service pricing or charging what the traffic will bear. Indeed, it is probable that total costs could not have been covered without price discrimination.

FIGURE 3.2

Stylised Supply and Demand: Rail Transport

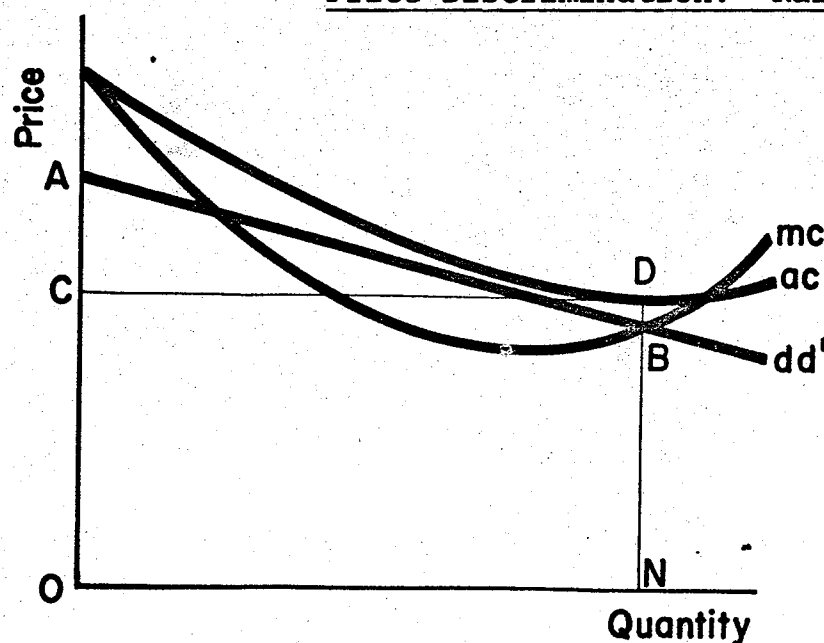


*The argument in this sub-section was developed earlier in my article (49).

Figure 3.2 above shows a hypothetical demand for and supply of rail transport, where railway companies are not competing on price. This approach is, of course, stylised; as a simplification, quantity is measured in terms of units of rail service in spite of valid criticisms of assumptions of homogeneity of output units in transport (see 93, pp. 14-30). The average cost curve ac is consistently above the demand curve dd^1 and there is no achievable output where average costs can be covered without price discrimination.

FIGURE 3.3

Price Discrimination: Rail Transport



Now introduce price discrimination in Figure 3.3 and allow this to be complete in the sense that the railways can capture all the revenue below the demand curve. This makes the demand curve dd^1 also a marginal revenue curve. A marginal cost curve mc is shown and output is determined at ON where marginal cost is equal to marginal revenue. The total revenue enjoyed by the railways is $ABNO$ and this allows a monopoly profit in excess of costs $CDNO$.

There is no unique method of recapturing monopoly profit through regulation and there are a large number of alternative feasible solutions. These solutions must involve some or all of the following:

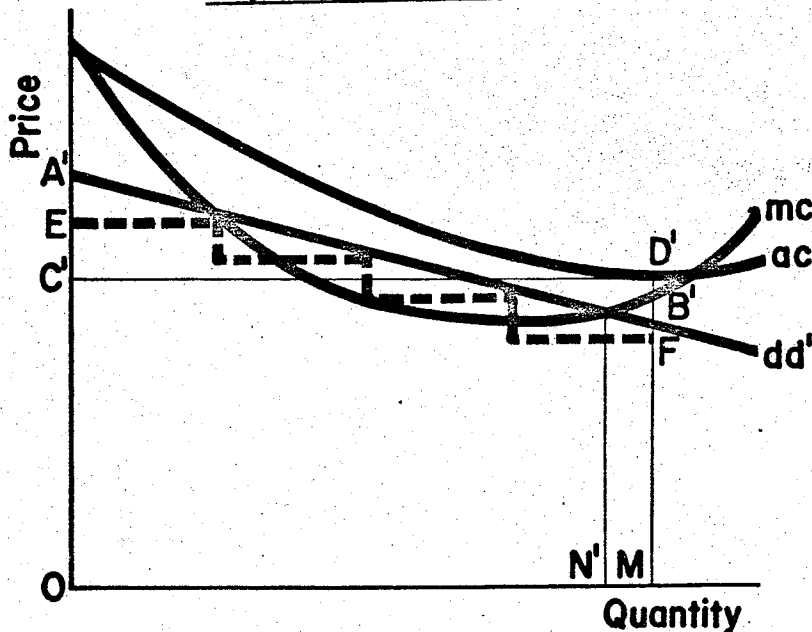
- (i) An increase in costs through inefficient regulation, which would be portrayed graphically by an upward movement in the ac and mc curves.
- (ii) Rate regulation to reduce the exercise of monopolistic powers in collecting revenue from customers for output ON in Figure 3.3.
- (iii) Rate regulation and common carrier obligations forcing the railways to extend output beyond ON and provide some units of output where marginal revenue does not cover marginal cost.

In Figure 3.4 below, all three developments have been allowed to take place. The demand curve dd^1 is the

same as in Figure 3.3 but the ac and mc curves have been forced upwards by the inefficiencies of regulation. On the new cost curves, the railways would try to maximize revenue by producing an output ON^1 , which because of increased costs is somewhat less than ON in Figure 3.3. However, the regulatory body insists that some transport services be provided where revenue does not cover costs and output is therefore pushed to OM .

FIGURE 3.4

Regulated Price Discrimination: Rail Transport



At this output, the potential revenue, practicing complete price discrimination, is A^1B^1MO , which still exceeds total costs of C^1D^1MO . By rate controls, the regulatory body pushes prices actually charged down from A^1B^1 to some lower level, say to the step function

labelled EF and revenue becomes EFMO. (The EF function can, of course, take a multitude of different forms; the constraint that total revenue must equal total costs leaves a vast number of alternative pricing strategies under conditions of price discrimination.) Assuming complete efficiency on the part of the regulatory body, this revenue EFMO just covers total costs of C^1D^1MO . Monopoly profit is eliminated and only a "normal" profit left, which is included within the definition of costs. Inefficient regulation will either allow the continuation of some monopoly profit or, conversely, result in revenue which is not sufficient to cover total costs.

Under this type of regulation, there is no problem of failing to achieve the "ideal output". In fact, the output OM is in excess of that of ON^1 where the demand curve intersects the marginal cost curve. However, the problem of price discrimination still exists in that different sectors of output are charged different prices for comparable service. If the price charged to the marginal unit of demand were to be levied on all units of output, a substantial subsidy would be required to meet that proportion of total costs not recovered through user charges.

4. SOCIAL COSTS AND BENEFITS

Although there are social costs associated with transport, such as the air pollution of the internal combustion engine and the noise of the jet aircraft, the literature, particularly that of the period when rail transport was dominant, stresses the social benefits rather than the social costs of transport. As it is the object of this chapter to examine the conceptual basis for transport subsidies as distinct from transport taxes, there will be no detailed consideration of social costs. However, these must be taken into account in respect of net subsidies to transport.

The social benefits claimed for transport are broadly of two categories. The first category relates to the strategic role of transport in an economy and the benefits which a good transport system can bestow in terms of an increased division of labour and a greater rate of economic growth. The second category of social benefits attributed to transport can be classified as non-economic. The relationship of transport to regional development is introduced later in Section 5 although many of the benefits covered in the present section obviously have repercussions on regional development.

(a) *Transport as a Strategic Factor in Economic Growth*

In The Stages of Economic Growth, first published in 1960, Rostow stated the case for the strategic role of rail transport in economic growth.

The introduction of the railroad has been historically the most powerful single initiator of take-offs. It was decisive in the United States, France, Germany, Canada, and Russia; it has played an extremely important part in the Swedish, Japanese and other cases.

The railroad has had three major kinds of impact on economic growth during the take-off period. First, it has lowered internal transport costs, brought new areas and products into commercial markets and, in general, performed the Smithian function of widening the market. Second, it has been a prerequisite in many cases to the development of a major new and rapidly enlarging export sector which, in turn, has served to generate capital for internal development, as, for example, the American railroads before 1914. Third, and perhaps most important for the take-off itself, the development of railways has led on to the development of modern coal, iron and engineering industries.

(84, p. 55).

The Rostow thesis is not, of course, a new departure. Max Weber considered the railway the greatest innovation in history. Schumpeter was equally enthusiastic when he wrote that it was possible to treat the economic history of the United States in the second half of the nineteenth century solely "in terms of railroad construction and its effects" (35, p. 13). Pigou was more restrained, but he also described "the indirect advantages of cheap railway transport in facilitating the division of

labour between different parts of the country, making possible the development of large-scale localised industries, and, through the improved communication of markets, lessening local price fluctuations" (80, p. 313).

In the last few years, considerable doubts have been cast upon the structural role of rail transport in the United States, mainly on the grounds that inland water transport was a readily available alternative and that railway development was not the indispensable cause of the vast economic expansion of the nineteenth century. Writing of the period before the Civil War, Fishlow has argued that the evidence denies the hypothesis that economic development was substantially the result of railway construction in anticipation of traffic demand (35, p. 204). Fishlow concludes his argument in the following terms:

The prime beneficiary during the ante-bellum period was not industry, however, but agriculture.... Derived demands, a favored Rostow linkage, although they had positive effects by the 1850's as railroad investment increased, were an insignificant influence earlier. In particular, railroad demands for iron were independent of the rapid growth of domestic industry in the 1840's. Nor do the inducements afforded manufacturing by lower transport costs seem capable of explaining the observed industrial surge of that decade. Distribution costs were a small fraction of total expenses, and it is possible to identify other factors, like lower cotton prices, tariff protection, and the large English demands for iron, that were more significant to the initiation and continuation of that expansion.

(35, p. 303).

Without the railroad (sic), growth would surely have been slower, but the country would not have withered: 5 percent, or even 10 percent, of 1859 income is a small sum in this context. Few innovations can be expected to become indispensable within brief years of their introduction.

(35, p. 305).

Writing of a later period, Fogel reached similar conclusions. Without railways, U.S. national income in 1890 would have been reduced by some 6 to 7 percent.

(36, pp. 219-20). The railway was an important part of nineteenth century economic development but not a condition for the accelerated rate of growth.

This stress on the multiplicity of solutions along a wide front of production problems clashes with the notion that economic growth can be explained by leading sector concepts. Such concepts suggest that the search for, or discovery of, new solutions was limited to narrowly selected industries and that growth in other sectors had to wait for breakthroughs in the anointed ones. It is the hero theory of history applied to things rather than persons.

(36, p. 236).

In respect of England and Wales, Hawke concluded that the impact of the railways had been greater than in the United States because the alternative of cheap water transport was not so readily available. Without the railways, the national income of England and Wales in 1865 would have been reduced in the order of 10 percent (45, pp. 404-5). However, Hawke also concluded that the linkages between railways and the iron industry

were much smaller "than many literary accounts would seem to imply" (45, p. 409).

Fortunately, it is not the purpose of this thesis to mediate between conflicting claims in respect of the strategic nature of railway transport in the nineteenth century. In the Second Edition of The Stages of Economic Growth, Rostow tended to dismiss the work of Fishlow, Fogel and others as having deepened knowledge without shaking his original judgment (84, pp. 229-30). The present writer does not find Rostow's refutation entirely convincing, but there are also nagging doubts as to whether the Fishlow-Fogel analyses have taken fully into account the external effects of railway development on the economy. But perhaps this historical consideration may be closed with a quotation from Fishlow: "The ability of an infrastructure to alter the economic environment in favor of industrialization is perhaps weaker than we appreciate" (35, p. 306).

The argument as to whether transport investment must take place in order to allow other developments is still crucial today in respect of under-developed economies. Thus, writing recently of rural road construction in Malaya, Hughes concluded that "If social development is a policy goal, such packages of investment may be desirable in many developing countries, even in cases where rural roads alone could not qualify

for investment funds on normal economic grounds" (56, p. 121). However, it is intuitively obvious that the marginal social benefit of additional transport increments must be a declining function. If the first road to an area is planned efficiently to tap the maximum resources available, the impact must generally be greater than that of the second road, which in its turn will have a greater impact than subsequent roads.

The structural role of transport facilities may still be argued in respect of the remote areas of Canada, but there must be considerable justification for Wilson's views in respect of transport infrastructure in settled areas of Canada.

While a good case could be made for the strategic nature of transport in the late 19th and early 20th centuries, this is no longer valid. This does not mean that present inequities and imbalances, to the extent to which they can be identified, should not be corrected, nor does it mean that such corrections would fail to improve the overall efficiency of the transport system as well as the whole economy. The point is that general improvements in efficiency and acceleration of the growth rate both on the Prairies and for Canada as a whole will receive but marginal support from improvements in transport under present circumstances.

(95, p. 60).

(b) *Non-economic Benefits of Transport*

The non-economic benefits claimed for transport have always been considerable and varied. In Canada, the first transcontinental railway was built after Confederation

as an instrument of national purpose. Canada is not unique in placing a high non-economic benefit on transport as an essential condition of political unity and national defence. Indeed, permanent transport subsidies could well be urged on the grounds of fostering national unity, and the economist *per se* can say little on this issue.

Transport has also been regarded as a "merit" good in itself. Transport allows workers to live outside congested urban areas, it facilitates outdoor recreation, it is educational and so on. The non-economic social benefits of transport need not be confined to users; for example much of the benefit of urban transit systems is credited to non-users in terms of reduced congestion on the roads. Subsidies on transport services to remote communities are justified on the grounds that the benefits of transport to these communities far exceed the sums carriers can collect in the market place and that these services must therefore be provided even although they do not cover costs. Uneconomic passenger train services are retained in the public interest partly as a form of transport insurance. The examples of social benefits of transport are legion and can only be considered on their individual merits rather than in generalized terms.

5. INCOME DISTRIBUTION AND REGIONAL DEVELOPMENT

Transport policy has traditionally been used to secure non-transport public policy goals. This section comments briefly on the use of transport subsidies to redistribute income and introduces transport subsidies on freight rates as a tool of regional development.

The price mechanism of a free enterprise economy allocates income to individuals in accordance with what they can produce either through their own labour or through ownership of capital and land. The income distribution which results is not normally regarded as "ideal" by society and measures are taken to redistribute income to those who are poorly endowed. The economist is not qualified to comment on society's value judgments, but he does have technical expertise relevant to the problem of distinguishing efficient from inefficient ways of income redistribution. If the consumer is the best judge of his own welfare, it is generally more efficient to carry out income redistribution by direct money transfers, allowing the recipients to decide how they wish to spend their transfer receipts. It is not so efficient to transfer income to the less well endowed by making specific products available to them at subsidized prices or as free goods. For a given net transfer payment, the increase in utility is greater if

consumers are allowed to spend without restriction rather than have consumption concentrated on specific products.

In special cases -- for example, encouragement of "merit" goods, the existence of increasing returns to scale, or administrative and political difficulties in arranging selective mechanisms of direct income transfer -- there can be justification for redistributing income through specific product subsidies as distinct from money transfer payments. Nevertheless, there is a presumption in economic theory against income redistribution through subsidizing specific prices rather than by making direct money transfer payments.

It is not the intention to review at length the present structure of transport subsidies in Canada from the standpoint of income redistribution effects. Nevertheless, considerable income redistribution occurs and the beneficiaries present a very diverse group, ranging from western grain farmers to eastern livestock producers, and from businessmen travelling by air to old people travelling by passenger train.

From the standpoint of regional development, transport subsidies can be used to reduce the extent of inter-regional disparities. However, the potential in this direction would be slight if the only effect were to reduce consumer prices. In respect of the Prairie Provinces, the Batten Commission concluded in 1968 that for most consumer goods rail freight charges ranged from about 2% to 13% of

the wholesale price (10, p. 124). Taking an average of 7% and making the very broad assumption that transport charges through all modes affected half of total consumer expenditure on goods and services, transport costs would be equivalent to $3\frac{1}{2}\%$ of total expenditure. Even a 25% reduction in transport charges would only increase real income by 1%. The corresponding effect in the Atlantic Region would probably be slightly less than in the Prairies. But a reduction of consumer prices is not, of course, the prime objective of transport subsidies in respect of inter-regional disparities.

The major regional development justification for transport subsidies is to bring employment to otherwise unemployed resources. A formal version of the argument would seem to run as follows.. As a result of rigidities, factor prices do not fall in depressed areas of Canada to the extent necessary to achieve a full employment of resources. Moreover, as a matter of social policy, the people of Canada would not wish to see wage rates fall, for example in the Atlantic Region, to the extent necessary to achieve full employment of labour there. The downward inflexibility in wages is accompanied by labour immobility so that unless special action is taken labour will be unemployed. If the prices of other inputs such as transport can be reduced, this would allow increased employment in the depressed regions of Canada.

The conventional response is that it would be more efficient to provide funds directly for regional development rather than subsidize application of a specific input such as transport. Yet, this is a criticism more easily offered in theory, as it is very difficult to stimulate regional development without subsidizing some specific input. For example, a major government tool for regional development in the past has been capital grants; this is, of course, a subsidy on the factor of production capital and there can be obvious criticisms of the dangers in trying to promote employment in the undeveloped regions by stimulating heavily capital-intensive projects.

Location cost studies between centres in the Prairies and Ontario, Quebec and British Columbia have shown freight charges as an important source of cost differences between locations. An approach admittedly subject to statistical criticism has shown 30% of the total cost variation between highest and lowest locations attributable to freight costs (48, pp. 18-29). The efficiency of transport subsidies as against other incentives for regional development requires much more investigation and the objective of Chapters IV - VI of this dissertation is to make a contribution in this direction.

To conclude the discussion in this chapter, the justification of transport subsidies would appear to rest on four major categories of argument.

Firstly, where increasing returns to scale prevail, there is a case for transport subsidies on the grounds that the total benefits from subsidy exceed the total costs. Returns to scale are not identical for all transport modes; subsidy payments should generally be selective of modes with increasing returns to scale and this denies the argument that all modes should necessarily receive equal subsidy treatment.

Secondly, transport subsidies can be used to offset the effects of the exercise of the vestigial monopoly powers of carriers. The examination of the use of subsidies to counteract monopoly without the use of price discrimination is of considerable theoretical interest and has some practical applications. However, transport pricing is generally characterized by price discrimination in that rates are to some extent determined from consideration of what the traffic can bear. This price discrimination may well be inevitable if total transport costs are to be met without subsidy, and the subsidy cost of eliminating all discrimination would be very substantial.

Thirdly, transport subsidies can be justified on the grounds of social benefits which accrue in excess of the charges that can be recouped in the market place by carriers. Additional increments of transport infrastructure would not generally exercise a strategic role in the development of the non-isolated parts of Canada today. However, a number of other social benefits are claimed for transport and these must be considered on their individual merits.

Fourthly, transport subsidies can be justified on the grounds that they can form part of a package to secure other public policy goals such as income redistribution and regional development. The next three chapters examine the efficiency of transport subsidies as against alternative measures to aid regional economic development.

CHAPTER IV: TRANSPORT SUBSIDIES AND REGIONAL DEVELOPMENT: THE THEORETICAL MODEL

1. BACKGROUND

The general economic basis for transport subsidies has been examined in Chapter III in terms of increasing returns to scale, counteracting monopoly power, obtaining social benefits where the costs cannot be recouped in the marketplace, and using transport to pursue non-transport public policy goals. The use of transport subsidies to promote regional economic development was briefly introduced. This theme is pursued further in the next three chapters, where transport subsidies are compared with a number of alternative incentives as a means of promoting increased output in the slow growth areas of Canada.

The regional development objective examined in Chapters IV-VI is assumed to be an increase in output of a specified amount by a one-plant firm in a low growth area. In view of the anxieties frequently expressed in the low growth areas of Canada for more employment opportunities, this objective is hardly a theoretical abstraction. However, for purposes of this study it is a datum and will not be examined further. The basic objectives of regional development policy are beyond the terms of reference of the present research and there is no discussion of such issues as the relative importance of maximization of income per head in the slow growth areas as against minimization of unemployment there.

The firm in the low growth region is assumed to be a profit maximizer, and it is specified that increased output can be attained only by expanding the geographical area in which the firm sells. Increased output must be shipped greater distances to markets outside the region. As incentives towards increased output, transport subsidies are compared to subsidies on output price and subsidies on specific factors of production. This model is highly relevant to cases where the growth of a firm is limited by the small size of the local market, but it is well to note other impediments to regional development which cannot be examined in the framework of the present model.

The model precludes consideration of potential output increases to be achieved in slow growth areas from import substitution, improvements in the quality of technology or labour productivity, and the effects of infrastructure developments. Thus, the study does not provide a framework for the examination of alternative incentives to produce goods previously obtained from other parts of the country or abroad. Similarly, the study does not examine the relative efficiency of providing incentives for increased production as against spending funds on improving technology or upgrading labour in the slow growth area.

There is also no discussion of infrastructure investment either in respect of social capital in its broadest sense or

in respect of transport infrastructure. The model does not allow appraisal of social capital expenditures aimed at improving the general quality of life in the slow growth areas. By extension, although allowance is made for varying degrees of returns to scale in the firm's production function, there is no provision for economies of scale which are external to the firm and enjoyed only by the industry as a whole or by the economy as a whole. The model therefore is not designed to compare the efficiency of securing increases of output from subsidizing a firm as against subsidizing the industry or the area to which it belongs.

On the specific issue of transport infrastructure, as George Wilson has argued (95, p. 60), it is only in the most isolated areas of Canada that regional development is inhibited by an actual shortage of transport facilities. Transport investments must obviously be made where there is a lack of transport capacity, but additional increments of transport infrastructure would not generally have a major effect in stimulating regional development. Of more practical concern, the model examines transport costs only in respect of freight charges actually paid by the shipper. There is no explicit discussion of inadequacies in the quality of transport, although it can be argued that a remedy here should first be sought by eliminating any market imperfections which prevent shippers from purchasing the quality of service for which they are prepared to pay. This would not, of course,

cover cases where increasing returns to scale operate in the transport industries, and particularly where increased total movements of traffic provide external economies in the form of greater frequency of service. However, these external economies are beyond the scope of the present discussion.

The model developed in this study allows an increase in output to be achieved by a subsidy on output price, on a specific factor or production, or on outbound transport charges. At first glance, the most serious omission from this list would appear to be raw material costs. However, if raw material costs are constant in price and constitute a fixed input to each unit of output, then a subsidy on raw materials becomes conceptually the same as a subsidy on output price. If the amount of raw materials used is not fixed and the production process allows the possibility of greater use of raw materials as a substitute for labour or capital, then a subsidy on raw materials falls analytically between subsidy on output price and subsidy on a specified factor of production.

The model assumes perfect competition modified by spatial separation, and the firm has no influence on the prices of the labour and capital it employs. The same assumption is made in respect of the prices of raw materials, but it is necessary to comment on the question of inbound transport charges for raw materials, which can be an appreciable part of a firm's total costs. If transport charges per unit of raw materials do not change for different quantities of

raw materials bought by the firm, then a subsidy on inbound transport charges is analytically the same as a subsidy on raw material prices. However, this analytical similarity does not hold if, as a firm increases output, it has to bring raw materials over increasingly longer distances at increasingly higher freight charges. In view of the stress placed on developing production in low growth areas of goods where comparative disadvantages are least, the case of increasing inbound transport charges per unit of output should be less important than increasing outbound transport charges, as product has to be shipped to more distant markets. Nevertheless, perhaps these inbound transport costs should be examined further at a later date.

Of a firm's costs of production, labour, capital and outbound transport costs are covered within the model and the effects of subsidy on raw materials would fall somewhere between the effects of subsidy on price and subsidy on a specified factor of production. This covers the bulk of the firm's costs of doing business, leaving only fuel and light and taxes at the municipal, provincial and federal levels. When costs of fuel and light vary with output, the effects of subsidy are similar to subsidizing raw material prices; when fuel and light are fixed costs, by definition a subsidy would not lead to any increase in output.

Municipal taxation may be assumed to be broadly a function of plant size. If plant size does not change with changes

in output, a subsidy on municipal taxation has no effect on output; if plant size increases *pari passu* with output, a subsidy on municipal taxation is similar to subsidy on output price; if size of plant is a variable which can be substituted to some extent for other factors of production, a subsidy on municipal taxation is equivalent to subsidy on a specific form of capital. Corporate taxation at the provincial and federal levels may be considered as levied on the earnings of capital and on profit as an economic surplus. To the extent that corporate earnings represent a return on capital required by competitive factors, a corporate tax reduction is a subsidy on capital. Insofar as corporate earnings represent an economic surplus, reduced taxation would not lead to increased output.

The model developed in this study focusses on the firm and examines the relative subsidy costs of achieving a specified increase in output through subsidizing product price, a specified factor of production, or transport charges. It would seem that this range of alternatives would cope reasonably adequately with the various possibilities for subsidy on product price and the various inputs used in production. Limitations to this approach have been stated; not surprisingly, the model does not provide a mechanism for the appraisal of all possible means of stimulating regional output and it is hardly unique in its incapacity to deal with external economies.

The model is also partial in that it examines alternative subsidy incentives to a given firm without tracing through

the effects of these subsidies on other sectors of the economy. A more general interregional model would be conceptually superior to the partial equilibrium analysis of the present study. An explanation is therefore necessary as to why a more generalized model was not selected.

The first problem in using a more generalized model is that the very process of generalization itself can be a delusion. Nearly forty years ago, Hicks initiated the revival of interest in general equilibrium theory, regretting that the teachings of Marshall had confirmed so many people in the belief that the Walrasian approach was no more than a mathematical counting of equations (52, pp. 2-3). Since the Second World War, economic theorists have devoted considerable efforts to developing and improving general equilibrium theory (60, pp. 364-7). Nevertheless, it has recently been cogently argued by Kornai that the Walrasian models are not general but "valid only within a highly restricted sphere" (60, pp. 28-9).

Recognizing that the areas in which an economic system can be evaluated are numerous, Kornai lists seven groups of desiderata, ranging from the ability of the economic system to generate growth to its ability to obtain desired income distributions. Efficiency in resource allocation is included in one of these seven groups, the adaptive properties of the system, but Kornai argues that the phenomena with which the general equilibrium school is concerned do not even cover all the factors classified under ability to adapt (60, pp. 210-17).

Kornai may overstate his indictment of general equilibrium theory and he is obliged to recognize that the present corpus of non-equilibrium theory does not constitute an adequate replacement. Nevertheless, Kornai has given very effective indication of the limits to the generality of the Walrasian approach and shown that reservations are not simply the result of training in the Marshallian tradition.

With an explicitly partial approach, it is difficult to forget that the conclusions are partial because all subsequent ripple effects throughout the economy have not been examined. It can also be argued that this awareness of limitations extends to a greater consciousness of the dependence of the model on its basic assumptions. With more complex simulations, there is a danger that the greater efforts at comprehensiveness detract attention from the fact that the approach is still inevitably incomplete. Thus, in the specific area of the application of system simulations to transport planning, Roberts and Dewees have pointed out that simulation of the entire world is not practicable or even useful, that judgment and experience are necessary in determining the realism and coverage of the model, and that hence model credibility can never be established perfectly (82, pp. 72, 77).

The second problem in using complex models is the difficulty in obtaining the data necessary for calibration. There are obvious conceptual attractions, for example, to a general equilibrium approach where prices, factor utilizations,

output and location choices for several regions are determined simultaneously. However, the data requirements for this type of model are very substantial and the models can become very elaborate. As Straszheim has stated, the greater generality of general equilibrium models is "gained at the expense of a huge increase in the number of variables and functions which must be dealt with. Only the very simplest of applications of this approach can be solved" (88, p. 215). Similar views on the costs of empirical implementation of general interregional models have also been expressed by Kraft and his associates (63, p. 94).

Although the search for more generality should not be abandoned, the model used in the present study is to some extent a trade-off between generality and empirical calibration.

The chapter proceeds to examine the model specifications in detail; to present empirical data on the relationship of freight charges to the selling prices of commodities; to assess evidence on the relative contributions of terminal and line haul costs to transport charges; and to review at greater length the appropriateness of the production function used in the model.

2. MODEL SPECIFICATIONS

The model considers an industry in a slow growth area which consists of a single firm producing a single homogeneous product in a single plant. The regional development objective, which is determined exogenously to the model, is to increase the output of this plant by a specified amount and it is assumed that this can be attained only by expanding the geographical area in which the firm sells. The model is developed in two forms, corresponding to alternative hypotheses on the geographical distribution of product demand.

The required increase in output can be achieved by (i) a subsidy on the output price; (ii) a subsidy on a specific factor of production; or (iii) a subsidy on transport charges. The cost implications of these alternative subsidy approaches are considered in terms of (i) subsidy costs; (ii) increased profits of the firm; and (iii) subsidy costs minus increased profits, which is (i - ii). These costs are examined firstly when the subsidy is applicable to the entire output of the firm, and secondly when the subsidy is paid only to output in excess of that originally produced by the firm before the subsidy scheme was introduced. Clearly, it is always less expensive to follow the second alternative and confine subsidy payments to incremental units of output, but sometimes this is not administratively feasible.

(a) Prices and Profit Maximization

The firm seeks to maximize profits under conditions where

it has no influence on the prices of factors of production used. The prices of capital and labour, p_k and p_l are constant and not influenced by the firm's level of production. The firm is assumed to receive a constant selling price p_x for each unit of output produced, but it has to meet transport costs as well as production costs on each unit of output. Profit maximization therefore requires that, within the constraint of a given production function, output be carried to the point where marginal revenue (which is the same as average revenue p_x) is equal to marginal production cost plus marginal transport cost.

Equilibrium conditions require that profits should not be negative and second order conditions require that the combined marginal cost of production plus transport is increasing. It is shown later that the marginal cost of transport is always increasing and it is therefore possible to have decreasing cost of production as output increases and still have a determinate output. The firm is therefore not required to produce at minimum production cost and it may also enjoy a non-zero profit.

There are two aspects of this model which need specific comment in the light of micro-economic theory.

(i) The assumption that the firm receives a constant selling price for each unit of output can be regarded as an extension of the theory of perfect competition to the case of

spatial separation (see, for example, 51 pp. 121-4). However, in the present model, a firm without competition in its initial marketing area could exercise monopoly powers to the extent that the costs of spatial separation prevent competition from firms located in adjoining areas. The firm could charge differential prices in its initial marketing area, according to the closeness of alternative sources of supply to its various customers, and it might have to offer lower prices to new customers in order to compete beyond its initial marketing area.

It is always difficult to incorporate spatial separation into a model based on perfect competition. Initially, an attempt was made to include a generalized approach to imperfect competition in the present model but the algebra became extremely burdensome. It was also difficult to disentangle the effects of the spatial issue from the more general behavior of a firm in an imperfect market. The decision was therefore made to postulate a constant selling price of p_x . This is not an unreasonable assumption for, even in a country as large as Canada, a manufacturer's selling prices may show very little regional variation.

(ii) The model has been developed on the assumption that there is only one firm producing the product in the region and therefore only one firm to be subsidized. An increase in this firm's output has already been specified as an exogenous

regional development objective, but some comment is necessary as to conditions if there were several firms in the region operating under similar production functions and identical factor and product prices. In a model of spatial separation without product differentiation, this would mean that each firm would initially have its own section of the regional market. Firms near the periphery of the region would have a greater incentive to expand to markets outside the region, because their transport costs would be less than for firms in the center of the regional market. On the other hand, firms situated in the center might be able to gain some of the markets at present enjoyed by firms situated by the periphery. However, it is beyond the scope of the present study to develop detailed interactions within the regional market. The present model is an approximation to show in aggregate terms the effects of different subsidy schemes in encouraging increased output where this has to be shipped to markets outside the region.

(b) Production Costs

Production costs are determined by the fixed factor prices, p_k and p_ℓ , and the production function under which the firm operates. The production function expresses the maximum outputs which can be produced from various combinations of inputs when the production process is organized with maximum technical efficiency. The factor prices then determine the

most economic combination of inputs to be used.

The present model uses the familiar Cobb-Douglas form of production function.

$$x = ak^{\alpha}l^{\beta} \quad (4.1)$$

where x is output,

k is capital,

l is labour,

and, $0 < \alpha < 1$

$0 < \beta < 1$

$0 < a$

There are diminishing returns to inputs of each separate factor, but not necessarily diminishing returns to scale for a proportionate increase in all inputs; $\alpha + \beta$ can be less than, equal to, or greater than unity. In the empirical calibration of the model, alternative values of $\alpha + \beta$ are specified, thus allowing consideration of different degrees of returns to scale.

In the final section of this chapter, the production function problem is discussed at greater length, particularly with reference to the choice of a Cobb-Douglas type of function rather than the more generalized CES (constant elasticity of substitution) production function. There is also consideration of empirical data relating to the values to be assigned to α and β in the present model. It will be noted that the production function specified above ignores the question of raw material inputs; implicitly, these are assumed to be constant for each

unit of output and the production function is measuring output x in units of "value added".

(c) *Transport Costs*

The model specifies that, as the firm increases output, sales must be spread over an increasingly wide area and that hence distance travelled is an increasing function of the volume of output. If freight rates paid by the firm reflect the costs of providing transport services, the freight cost per unit of output paid by the firm will also increase with output, as additional units have to be shipped increasingly longer distances.

The total transport costs $TRANS$ to be met by the firm may be defined as follows:

$$TRANS = bx + cdx \quad (4.2)$$

where x = output of the firm,

b = fixed terminal charges at origin and destination per unit of output,

c = line haul rate per mile per unit of output (subsequently described as line haul rate per ton-mile),

d = average distance travelled in miles per unit of output, which is an increasing function of output.

This specification considers the transport rate per unit of output as composed of fixed terminal costs, which do not

vary with distance travelled, and a line haul cost which is constant for each mile a unit of output is shipped. It would, of course, be completely incorrect to apply the concept of constant ton-mile costs to combined terminal and line haul costs. However, the assumption of a constant rate per ton-mile confined to the line haul part of transport cost is more realistic and allows the downward taper in ton-mile charges as distance travelled increases, which is a common feature in freight tariffs.

The model assumes that b and c are constants. If freight rates reflect cost, this would imply constant returns to scale in the provision of transport services. However, this implication is less restrictive than it may initially appear. The model is examining different types of subsidy as a means of securing a specified increase in output and, regardless of the form of subsidy used, the same additional product has still to be transported to the more distant markets. Obviously, the total use of transport resources for a given increase in output would be greater if there were decreasing returns to scale in the transport industries than if there were increasing returns. However, for any given degree of returns to scale in transport, the real use of transport resources to secure a specified increase in output would be the same regardless of which subsidy approach is adopted. The implications of returns to scale in transport on the model are not therefore as important as was initially feared.

The average distance that each unit of output is shipped is a monotonically increasing function of the output of the firm. The next stage in the development of transport costs is to establish the nature of this relationship and this requires examination of the geographical distribution of demand for the product under consideration. Two alternative assumptions are postulated and, although reality would seem to lie within these two extremes in respect of geographical distribution of demand, this still leaves the arbitrariness in the assumption of uniformity in the distribution.

(i) Uniform distribution of demand in an unbounded plane. This assumption is typically made for the population of a uniform agricultural area and would be relevant as a rough approximation, say, for the population distribution in the Province of Saskatchewan.

(ii) Uniform distribution of demand in a band of constant width. This second assumption could be applied as a rough approximation for Canada with population strung out in a line along the U.S. boundary. However, the assumption does not allow for variations in population density along this line.

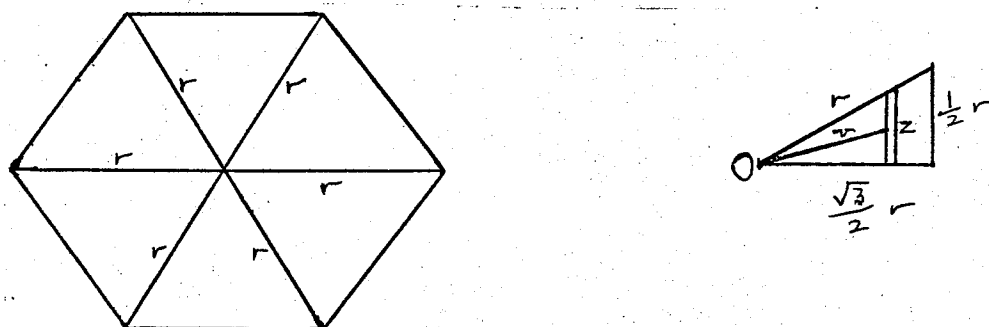
(i) Uniform distribution of demand in an unbounded plane

Christaller and Losch have separately examined the case of identical consumers, distributed at uniform densities over an unbounded plane and free to move in any direction they

choose over this plane. They have shown that the area served by identical firms offering a given good at identical prices will be of identical hexagonal shape. (See 3, pp. 59-73).

FIGURE 4.1

Demand in an Unbounded Plane



Consider the hexagon in Figure 4.1, where r is the distance from the centre to each vertex. The area of this hexagon is:

$$6\left(\frac{1}{2}r\right) \left(r^2 - \frac{1}{4}r^2\right)^{\frac{1}{2}} = \frac{3\sqrt{3}}{2} r^2$$

Let γ represent the density of consumer demand (tons per square mile) for the product under consideration, and the market size of the hexagon is:

$$x = \frac{3\sqrt{3}}{2} \gamma r^2 \quad (4.3A)$$

The hexagon consists of six identical equilateral triangles, each of which is divisible into two triangles of the dimensions shown in Figure 4.1. The market size contained in the Figure 4.1 triangle is one-twelfth of the size of the hexagon:

$$\frac{\sqrt{3}}{8} \gamma r^2 = .2165 \gamma r^2$$

The next step is to establish the number of ton-miles travelled in this triangle. Consider the triangle as composed of strips of height z and width dv , where dv is infinitesimally small. The average distance of each strip from the plant is represented by the variable v . The number of ton-miles is:

$$\int \gamma z v dv$$

The upper limit on v can be obtained by numerical methods and is $0.91r$. By similar triangles and the assumption that dv is infinitesimally small, $z = .55v$.

Substituting, the number of ton-miles becomes;

$$.55 \gamma \int_0^{.91r} v^2 dv = .1380 \gamma r^3$$

Average distance travelled over the triangle as a whole, d , is obtained by dividing ton-miles by tons moved:

$$d = .1380 \gamma r^3 / .2165 \gamma r^2 = .64r$$

$$\text{From IIIA, } r = (2x/\gamma 3\sqrt{3})^{\frac{1}{2}} = (.385x/\gamma)^{\frac{1}{2}}$$

$$\therefore d = .64 (.385x/\gamma)^{\frac{1}{2}}$$

Defining g as a constant $.64 (.385/\gamma)^{\frac{1}{2}}$

$$d = gx^{\frac{1}{2}}$$

Substituting for d in (4.2),

$$\text{TRANS} = bx + cgx^{\frac{3}{2}} \quad (4.4A)$$

Transport costs are now transformed into a function of output x and the constants b , c and g .¹

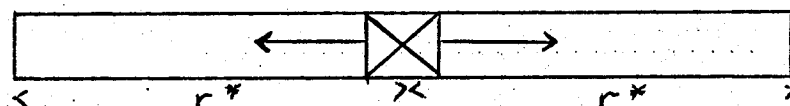
¹In an earlier formulation of this model, the market area of the firm was assumed to be a circle rather than a hexagon. Under this assumption, $x = \gamma \pi r^2$, number of (cont'd. next page)

- (ii) Uniform distribution of demand in a band of constant width.

Figure 4.2 shows a firm shipping equal amounts in both directions along a band of constant width w and uniform density of demand γ .

FIGURE 4.2

Demand in a Band of Constant Width



Under this formulation, the algebraic manipulation is extremely simple to express average distance travelled as a function of output.

Market size is simply:

$$x = 2\gamma w r^* \quad (4.3B)$$

Assuming a very small w , average distance travelled d^* approximates to $r^*/2$.

Substituting for r^* from Equation (4.3B),

$$d^* = x/4\gamma w$$

Defining g^* as a constant $(1/4\gamma w)$

$$d^* = g^* x$$

Substituting in Equation (4.2), transport costs become:

$$\text{TRANS} = bx + cg^* x^2 \quad (4.4B)$$

ton-miles $= 2\gamma \Pi r^3/3$, $d = 2r/3$, and g is redefined as $(4/9\gamma \Pi)^{1/2}$. With a different g the equation for transport costs was still of the same form, with x terms to the power of 1 and 1.5. This formulation is robust for considerable variation in market specification under conditions of uniform density of population in an unbounded plane.

Transport costs in Equation (4.4B) are higher than in Equation (4.4A).¹ As output increases, transport costs increase more rapidly under the assumption of a uniform distribution of demand in a band of constant width than under the assumption of a uniform distribution of demand in an unbounded plane. Transportation costs are a relatively much heavier burden in the Canadian situation, with population to some extent distributed in a band along the U.S. border, than under conditions of uniform distribution of population in an unbounded plane.

Empirical evidence is examined in Section 3 of this chapter in respect of the relationship of transport costs to product selling prices, and in Section 4 in respect of the relative contributions of terminal and line haul charges to transport costs. The model is developed in the next chapter

¹This statement is virtually self-evident on the assumption of identical market sizes in equations (4.3A) and (4.3B). Given that all the terms in equations (4.4A) and (4.4B) are positive, it is merely necessary to show that $g^*x > gx^{\frac{1}{2}}$. Substituting from (4.3B), $x = 2\gamma wr^*$, g^* is defined as $(1/4\gamma w)$, therefore $g^*x = r^*/2$.

Prior to (4.4A), g is defined as $.64(.385/\gamma)^{\frac{1}{2}}$, therefore $gx^{\frac{1}{2}} = .64(.385/\gamma)^{\frac{1}{2}} (2\gamma wr^*)^{\frac{1}{2}} = .563(wr^*)^{\frac{1}{2}}$.

It is now necessary to show that:

$$r^*/2 > .563(wr^*)^{\frac{1}{2}}$$

which is equivalent to showing that: $r^* > 1.27w$

This is true by assumption that r^* is much greater than w .

on the assumption of a uniform distribution of demand in an unbounded plane and in the subsequent chapter on the assumption of a uniform distribution of demand in a band of constant width.

(d) *Output Increases*

The model considers a firm with initial output x where for regional development reasons it is desired to secure an increase in output to x_2 such that $x_2/x = h^2$. (The h^2 notation is used merely to simplify the algebraic presentation in the following chapters.)

In respect of the range of output increases to be considered in the arithmetical simulations of the model in the next two chapters, it seems logical to start by considering a small increase in output, say of the order of 5%. The choice of an upper limit of output increase is more arbitrary, but clearly where transport costs increase at a fast rate subsidy could exceed product price if very large increases in output were sought. An upper limit of output increase after subsidy in the model is specified as four times the output before subsidy, i.e. for an increase of 300%. This upper limit was chosen because the four Western Provinces accounted for 27% of the total population of Canada, on latest figures for October 1975, and a firm extending its market from Western Canada to the whole of Canada would require *ceteris paribus* an increase in market of some 300%. Of coincidental interest,

relating the population of only the three Prairie Provinces (16.3%) to the population of Canada from Ontario to British Columbia (63.1%) also produces a required increase in output of some 300%. On the other hand, to allow a firm to extend its market coverage from the Atlantic Region, with only 9.5% of Canadian population, would clearly require an increase in market size substantially greater than the 300% postulated.

The following range of output increases and values for h^2 and h are used to calibrate the model.

<u>Percentage Increase in Output</u>	<u>h^2</u>	<u>h</u>
5	1.05	1.025
25	1.25	1.118
50	1.50	1.225
100	2.00	1.414
300	4.00	2.000

(e) *The Subsidy Approaches*

The output increase required for regional development purposes can be secured through subsidizing

- (i) the output price p_x ; or
- (ii) factor input prices for capital p_k or labour p_l ; or
- (iii) transport costs in respect of the terminal component b or the line haul rate c .

In respect of each of these alternative subsidy schemes, a determination is made of

- (i) total subsidy costs paid by government;
- (ii) increased profits earned by the firm; and
- (iii) net social cost, which is defined as (i) - (ii).

Firstly, these quantities are determined on the assumption that subsidy is paid on the entire output of the firm, the entire employment of the subsidized factor of production, or the entire transport cost in respect of the terminal or line haul component. Secondly, these quantities are determined on the assumption that subsidy is paid only on the incremental units of output over and above the initial output already produced without subsidy.

The analytical approach of this model is one of comparative statics, but once allowance is made for the dynamic change of the real world, the administrative difficulties of marginal subsidies become more evident. Initial equilibrium output is only a transitory concept in a world characterized by changing demand, changing technical possibilities and changing factor prices and in practice it would be very difficult to distinguish *ex post* variations in output induced by subsidies from variations attributable to dynamic change.

Net social cost has been defined in the model as total subsidy cost minus the increased profits earned by the firm. This definition ignores the issue of income distribution and the costs of raising taxes. *Ceteris paribus*, public policy considerations would call for minimizing the income redis-

tribution necessary to secure the required increase in output, on the assumption that income redistribution from taxpayers at large to the owners of the firm would in general be regressive. In other words, with net social cost the same for two alternative methods of subsidy, the method incurring the smaller actual subsidy payment and the smaller increase in profits to the firm would generally be preferred on income redistribution grounds.

Moreover, government does not operate in a frictionless economy where taxes are raised and spent without cost and without distortions. In reality, the average cost of raising taxes in Canada is equivalent to some 2% of total tax collected and perhaps the expenditure of tax revenues in subsidies would add a further 2%, to make a combined cost of tax/subsidy administration of 4%. To this, must be added the cost of distortions caused by taxation. Direct taxation has its distortion effect through making the return from work less attractive vis-a-vis leisure while indirect taxation affects not only this relationship but also the pattern of consumer expenditure.

There are equity considerations involved in income transfers from general taxpayers to individual firms and very real costs involved in raising tax revenue to finance subsidies. Therefore, when the net social costs of two different subsidy programs are the same, the one involving the lowest actual

subsidy payment is generally to be preferred. Indeed, a lower actual subsidy payment may under certain circumstances justify the choice of a program with a higher net social cost, as defined in this paper.

3. TRANSPORT CHARGES AS A PERCENTAGE OF SELLING PRICE

In equation (4.2) of Section 2 above, the firm's total transport costs TRANS for output x were defined as follows:

$$\text{TRANS} = bx + cdx$$

Transport costs per unit of output y can then be expressed as $y = b + cd$. If the selling price of the product is designated as a numéraire, $p_x = 100$, then the expression y also represents transport costs as a percentage of the selling price of the product. Given that average distance travelled d is a function of output, y is not a constant. However, in order to calibrate the model, it is necessary to obtain some initial estimate of the range of values for y before application of the alternative forms of subsidy.

Table 4.1 shows unpublished 1971 Canadian data on the percentage relationship between outbound freight charges and the delivered values of products. The charges represent complete transport costs from origins to destinations and, although some products may be shipped by truck rather than by rail, nevertheless the table gives a reasonable indication of the incidence of freight charges. Of the 30 products included in the table, 11 had freight rate ratios of under 5%; 9 had ratios between 5 and 10%, and 10 had ratios exceeding 10%. Most of the products with a high ratio of freight charges to delivered values could be

regarded as either raw materials or only semi-manufactured goods. Freight charges tended to be a much smaller portion of price for manufactured articles with a high value relative to their weight and bulk.

This general pattern is confirmed by U.S. figures in Table 4.2. The U.S. data cover some of the commodities examined in Canada - meat, butter, wheat flour, sugar, lumber, copper, and gasoline. Except for sugar, the Canadian freight charges are a greater proportion of product selling price for all of these commodity groups. Given that product has in general to be hauled greater distances in Canada, a relatively higher freight burden is to be expected here.

In recent years, there have also been important regional investigations which have included examination of the relationship of freight rate charges to the delivered values of products. Comprehensive material was compiled by Wilson and Darby in 1968 as background information for the Prairie Provinces Royal Commission on Consumer Problems and Inflation (96, pp. 5-15). Using these data, the Prairie Provinces Royal Commission concluded that, for most consumer goods used in the Prairie Provinces, freight charges ranged from 2% to 13% of the wholesale price (10, p. 124). Although this related to products entering the Prairie Provinces rather than products being shipped from that region, there was considerable overlap in the pattern of shipments covered. Consequently, this would not serve too

TABLE 4.1

Rail Carload Freight Charges as percentages of Delivered Values:Canada - 1971

<u>Product</u>	<u>Freight Charges as % of Delivered Values</u>
Meat, fresh or frozen	6.2%
Animal oils and fats	10.3
Fish and marine animals	4.7
Butter	3.7
Wheat flour	9.1
Wheat bran, shorts and middlings	17.4
Bakery products	8.8
Sugar	4.3
Synthetic rubber	3.4
Rubber tires and tubes	3.6
Pulpwood chips	18.5
Lumber	21.0
Plywood	14.0
Household furniture and fixtures	4.7
Newsprint	7.3
Steel bars and rods	4.4
Sheet and strip steel	8.2
Pipes and tubes, iron and steel	6.8
Copper and alloys in primary form	1.3
Zinc and alloys	5.2
Metal containers	9.8
Motor vehicle engines, accessories, parts and assemblies	3.6
Women's apparel	0.2
Leather and dressed furs	2.7
Agricultural machinery and equipment	8.4
Road motor vehicles	15.9
Cement and concrete basic products	24.2
Glass basic products	14.8
Gasoline	16.0
Sulphuric acid	17.9

Source: Unpublished data made available for this study.

TABLE 4.2

Relation of Railroad Freight Revenue to Average WholesalePrice at Destination: U.S. - 1959

<u>Product</u>	<u>Freight Charges as % of Delivered Values</u>
Fluxing stone and raw dolomite	57.3
Gravel and sand	54.9
Hay	45.1
Bituminous coal	42.0
Cabbage	38.1
Watermelons	37.5
Common brick	27.7
Potatoes	27.5
Lettuce	27.2
Oranges and grapefruit	23.6
Lumber, shingles and lath	20.7
Iron ore	19.7
Corn	12.2
Gasoline	10.8
Pig iron	8.3
Flour, wheat	7.5
Eggs	6.4
Sugar	6.3
Automobiles, passenger	5.3
Meats, fresh	4.2
Butter	1.7
Cigarettes	1.0
Copper ore and concentrates	0.7
Business and office machines	0.6
Airplanes, aircraft, and parts	0.2

Source: Bureau of Transport Economics and Statistics, Interstate Commerce Commission, quoted in Locklin (67, p. 57). Unsuccessful attempts were made to obtain more recent data from the Interstate Commerce Commission.

badly as an order of magnitude for transport costs as a proportion of selling prices of manufactured goods then being produced in the Prairies, and whose production might be increased in order to stimulate regional economic development.

In respect of the Atlantic Region, data on freight charges in relation to product selling prices compiled in 1967 by The Economist Intelligence Unit showed transport costs in manufacturing running at about 5% or less of total cost of production. These findings were consistent with a later study by George of 1962 data for Nova Scotia where transport costs range from a negligible proportion to 16%, with a median of 3%. The bulk of these shipments did not leave the Atlantic Region and it was estimated that, if all output had been sent to Quebec-Ontario, outbound costs would have been of the order of 5.3% of product value (38, pp. 89-90).

On the basis of this empirical evidence, it was initially decided that, for purposes of arithmetical simulation in later chapters, five cases should be considered of transport costs y equivalent to 1%, 3%, 5%, $7\frac{1}{2}\%$ and 10% respectively, of the selling price of the product p_x . Inevitably, there is an element of arbitrariness in the choice of these cases. The figure of 1% represents a product not sensitive to transport charges; 3% and 5% are chosen to represent an average and a "high" for the Atlantic Region;

7½% and 10% serve the same functions for the Prairies.

These figures relate transport costs to the wholesale prices of products under consideration. The Cobb-Douglas type of production function used in this model examines output as produced by the combined operation of two factors of production and, as already explained, therefore relates to value added. The table below shows that value added in Canadian manufacturing industry in 1971 and 1972 was equivalent to 43% of the value of manufacturing shipments. The comparable figure was 37% for the Prairie Provinces and for the Atlantic Region.

TABLE 4.3

<u>Value Added in Manufacturing</u>			
	<u>Value of Shipments</u>	<u>Value Added</u>	<u>(2) as %</u>
	<u>\$ million</u>	<u>\$ million</u>	<u>of (1)</u>
	(1)	(2)	
Canada - 1971	50,276	21,738	43.2
- 1972	56,192	24,292	43.2
Prairies - 1971	4,004	1,499	37.4
- 1972	4,580	1,693	37.0
Manitoba - 1971	1,345	534	39.7
- 1972	1,509	600	39.8
Sask. - 1971	578	210	36.3
- 1972	646	244	37.8
Alberta - 1971	2,081	755	36.3
- 1972	2,425	849	35.0
Atlantic - 1971	1,925	719	37.4
Region - 1972	2,310	860	37.2

Source: Statistics Canada 31-203, 1971, p. 12 and 31-203P, 1972, p. 3.

Relating transport costs to value added, which is roughly two-fifths of the value of shipments, the transport charges specified earlier of 1%, 3%, 5%, 7½% and 10% have to be multiplied by a factor of 2.5. Rounding these multiplications, the model is calibrated with transport costs as a percentage of value added at figures of 3%, 7%, 12%, 20% and 25%.

The model requires that, in equilibrium before the application of any subsidy, the firm must not be making a loss. In economic terms, the firm exercises no monopsonistic powers over the factors of production and each unit of each factor employed receives the value of its marginal product. Under conditions of increasing returns to scale, this is only feasible if the firm's marginal revenue less transport costs has declined sufficiently to allow non-discriminatory payment of factors without creating a loss.

Values of returns to scale are specified in Section 5 below and there is no problem in reaching a determinate solution before application of subsidy under conditions of decreasing and constant returns to scale. As explained in Chapter V, a pre-subsidy equilibrium is not attainable for transport costs as a percentage of value added at 20% and less, when conditions of increasing returns to scale are specified. The value of 25% can be used when $\alpha + \beta$ is 1.1. For $\alpha + \beta = 1.2$, it is necessary that this percentage exceed 33.3. In order to accommodate this in the model, a further value of 35% is specified. For $\alpha + \beta = 1.3$, it is necessary

to exceed 40.9, and a further value of 42% is therefore added. The model in Chapter VI has to be constrained to a lesser extent because transport costs rise more rapidly in this version; the value of 35% is still needed, but not the value of 42%.

To summarize, the model is to be calibrated in Chapter V with seven values of transport costs as a percentage of value added, namely 3%, 7%, 12%, 25%, 35% and 42%; the highest value of 42% is omitted in Chapter VI. All values are to be used when $\alpha + \beta$ is equal to unity or less. Where there are increasing returns to scale, only the higher ratios of transport costs can be used. This is an annoying limitation, but hardly surprising in view of the general theoretical difficulties in examining increasing returns to scale within a non-monopolistic competitive model.

4. TRANSPORT COSTS: TERMINAL AND LINE HAUL

Estimation of the model in subsequent chapters requires data on the relative contributions of terminal and line haul costs to total transport costs. Although the characteristics of different products clearly affect this relationship, the examination in this section is confined to the relative contributions of terminal and line haul costs for different distances travelled.

Table 4.4 is derived from published data on Canadian carload all-rail traffic carried in 1973 by Canadian National Railways and CP Rail. Data are published for seven broad commodity groups but, given the context of the present model, Table 4.4 is confined to the manufacturing and miscellaneous group. Figures for the Prairie region were obtained by using weights of 29.1% for Manitoba, 24.4% for Saskatchewan and 46.5% for Alberta, corresponding to the proportions of the total number of Prairie Region cars originating from each province in respect of manufacturing and miscellaneous products.

From Table 4.4, it is seen that for manufacturing and miscellaneous products, the average load per car in 1973 was 51.1 tons for traffic originating from the Prairie Region. This compared with a figure of 37.9 tons for Canada as a whole and a figure for the Atlantic Region very close

to this national average. The high figure from the Prairie Region is attributable mainly to shipments from Alberta and Saskatchewan and may imply a larger proportion of heavier loading miscellaneous products there. The average length of haul of manufacturing and miscellaneous products was 683 miles from the Prairie Region. The three individual Prairie Provinces were all fairly close to this average and, surprisingly, this average length of haul was only slightly higher than the overall Canadian figure of 673 miles. Average length of haul for manufacturing and miscellaneous products was rather shorter from the Atlantic Region at 505 miles.

TABLE 4.4

Average Carload and Length of Haul: Manufacturing and Miscellaneous Products - 1973

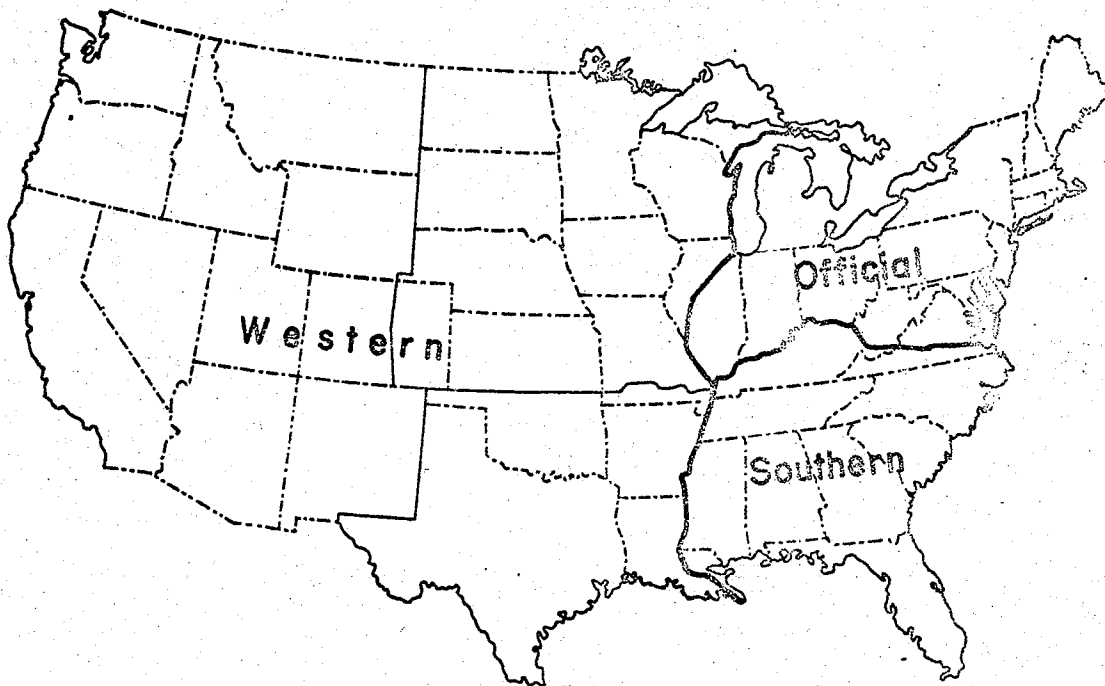
<u>Origin</u>	<u>Number of Cars thousands</u>	<u>Average Load per Car tons</u>	<u>Average Haul Miles</u>
Manitoba	38.5	39.3	674
Saskatchewan	32.3	53.5	670
Alberta	61.7	57.3	695
Prairie Region	132.5	51.1	683
Atlantic Region	113.1	37.6	505
Canada	853.3	37.9	673

Source: Canadian Transport Commission. Commodity Flow Analysis 1973, Traffic and Tariffs Branch Reference Paper No. 1.1 (Ottawa: Information Canada, 1974), Tables 10 and 12.

There are no published figures in Canada relating terminal costs to line haul costs and it was therefore necessary to go to the latest U.S. figures for the year 1970. Figure 4.3 below shows the three U.S. Major Rail Territories; published data do not include consolidated figures for the whole of the United States and the examination in the present section is confined to the Western and Official Territories.

FIGURE 4.3

U.S. Major Rail Territories



U.S. data on terminal and line haul costs are available for a variety of car weights in the range of 18 tons to 70 tons and for a number of different types of equipment. Table 4.5 has been compiled in respect of unequipped boxcars. For the Western Region, costs are shown for 50 ton cars to correspond broadly with the 51.1 ton figure estimated for the Canadian Prairie Region in Table 4.4. The U.S. Official Territory is taken as the closest approximation to the Canadian Atlantic Region and the 37½ ton car is virtually the same as the average car loading shown for the Atlantic Region in Table 4.4. Average figures have been calculated for the Western and Official Territories in respect of 37½ ton cars to give a comparison with the 37.9 ton average car loading for Canada.

TABLE 4.5

U.S. Rail Carload Cost Scales: General Service Unequipped
Boxcars - 1970

<u>Region</u>	<u>Load per Car tons</u>	<u>Fully Allocated - cents per cwt.</u>	
		<u>Terminal Costs</u>	<u>Line Haul Costs per mile</u>
Western	50.0	11.638	.04004
Official	37.5	15.343	.05593
Western	37.5	14.448	.04598
Official	37.5	15.343	.05593
Average	37.5	14.896	.05096

Source: U.S. Interstate Commerce Commission. Rail Carload Cost Scales by Territories for the year 1970, (Washington, D.C.: I.C.C., 1973), pages 99 and 39. Line haul costs relate to so-called average weight trains, as distinct from separate figures for way trains and through trains.

The next step in these calculations is to establish terminal costs and line haul costs per cwt. on the basis of U.S. costing data for the car loadings and length of haul recorded in Table 4.4 for the Prairie Region, the Atlantic Region and Canada. The calculations in Table 4.6 are self-explanatory.

TABLE 4.6

Terminal and Line Haul Costs per cwt - 1970

<u>Haul of 683 miles in Western Territory - 50 ton cars</u>		
	<u>cents</u>	<u>%</u>
Terminal costs	<u>11.638</u>	<u>29.9</u>
Line haul costs at .04004¢ per mile	<u>27.347</u>	<u>70.1</u>
Total	<u>38.985</u>	<u>100.0</u>

<u>Haul of 505 miles in Official Territory - 37½ ton cars</u>		
	<u>cents</u>	<u>%</u>
Terminal costs	<u>15.343</u>	<u>35.2</u>
Line haul costs at .05593¢ per mile	<u>28.245</u>	<u>64.8</u>
Total	<u>43.588</u>	<u>100.0</u>

<u>Haul of 673 miles in average Western/Official Territories - 37½ ton cars</u>		
	<u>cents</u>	<u>%</u>
Terminal costs	<u>14.896</u>	<u>30.3</u>
Line haul costs at .05096¢ per mile	<u>34.296</u>	<u>69.7</u>
Total	<u>49.192</u>	<u>100.0</u>

For a 50 ton load and a 683 mile haul for traffic originating in the Prairie Region, calculations from these U.S. figures suggest that terminal costs account for 30% of total transport costs and line haul costs for the remaining 70%. The breakdown between terminal and line haul costs is very similar to this

for Canada as a whole. With the shorter length average haul of 505 miles on manufacturing and miscellaneous products originating in the Atlantic Region, the share of terminal costs increases to 35%. The objective of these calculations is to place an order of magnitude on the initial breakdown between terminal and line haul costs, before considering the effects of application of subsidy. The model will therefore be calibrated in subsequent chapters on the assumption that terminal costs initially represent one-third of total transport costs and line haul costs the remaining two-thirds.

5. THE PRODUCTION FUNCTION

In Section 2 above, the production function was defined in the familiar Cobb-Douglas form.

$$x = ak^{\alpha}l^{\beta}$$

where x is output,

k is capital,

l is labour,

and, $0 < \alpha < 1$

$0 < \beta < 1$

$0 < a$

Under this specification, there are diminishing returns to inputs of each separate factor of production, but not necessarily diminishing returns to scale for a proportionate increase in all inputs. In a constrained Cobb-Douglas formulation of $\alpha + \beta = 1$, the production function is homogeneous of degree one, i.e. showing constant returns to scale. Under the formulation of the present model, there can be increasing $\alpha + \beta > 1$, constant $\alpha + \beta = 1$, or decreasing $\alpha + \beta < 1$ returns to scale. The Cobb-Douglas type of production function suffers from the well-known limitation that it postulates the same returns to scale for all levels of output. Depending upon the specification of $\alpha + \beta$ the function must always show either increasing or constant or decreasing returns. However, by postulating different values of $\alpha + \beta$ in the present

model, it is possible to consider a firm producing a single product in a single plant at varying degrees of returns to scale.*

The present section commences with a discussion of desirable qualities of production functions and then proceeds to the choice between Cobb-Douglas and the more generalized CES (constant elasticity of substitution) production function. Finally, there is consideration of the empirical values to be attached to the Cobb-Douglas function used in the present model.

(a) Desirable Qualities of Production Functions

The objective of a production function is, of course, to express maximum outputs which can be produced from various combinations of inputs when the production process is organized with maximum technical efficiency. The theoretical concept of the production function is long-established and goes back as far as Wicksteed in 1894, but this area of economic theory is still not without its problems. In his introduction to the Proceedings of a 1965 Conference on Production Relations, Murray Brown commented that production

*Attempts have been made to generalize production functions, including the Cobb-Douglas, to allow declining returns to scale as output increases (see 97). However, it is not necessary to go to this degree of complexity in the present model, as the impact of changing returns to scale can be considered quite adequately by using different values of $\alpha + \beta$.

economics was in its "winter of discontent" (7, p. 3). In 1968, the introductory article to a symposium on CES production functions noted the debate concerning the "question of the conditions permitting many productive factors to be collapsed for purposes of analysis into one homogeneous jelly conforming to neo-classical parables" (26, p. 443). In 1970, Georgescu-Roegen stressed that production economics "is not a domain where one runs no risk of committing some respectable errors. In fact, the history of every science, including that of economics, teaches us that the elementary is the hot-bed of the errors that count most" (39, p. 9).

In the current state of debate on the subject of production functions, there is clearly no definitive generally-accepted approach. There are a great variety of functions that can be used in econometric analysis,* although most research into empirical relations has used either Cobb-Douglas, CES, or the fixed coefficients form (90, p. 288). The fixed coefficients form is clearly unsuitable in the present model, as this would not allow comparison of factor subsidies with the other methods

*In the original formulation of this model, it had also been the intention to consider quadratic and cubic production functions. In his short story "Eupompus Gave Splendour to Art by Numbers" (57), Aldous Huxley recounted the fate of an imaginary Alexandrian portrait-painter who came to the conclusion that the only pure artistic beauty was to be found in numbers. The result of this mathematical obsession was "mental leprosy" followed by madness. The present writer must thank Dr. P.S. Dhruvarajan and Dr. O.P. Tangri of the University of Manitoba for saving him from a similar algebraic fate, by advising him against pursuing the quadratic and cubic models.

under consideration for securing an increase in output. The Cobb-Douglas function has already been specified at the beginning of this section. The CES function is as follows:

$$x = y [ak^{-s} + (1 - a)l^{-s}]^{-v/s}$$

where x is output,

k is capital,

l is labour,

y , a and s are constants,

where $y > 0$

$0 \leq a \leq 1$,

$s > -1$, but $s \neq 0$.

v is indicator of returns to scale,

viz., $v > 1$ means increasing returns,

$v = 1$ means constant returns,

$v < 1$ means decreasing returns.

and $\frac{1}{1+s} = \sigma$, where σ is the elasticity of substitution of labour for capital.

A minimal set of three criteria have been specified as operationally desirable properties in a production function. Firstly, the marginal products of factors of production should be positive. Secondly, to achieve a determinate solution, each marginal product should decrease, at least over some range of output. Thirdly, the degree of returns to scale should be determined by the data and not specified a priori in the function (6, pp. 29-30). With $\alpha < 1$ and $\beta < 1$, the Cobb-

Douglas type of production function satisfies these requirements (6, pp. 31-3). With similar restrictions, the CES function also satisfies these criteria (6, pp. 46-8).

The elasticity of substitution σ is a pure number that measures the rate at which substitution takes place. It is defined as follows:

$$\sigma = \frac{d \log (\ell/k)}{d \log R} = \frac{k}{\ell} R \frac{d (\ell/k)}{d R}$$

$$\text{where } R = \frac{\partial x / \partial k}{\partial x / \partial \ell}$$

The most famous quality of the Cobb-Douglas production function is that the elasticity of substitution is unity for all values of capital and labour and for any degree of returns to scale (6, pp. 35-6). For the CES production function, the elasticity of substitution is a constant $(1/1 + s)$, but not necessarily unity. The higher the value of s , the lower the elasticity of substitution. As s approaches infinity, the elasticity of substitution becomes extremely small and the production function approximates to the fixed coefficients of linear programming. As s approaches its lower limit of -1 , the elasticity of substitution tends to infinity. As s approaches zero, the elasticity of substitution tends to unity and approximates to the Cobb-Douglas function (90, pp. 286-7).

(b) *The Choice Between Cobb-Douglas and CES Production Functions*

The model outlined in this chapter of alternative forms of subsidy to regional development must not be limited to examination of constant returns to scale. In part, the model examines the potential trade-off of the advantages of large-scale production against increasing transport costs. It would be a very serious limitation to the analysis to confine consideration to production functions homogeneous of degree one. Both Cobb-Douglas and CES production functions do not require this limitation. The model includes subsidy to factors of production among the various alternatives available, and must therefore postulate some possibilities of substitution between capital and labour. The Cobb-Douglas function specifies an elasticity of substitution of unity, while the CES function is not constrained in this way.

In principle, it could be best to use the CES function rather than the more limited Cobb-Douglas. However, in the specific context of the subsidy model of this paper, the Cobb-Douglas constraint on the elasticity of substitution is not too serious a drawback. The only essential assumption in the examination of the effects of subsidy on one factor of production is that there is some substitutability between factors, but that this is not sufficiently great to allow the elasticity of substitution to approach infinity. The theoretical purity of CES with variable returns to scale as against Cobb-Douglas

with variable returns to scale must be measured against the greater complexity of manipulating CES and the more limited empirical results available for this type of function. In short, it may be possible to invoke Occam's Razor on behalf of Cobb-Douglas.

There are difficulties in the estimation of production relationships which are common to all forms of function. These include, for example, data availability and the definition of inputs of factors of production. Analysis of cross-section data is characterized by problems of multicollinearity attributable to small variations in capital-labour ratios between firms (90, p. 323). Time series analysis is complicated by the effects of technical change and by economies and diseconomies of scale which are enjoyed by the industry as a whole and not by individual firms (91, p. 8). In addition to these general problems, the Cobb-Douglas function implies a risk of specification error that can be serious arising from the requirement of an elasticity of substitution of unity. The Cobb-Douglas function is also limited in its application to aggregation work beyond the level of the firm (90, pp. 305-8), but this is not of serious importance in the present study.

The major disadvantage of the CES function is that the difficulties of estimation are much greater than for Cobb-Douglas. The Cobb-Douglas equation can be easily transformed logarithmically and a simple least-squares procedure can be applied, although of course there still remain problems of

data availability, input definition, multicollinearity and equation misspecification. On the other hand, the CES function cannot be converted into a simple linear form. Methods of overcoming this problem through the estimation of some parameters from side relations have been described in the literature, and it is shown that the greater generality of the CES function exacts a considerable price in the burden of fitting (6, pp. 128-40). It is therefore not surprising to find Griliches stating that "Since the CES production function form is highly nonlinear in the parameters, it is rather difficult to estimate, and very few direct estimates of this function have been reported in the literature" (41, p. 296).

Given the practical difficulties in fitting CES production functions, the Cobb-Douglas function has obvious attractions, provided that there is not too serious a misspecification caused by the assumption of an elasticity of substitution of unity. However, analysis of time series data has suggested that this misspecification is not trite. The original 1961 CES article by Arrow et al. concluded that "the elasticity of substitution between capital and labor in manufacturing may typically be less than unity" (1, p. 246). Time series analysis by Kotowitz in respect of Canadian manufacturing industry also supported this conclusion, although it was recognized that a fair amount of residual variance had not been explained (62, pp. 619-32).

On the other hand, analysis of cross-section data does not

support the hypothesis of misspecification based on time series results. For example, surveying United States evidence, Griliches concluded that cross-section estimates suggested an elasticity of substitution not significantly different from unity, while time series estimates averaged below unity although often not to a very large extent (41, p. 286). At a theoretical level, Maddala and Kadane have concluded that it is a plausible assumption that factors of production are independently lognormally distributed and that hence there is no appreciable bias in estimating returns to scale by using the Cobb-Douglas function as an approximation for CES (68, p. 422).

The algebra of the Cobb-Douglas production function is much more tractable than the CES for the subsidy model of the present study, and relevant empirical results are available only for Cobb-Douglas. Although the issue is far from a definitive solution, the cross-section data suggest that the Cobb-Douglas assumption of an elasticity of substitution of unity is not unreasonable. In any event, the present model is more concerned with economies of scale than with precise measurement of the elasticity of substitution and the Cobb-Douglas production function seems to be a reasonable theoretical approximation.

(c) Empirical Values

The final part of this section considers the empirical values to be attached to the Cobb-Douglas production function in respect of the arithmetical simulations carried out

later in the paper. The discussion commences with consideration of returns to scale as a whole $\alpha + \beta$, and then proceeds to the individual coefficients attached to capital α and labour β . The examination is entirely in terms of value added, omitting material inputs. As Domar has remarked, this is suggestive of making "potato chips without potatoes" (27, p. 472), but it is the favoured approach often because of problems of data.

In 1970, Walters conducted an extensive summary of econometric studies of production. The results were drawn from a number of different countries and the production functions used were all Cobb-Douglas. He concluded that evidence of economies of scale was found chiefly in public utility industries and that there seemed to be constant returns to scale in most inter-firm studies (90, p. 338). Eisner reached a similar conclusion in his examination of 1959-62 U.S. data (33, p. 436).

On the other hand, in a cross-section analysis of 1957 data for 15 U.S. industries, Hildebrand and Liu found increasing returns to scale in 12 industrial groups, with food products the highest at $\alpha + \beta = 1.24$, leather products the lowest at $\alpha + \beta = .92$, and an average reading of $\alpha + \beta = 1.07$. Moreover, they claimed that their estimating procedure produced the lower band of true values and underestimated increasing returns to scale (53, pp. 106-9). However, Walters has pointed out that these results are subject to relatively large standard errors

and that they might merely show inter-state locational advantages rather than the shape of the production function (90, p. 332). Analysing U.S. manufacturing data for 1954 and 1958, Griliches produces economies of scale indices in the order of 1.04, but showed that this would increase to above 1.10, if analysis were confined to the medium to large scale plant range where the main evidence for economies of scale was to be found (41, pp. 305-8).

Unfortunately, there are no specific Canadian results directly comparable with these U.S. findings. In his studies of the Canadian CES production function, Kotowitz constrained his production function to be homogeneous of degree one on the grounds that economies of scale could only be estimated from cross-section analysis which was outside his scope of reference (61, p. 430). The study of Canadian production relationships carried out by Lithwick et al. focussed mainly on the growth rates of manufacturing in the postwar period and excluded examination of returns to scale (66).

If Kotowitz's statement is accepted that returns to scale should be estimated from cross-section data, it becomes almost impossible to estimate production functions from Canadian manufacturing data that are unconstrained with respect to scale. If production functions were estimated across provinces for the 20 major industry groups on which data are given in Statistics Canada 31-203, there would be a formidable problem of lack of homogeneity in these broad

categories. If a greater degree of product disaggregation were sought, data would soon disappear for the smaller provinces because of Statistics Canada requirements on confidentiality. The estimation of a two factor production function would only allow seven degrees of freedom even if data were available for all ten provinces; at low levels of disaggregation, the data availability could easily fall towards a figure of only three provinces and the production function estimation becomes impossible. Resolution of this data problem would be extremely difficult and is clearly beyond the terms of reference of the present study.

The existence of economies of scale has been a favourite area of controversy among economists for at least the last fifty years, as evidenced in the exchange of the 1920's between Clapham, Pigou and Robertson. Yet, given the indivisibilities in many production processes, it is difficult to believe that economies of scale exist only in the imagination of the theorist. Extending Georgescu-Roegen's argument that the arrangement of a number of processes in line can ensure that no production fund is idle at any time (39, p. 6), it would follow that a widening of the market and the adoption of more complex processes should allow increasing returns to scale. In the specific case of Canada, it can be argued that higher output per unit of labour in the United States is attributable to economies of scale.

In 1963, net value added per employee in

manufacturing as a whole in the United States was U.S. \$11,843 as against a comparable figure for Canada of C. \$9,096 (21, p. 10). Net value added was therefore 30% higher in the United States, even treating the two currencies as at parity, while in actual fact the Canadian dollar was below the U.S. dollar at that time. Eastman has argued that generally the basic equipment used in manufacturing industries is very similar between the two countries (31, p. 440). The explanation of greater U.S. output per man is not normally couched in terms of different production functions, or in terms of more heavily capital-intensive production in the United States. Size of plant is not generally viewed as the dominant factor in the differences in productivity between the two economies, but rather it is argued that the limited extent of specialization is the major factor adversely affecting productivity in Canadian manufacturing (21, pp. 20-3). A Staff Study of the Economic Council of Canada has argued that Canadian manufacturing does not reap the economies of scale and specialization that are available to American industry (21, p. 7).

This raises the possibility of an interesting, if admittedly superficial calculation. Equation 1 below is a stylised Cobb-Douglas function for output per head (index = 100) in Canadian manufacturing industry. Equation 2 is a similar version for the United States, where the capital to labour ratio is held the same as in Canada, inputs of each factor are increased tenfold, and output per head is indexed at 130.

$$ak^{\alpha}l^{\beta}/l = 100 \quad (1)$$

$$a(10k)^{\alpha}(10)^{\beta}/10l = 130 \quad (2)$$

Solving these two equations for $\alpha + \beta$, the production function is homogeneous of degree 1.114. This calculation may be crude in its assumptions of equivalent stylised production functions with the same constant a , and equal capital to labour ratios, yet in conjunction with other evidence it could be argued that a mean value of $\alpha + \beta = 1.1$ is not unreasonable for manufacturing industry. However, this suggestion is not crucial to the present study, as it is the intention to estimate the model from a low of $\alpha + \beta = .8$ to a high of $\alpha + \beta = 1.3$.

The final stage in determining the calibration of the model is to assign values individually to α , the capital coefficient, and β , the labour coefficient. As far as subsidies on product price and subsidies on transport costs are concerned, only the total of $\alpha + \beta$ is of interest, but obviously alternative values have to be assigned to α and β to determine the effects of subsidy on factor prices.

In the original formulation of the Cobb-Douglas production function constrained to be homogeneous of degree one, Douglas recalled that least squares were applied to U.S. manufacturing data to estimate $\alpha = .25$ and $\beta = .75$. Subsequent investigations were carried out in respect of Australia, New Zealand, the United States and a number of other countries and, for a function constrained to constant returns to scale, estimates

of β were around the .65+ range on the basis of pre-war manufacturing data (28, pp. 16-20). Using data for 1947-60, Griliches has estimated the labour share of value added in U.S. manufacturing at .73 (41, p. 310).

The most detailed data available for Canada on value added in manufacturing industries are contained in Statistics Canada 31-203 "General review of the manufacturing industries of Canada". On latest figures for 1972, the proportion of value added in manufacturing attributable to labour is only .55 and this is broadly consistent with earlier years. However, this statistical series includes in value added the purchase of a number of external services which must be excluded in the type of calibration to be performed in the present study. It is therefore necessary to use Canadian National Income data (Statistics Canada 13-531), where calculations from Tables 28 and 29 show the labour share of value added in Canadian manufacturing as .68 on preliminary figures for 1973 and as .69 for the average of 1968-72.

In the light of the evidence on returns to scale and the labour share of value added in manufacturing industry, it was decided to simulate the seven values below in the calibration of the model.* The values of α and β have been specified to

*It was the original intention to simulate considerably more values of α and β and initially this temptation was not completely resisted. The additional results did not add to the understanding of the problem and have been excluded from the study.

only one significant figure and this has caused the labour share of value added ($\beta/\alpha + \beta$) to fluctuate from .63 to .73, with the mid-point of this range corresponding roughly to the best estimate based on recent Canadian data. The advantages of simple specification of α and β outweighed this fluctuation effect, particularly as individual specification of α and β was only relevant in the case of subsidy on a factor of production.

<u>$(\alpha + \beta)$</u>	<u>(α)</u>	<u>(β)</u>	<u>$(\beta/\alpha + \beta)$</u>
0.8	0.3	0.5	.63
0.9	0.3	0.6	.67
1.0	0.3	0.7	.70
1.1	0.3	0.8	.73
1.1	0.4	0.7	.64
1.2	0.4	0.8	.67
1.3	0.4	0.9	.69

CHAPTER V: DEVELOPMENT AND CALIBRATION OF THE MODEL: UNIFORM DISTRIBUTION OF DEMAND IN AN UNBOUNDED PLANE

In the previous chapter, the model is specified as a firm producing a single homogeneous product in a single plant. The production function is of the Cobb-Douglas type and the objective of the firm is profit maximization subject to the restrictions of given factor and product prices. The firm has no influence on the prices of the factors of production it uses and it receives a constant selling price for each unit of output produced. However, it has to meet transport costs as well as production costs on each unit of output. Increased sales can only be achieved by expanding the geographical area covered, thus incurring rising transport costs per unit of output.

In determining transport costs paid by the firm, two alternative assumptions were made on geographical distribution of demand. The present chapter develops and calibrates the model on the assumption that there is uniform distribution of demand in an unbounded plane, as outlined in Section 2(c) of the previous chapter. The case of uniform distribution of demand in a band of constant width is examined in Chapter VI.

The present chapter commences by establishing the equilibrium conditions for the firm where no subsidy is paid.

The model is then developed to show the costs of achieving a given increase in output from the application of subsidy to (a) output price; (b) factor prices for labour and capital; and (c) terminal and line haul transport charges. The cost implications of these alternative subsidy approaches are considered in terms of (i) subsidy costs; (ii) increased profits of the firm; (iii) net social cost, defined as subsidy costs minus increased profits. It has been argued in Section 2(e) of the previous chapter that, if two subsidy approaches result in the same net social cost, the approach involving the lowest subsidy costs is normally to be preferred.

Section 2 develops the model where subsidy payments are applicable to the entire output of the firm, and Section 3 where these payments are required only for output in excess of that originally produced before the subsidy scheme was introduced. Finally, arithmetical simulations of the model are presented in Section 4.

1. EQUILIBRIUM WITHOUT SUBSIDY

The production function has been specified as Cobb-Douglas.

$$x = ak^{\alpha}l^{\beta} \quad (5.1)$$

where x is output,
 k is capital,
 l is labour,
 and, $0 < \alpha < 1$
 $0 < \beta < 1$
 $0 < a$

When demand is uniformly distributed in an unbounded plane, transport charges TRANS paid by the firm are given on page 137.

$$\text{TRANS} = bx + cgx^{\frac{3}{2}} \quad (5.2)$$

where b is fixed terminal charges at origin
 and destination per unit of output,
 c is line haul rate per mile per unit of
 output,
 g is a constant.

The firm receives a constant price p_x for each unit of output sold*, so that revenue is simply $p_x x$. The factor prices, p_x and p_l , to be paid by the firm are constant and not influenced by the firm's level of production. The firm's

*Strictly speaking, for each unit of value added sold, but this slightly pedantic wording is not used in the argument which follows.

production costs are therefore $p_k k + p_l l$. Transport costs have already been shown in (5.2). The objective function of the firm is to maximize profits P , subject to the requirement that profits should not be negative. The next equation shows profits as revenue minus production costs and transport costs.

$$P = p_x x - (p_k k + p_l l) - (bx + cgx^{\frac{3}{2}}) \quad (5.3)$$

where $P \geq 0$

Substituting for x from (5.1) and rearranging the terms,

$$P = (p_x - b)ak^{\alpha}l^{\beta} - cg(ak^{\alpha}l^{\beta})^{\frac{3}{2}} - p_k k - p_l l$$

From the requirement for profit maximization that each factor be employed to the point where factor price is equal to marginal product,

$$\frac{\partial P}{\partial k} = \alpha(p_x - b)ak^{\alpha-1}l^{\beta} - \frac{3}{2}acg(ak^{\alpha}l^{\beta})^{\frac{3}{2}}k^{\frac{3}{2}\alpha-1} - p_k = 0$$

$$\therefore k = \alpha p_k^{-1} [p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}] \quad (5.4)$$

$$\frac{\partial P}{\partial l} = \beta(p_x - b)ak^{\alpha}l^{\beta-1} - \frac{3}{2}\beta cg(ak^{\alpha}l^{\beta})^{\frac{3}{2}}l^{\frac{3}{2}\beta-1} - p_l = 0$$

$$\therefore l = \beta p_l^{-1} [p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}] \quad (5.5)$$

Profit maximization requires that profit must be decreasing with respect to further applications of either k or l separately, and of both k and l together. It can be

shown that the specification in (5.1) of $0 < \alpha < 1$ and $0 < \beta < 1$ satisfies the first of these requirements. Given, from (5.3) that profit must not be negative, and that the model is not to be calibrated at values of $\alpha + \beta < 0.8$ (see p.174), the second requirement is also satisfied.*

*From (51, p. 68), profit maximization of P implies that the principal minors of the relevant Hessian determinant, f_{11} and f_{22} , be negative, and that $f_{11}f_{22} - f_{12}f_{21} > 0$. After algebraic manipulation and substitution of $p_k k$,

$$f_{11} = (\alpha-1)k^{-2}(p_k k) - \frac{3}{4}\alpha^2 c g k^{-2} x^{\frac{3}{2}}$$

$$f_{22} = (\beta-1)l^{-2}(p_l l) - \frac{3}{4}\beta^2 c g l^{-2} x^{\frac{3}{2}}$$

which are negative because $\alpha < 1$, $\beta < 1$.

$$f_{12} = f_{21} = \beta(kl)^{-1}(p_k k) - \frac{3}{4}\alpha\beta(kl)^{-1}c g x^{\frac{3}{2}}$$

$$\text{or } \alpha(kl)^{-1}(p_l l) - \frac{3}{4}\alpha\beta(kl)^{-1}c g x^{\frac{3}{2}}$$

$$f_{11}f_{22} - f_{12}f_{21} = \beta(p_k k)(kl)^{-2}[(1-\alpha-\beta)(p_x - b)x + \frac{3}{2}(\frac{3}{2}(\alpha+\beta)-1)c g x^{\frac{3}{2}}]$$

Substituting P from (5.6),

$$f_{11}f_{22} - f_{12}f_{21} = \beta(p_k k)(kl)^{-2}[P + \frac{1}{2}[\frac{3}{2}(\alpha+\beta)-1]c g x^{\frac{3}{2}}]$$

This expression is positive because $\beta(p_k k)(kl)^{-2} > 0$, $P \geq 0$, and $[\frac{3}{2}(\alpha + \beta) - 1] > 0$ in a model which is only estimated for $\alpha + \beta \geq 0.8$. However, not surprisingly, further calculations have shown that $f_{11}f_{22} - f_{12}f_{21} > 0$, when $\alpha + \beta < 0.8$.

Returning to (5.3) and substituting for $p_k k$ and $p_\ell \ell$ from (5.4) and (5.5),

$$P = [1 - (\alpha + \beta)] (p_x - b)x + \left[\frac{3}{2}(\alpha + \beta) - 1\right] c g x^{\frac{3}{2}} \quad (5.6)$$

where $P \geq 0$

There is no problem in satisfying the requirement that $P \geq 0$ for values of $\alpha + \beta$ of 0.8, 0.9 and 1.0, but higher values cause difficulties. From (5.2), transport charges per unit of output are $b + c g x^{\frac{1}{2}}$. Terminal costs b are initially taken as equivalent to one-third of total transport charges (Chapter IV, Section 4). Now divide (5.6) by x , substitute $b = \frac{1}{3} c g x^{\frac{1}{2}}$ and the requirement that $P \geq 0$ implies:

$$\left[2(\alpha + \beta) - \frac{3}{2}\right] c g x^{\frac{1}{2}} \geq (\alpha + \beta - 1)p_x$$

$$\text{Hence } \frac{3}{2} c g x^{\frac{1}{2}} / p_x \geq \frac{3\alpha + 3\beta - 3}{4\alpha + 4\beta - 3} \quad (5.7)$$

The expression $\frac{3}{2} c g x^{\frac{1}{2}} / p_x$ is simply transport costs per unit of output as a proportion of product selling price. As already noted (Chapter IV, Section 3), to achieve the equilibrium requirement of $P \geq 0$, the following conditions must hold:

$\alpha + \beta$	Transport costs as % of selling price
1.1	≥ 21.4
1.2	≥ 33.3
1.3	≥ 40.9

Finally, from (5.4) and (5.5), the well-known Cobb-Douglas property is established:

$$\ell = \beta p_k k / \alpha p_\ell \quad (5.8)$$

2. INCREASED OUTPUT THROUGH SUBSIDIES APPLICABLE TO ENTIRE PRODUCTION OF FIRM

From an equilibrium output without subsidy x , the objective is to apply subsidies to increase output to x_2 , such that $x_2/x = h^2$, where $h > 1.0$. (The h^2 notation is used merely to simplify the algebraic presentation below.)

This objective can be achieved by:

- (a) Subsidizing output price p_x ;
- (b) Subsidizing factor input prices of
 - (i) labour p_l ,
 - or (ii) capital p_k ;
- or (c) Subsidizing transport charges in respect of
 - (i) terminal component b ,
 - or (ii) line haul component c .

The cost implications are considered in terms of (i) subsidy costs incurred by government; (ii) increased profits of the firm; and (iii) net social cost, which is defined as (i) minus (ii). For each form of subsidy used, the costs are determined on the assumption that subsidy is paid on the entire output of the firm, on the entire amount of the relevant factor of production used, or on the entire transport charge in respect of terminal or line haul component. Consideration of subsidies paid only in respect of incremental units of output is contained in Section 3.

(a) *Subsidizing Output Price*

The price to the firm is increased from p_x to p_{x2}

and a subsidy of $p_{x2} - p_x$ per unit of output is paid by government on the increased output x_2 . Subsidy cost is therefore $(p_{x2} - p_x)x_2 = (p_{x2} - p_x)h^2x$.

From the production function (5.1) and substituting for l from (5.8),

$$\frac{x_2}{x} = \frac{ak_2^\alpha l_2^\beta}{a k^\alpha l^\beta} = \left(\frac{k_2}{k}\right)^{\alpha + \beta} \quad (5.9)$$

Substituting for k from (5.4),

$$\frac{x_2}{x} = \left[\frac{x_2 (p_{x2} - b - \frac{3}{2} c g x_2^{\frac{1}{2}})}{x (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}})} \right]^{\alpha + \beta}$$

Substituting $x_2 = h^2x$,

$$p_{x2} - p_x = h^{\frac{2(1-\alpha-\beta)}{\alpha+\beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) - (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) \quad (5.10)$$

and subsidy cost of $(p_{x2} - p_x)h^2x$ is

$$\frac{2}{\alpha+\beta} h (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}})x - h^2 (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}})x \quad (5.11)$$

This is positive by definition of the equilibrium requirements of the model in Section 1.

From (5.6), the firm's profit (which is ≥ 0 by

definition) is shown before subsidy P and after subsidy P_2 .

$$P = [1 - (\alpha + \beta)] (p_x - b)x + \left[\frac{3}{2}(\alpha + \beta) - 1\right] cgx^{\frac{3}{2}}$$

$$P_2 = [1 - (\alpha + \beta)] (p_{x2} - b)x_2 + \left[\frac{3}{2}(\alpha + \beta) - 1\right] cgx_2^{\frac{3}{2}}$$

Substituting for P_{x2} from (5.10) and $x_2 = h^2x$, the increased profit of the firm, $P_2 - P$, is:

$$\begin{aligned} & \frac{[1 - (\alpha + \beta)] \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) - (p_x - b - \frac{3}{2}cgh^3x^{\frac{1}{2}}) \right] x}{+ (h^3 - 1) \left[\frac{3}{2}(\alpha + \beta) - 1 \right] cgx^{\frac{3}{2}}} \quad (5.12) \end{aligned}$$

Net social cost is defined as subsidy cost (5.11) minus increased profit (5.12) and is:

$$\begin{aligned} & (\alpha + \beta) \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) \right] x \\ & - [h^2 + (\alpha + \beta) - 1] (p_x - b)x \\ & + [h^3 + \frac{3}{2}(\alpha + \beta) - 1] cgx^{\frac{3}{2}} \end{aligned}$$

which simplifies further to:

$$\begin{aligned} & \frac{(\alpha + \beta) \left[h^{\frac{2}{\alpha+\beta}} - 1 \right] (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) x}{- h^2 (p_x - b - cghx^{\frac{1}{2}}) x + (p_x - b - cgx^{\frac{1}{2}}) x} \quad (5.13) \end{aligned}$$

(b) *Subsidizing Factor Input Prices*

(i) *Subsidizing Input Price of Labour*

Through a government subsidy payment of s per unit of labour employed, the price of labour to the firm is reduced to $p_\ell - s$ in order to achieve an output x_2 , where $x_2 = h^2 x$. It is specified that $s < p_\ell$; otherwise labour would become a free or negatively priced factor to the firm, an infinite amount would be used with a Cobb-Douglas type of production function, and the model becomes indeterminate. This specification of $s < p_\ell$ also constrains h , but this is not a problem within the range of values for transport charges and h used to calibrate this model.* The subsidy cost is sl_2 .

*From the requirement $s < p_\ell$, it is necessary in (5.16) below that $[p_x - b - \frac{3}{2} cghx^{\frac{1}{2}}] > 0$. This means that $h < (p_x - b)(\frac{3}{2} cghx^{\frac{1}{2}})^{-1}$. Following the explanation on page 141, the expression on the right of this inequality is simply (product price minus one-third of transport charges) divided by (total transport charges). The highest value of transport charges as a percentage of p_x used to calibrate the model is 42%. This requires that $h < (86/42)$, i.e. $h < 2.05$. The highest value used for h is 2.0. The required inequality is therefore satisfied, although labour is becoming very close to being a free good when transport charges and h jointly approach their maximum values.

From (5.1) and substituting for k from (5.8),

$$\frac{x_2}{x} = \frac{a k_2^\alpha \ell_2^\beta}{a k^\alpha \ell^\beta} = \left(\frac{\ell_2}{\ell} \right)^{\alpha+\beta} \left(\frac{p_\ell - s}{p_\ell} \right)^\alpha$$

Substituting $x_2/x = h^2$,

$$\therefore \ell_2 = \ell h^{\frac{2}{\alpha+\beta}} (p_\ell/p_\ell - s)^{\frac{\alpha}{\alpha+\beta}} \quad (5.14)$$

$$\begin{aligned} \text{From (5.5), } \ell_2 &= \beta x_2 (p_\ell - s)^{-1} [p_x - b - \frac{3}{2} c g x_2^{\frac{1}{2}}] \\ &= h^2 \beta x (p_\ell - s)^{-1} [p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}] \end{aligned}$$

Solving (5.5) and (5.14),

$$\ell_2 = \ell^{\frac{\alpha+\beta}{\beta}} h^{\frac{2}{\beta}} \left[p_\ell / h^2 \beta x (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) \right]^{\frac{\alpha}{\beta}} \quad (5.15)$$

$$s = p_\ell - \ell_2^{-1} h^2 \beta x [p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}] \quad (5.16)$$

Subsidy cost $s \ell_2$ is

$$\begin{aligned} (p_\ell \ell)^{\frac{\alpha+\beta}{\beta}} h^{\frac{2(1-\alpha)}{\beta}} &\left[\beta x (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) \right]^{\frac{\alpha}{\beta}} \\ &- h^2 \beta x \left[p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}} \right] \end{aligned}$$

Substituting for $p_\ell \ell$ from (5.5), subsidy cost is

$$\begin{aligned} \beta h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} x \\ \hline - \beta h^2 (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) x \end{aligned} \quad (5.17)$$

From (5.6), the firm's profit (which is ≥ 0 by definition) is shown before subsidy and after subsidy.

$$P = [1 - (\alpha + \beta)] (p_x - b)x + \left[\frac{3}{2}(\alpha + \beta) - 1\right] cgx^{\frac{3}{2}}$$

$$P_2 = [1 - (\alpha + \beta)] (p_x - b)x_2 + \left[\frac{3}{2}(\alpha + \beta) - 1\right] cgx_2^{\frac{3}{2}}$$

Substituting $x_2 = h^2 x$, the increased profit of $P_2 - P$ is:

$$(h^2 - 1)[1 - (\alpha + \beta)] (p_x - b)x + (h^3 - 1) \left[\frac{3}{2}(\alpha + \beta) - 1\right] cgx^{\frac{3}{2}} \quad (5.18)$$

Net social cost is defined as subsidy cost (5.17) minus increased profit (5.18) and is:

$$\begin{aligned} & \frac{2(1-\alpha)}{\beta h^{\frac{2}{\alpha+\beta}}} (p_x - b - \frac{3}{2} cgx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} x \\ & - \frac{[(h^2 - 1)(1 - \alpha) + \beta] (p_x - b)x}{1} \\ & - \frac{[(h^3 - 1)(\frac{3}{2}\alpha - 1) - \frac{3}{2}\beta] cgx^{\frac{3}{2}}}{1} \end{aligned} \quad (5.19)$$

The next step is to compare subsidy cost, increased profit and net social cost from subsidizing the factor price of labour as against subsidizing the output price. The first comparison shows the subsidy cost on labour (5.17) minus the subsidy cost on output price (5.11):

$$h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} cgx^{\frac{1}{2}}) x \left[\beta \frac{(p_x - b - \frac{3}{2} cgx^{\frac{1}{2}})^{\frac{\alpha}{\beta}}}{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} - 1 \right]$$

$$- (\beta - 1)h^2 (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x \quad (5.20)$$

After lengthy algebraic manipulation, it was not possible to determine the sign of expression (5.20); in particular, it could not be shown from the first differential that (5.20) was a monotonically increasing function of h . We return later to the question of whether subsidy cost is greater when labour is subsidized than when output price is subsidized.

The next comparison shows the increased profit to the firm when labour is subsidized (5.18) minus the increased profit when output price is subsidized (5.12):

$$(\alpha + \beta - 1) \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x - h^2 (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x \right] \quad (5.21)$$

From (5.11), the expression inside the square brackets is positive, if $h > 1$.

Hence, (5.21) is positive if $\alpha + \beta > 1$,

zero if $\alpha + \beta = 1$,

negative if $\alpha + \beta < 1$.

If the production function shows increasing returns to scale, the profit of the firm increases more from a subsidy on labour than from a subsidy on output price. If the production function is homogeneous of degree one, both subsidy approaches have the same effect on the firm's profit. When there are diminishing returns to scale, the firm's profit

increases more from a subsidy on output price than from a subsidy on labour.

The net social cost from subsidizing labour (5.19) is now compared with the net social cost from subsidizing the output price (5.13):

$$\begin{aligned}
 & \alpha h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) \\
 & \left[h^{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} \left((p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) / (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) \right) - 1 \right] x \\
 & + \beta h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) \\
 & \left[\left(h^{\frac{2(1-\alpha-\beta)}{\alpha+\beta}} (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) / (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) \right)^{\frac{\alpha}{\beta}} - 1 \right] x \\
 & \hspace{15em} (5.22)
 \end{aligned}$$

Consider the value of (5.22) as h approaches its limits.

As $h \rightarrow 1$, (5.22) $\rightarrow 0$.

As $h \rightarrow (p_x - b)(\frac{3}{2}cgx^{\frac{1}{2}})^{-1}$, (5.22) $\rightarrow +\infty$.

Since $xh^{\frac{2}{\alpha+\beta}} > 0$, the sign of (5.22) is the same as the sign of:

$$\alpha \left[h^{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) - (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}) \right]$$

$$+ \beta \left[h^{\frac{2\alpha(1-\alpha-\beta)}{(\alpha+\beta)\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} - (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) \right] \quad (5.23)$$

It is shown that the first differential of (5.23) with respect to h , and hence the first differential of (5.22), is positive for all values of $\alpha + \beta \leq 1$. Given the equilibrium condition of the model that the firm's profit should not be negative (5.6), it can also be shown that these first differentials are positive for those values of $\alpha + \beta > 1$ used in the model.* Hence (5.22) is an increasing function

*The first differential of (5.23) with respect to h is:

$$\alpha \left[\frac{2(\alpha+\beta-1)}{\alpha+\beta} h^{\frac{\alpha+\beta-2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) - h^{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} \frac{3}{2}cghx^{\frac{1}{2}} \right] + \alpha \left[\frac{2(1-\alpha-\beta)}{\alpha+\beta} h^{\frac{2\alpha(1-\alpha-\beta)}{(\alpha+\beta)\beta} - 1} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} + h^{\frac{2\alpha(1-\alpha-\beta)}{(\alpha+\beta)\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha+\beta}{\beta}} \frac{3}{2}cghx^{\frac{1}{2}} \right]$$

continued....

of h and always positive when $h > 1$.

Under decreasing or constant returns to scale, the net social cost to achieve a given increase in the firm's output is greater from subsidizing the price of labour than from subsidizing the output price. This conclusion also holds for increasing returns to scale over the range for which the model is calibrated to satisfy equilibrium conditions.

This simplifies to:

$$\begin{aligned} & \frac{2\alpha(1-\alpha-\beta)}{(\alpha+\beta)} h^{\frac{-2}{\alpha+\beta}} - 1 \left[h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} \right. \\ & \quad \left. (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} - h^2 (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} \right] \\ & + \alpha h^{\frac{-2}{\alpha+\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-1} \frac{3}{2}cghx^{\frac{1}{2}} \\ & \left[h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} - h^2 (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} \right] \end{aligned}$$

which is equivalent to the product of the following three

terms:

(i) $\frac{2\alpha}{(\alpha+\beta)} h^{\frac{-(2+\alpha+\beta)}{\alpha+\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-1}$, which is clearly positive;

(ii) $\left[h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{\frac{\alpha+\beta}{\beta}} (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} - h^2 (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})^{-\frac{\alpha}{\beta}} \right]$

which is positive because (5.17) is positive;

(ii) *Subsidizing Input Price of Capital*

An analysis of subsidy on the input price of capital would largely parallel that already carried out for labour and the exercise is therefore not repeated. In the equation of subsidy cost (5.17), the coefficients α and β would be transposed. The increased profit of the firm in (5.18) would be unchanged, and α and β would again be transposed in the net social cost equation (5.19). To the extent that the regional development objective is creation of employment opportunities as well as increased production, subsidy on capital is less effective than subsidy on labour, but this aspect will not be explored further in this study.

(c) *Subsidizing Transport Charges*

(i) *Subsidizing Transport Terminal Charges*

The model has divided transport charges into two components, terminal charges which are constant for each unit of output sold and unrelated to distance travelled, and line haul charges which are a direct function of distance.

Before meeting freight charges, the firm receives a constant price for each unit of output sold. It also pays a constant amount in respect of terminal freight charges on

$$(iii) \left[(1 - \alpha - \beta) (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}) + \frac{(\alpha + \beta)}{2} (\frac{3}{2}cghx^{\frac{1}{2}}) \right],$$

which is positive for all values of $\alpha + \beta \leq 1$. Moreover, expression (iii) is also a form of (5.6), which was constrained to be positive for those values of $\alpha + \beta > 1.0$ used in the model.

each unit of product shipped. Analytically, a subsidy on transport terminal charges is therefore no different from a subsidy on product price. The results from subsidizing transport terminal charges parallel the results from subsidizing output price, examined above.

In practice, a subsidy applied only to the terminal component of transport charges would be a peculiar innovation for which there does not seem to be any precedent. Nevertheless, a subsidy applied as a percentage of total transport charges, for example under the Maritime Freight Rates Act, is in effect partly a subsidy on terminal charges and partly a subsidy on line haul charges. This "mixed" effect of transport subsidies affecting both terminal and line haul charges is often administratively unavoidable. However, there does not seem to be any case for attempting to develop subsidy schemes that deliberately concentrate on the terminal component of freight charges; within the constraints of the present model, this would only have the same effect as the simpler procedure of subsidizing output price. Yet, every model is inevitably the prisoner of its own assumptions and, if monopolistic competition were assumed with the firm able to influence the selling price of its product, this conclusion might not still hold.

(ii) Subsidizing Transport Line Haul Charges

This sub-section considers a subsidy which reduces the

line haul charge per mile per unit of output. Although transport subsidies generally apply to both terminal and line haul charges, it would not be difficult to introduce a transport subsidy scheme that applied only to the line haul component. This could be accomplished by specifying that on each unit shipped the manufacturer must meet in full the first part of his freight charges per unit of output (covering at least the terminal charges) with subsidy paid on excess costs above this minimum and therefore a function only of line haul charges.

Through subsidy action, the line haul charge per mile per unit of output is reduced in the model from c to c_2 in order to achieve an increased output x_2 , where $x_2 = h^2 x$.

From (5.2), for an output x_2 the aggregate number of "output unit miles" is $gx_2^{\frac{3}{2}}$. Subsidy cost is therefore $(c - c_2)gx_2^{\frac{3}{2}} = (c - c_2)gh^3x^{\frac{3}{2}}$.

Repeating (5.9) and substituting for k from (5.4),

$$\frac{x_2}{x} = \left[\frac{k_2}{k} \right]^{\alpha + \beta} = \left[\frac{x_2(p_x - b - \frac{3}{2}c_2gx_2^{\frac{1}{2}})}{x(p_x - b - \frac{3}{2}cgx^{\frac{1}{2}})} \right]^{\alpha + \beta}$$

Substituting $x_2 = h^2 x$,

$$h^2(p_x - b - \frac{3}{2}c_2ghx^{\frac{1}{2}})x = h^{\frac{2}{\alpha + \beta}}(p_x - b - \frac{3}{2}cgx^{\frac{1}{2}})x$$

and subsidy cost of $(c - c_2)gh^3x^{\frac{3}{2}}$ is

$$\frac{2}{3} \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x - h^2 (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x \right] \quad (5.24)$$

From (5.6), the firm's profit is shown before subsidy P and after subsidy P_2 .

$$P = \left[1 - (\alpha+\beta) \right] (p_x - b)x + \left[\frac{3}{2}(\alpha+\beta) - 1 \right] cghx^{\frac{3}{2}}$$

$$P_2 = \left[1 - (\alpha+\beta) \right] (p_x - b)x_2 + \left[\frac{3}{2}(\alpha+\beta) - 1 \right] c_2gx_2^{\frac{3}{2}}$$

Substituting $x_2 = h^2x$,

$$P_2 - P = \left[1 - (\alpha+\beta) \right] (p_x - b)(h^2 - 1)x$$

$$+ \left[\frac{3}{2}(\alpha+\beta) - 1 \right] (c_2gh^3x^{\frac{3}{2}} - cghx^{\frac{3}{2}})$$

Substituting for $c_2gh^3x^{\frac{3}{2}}$ from (5.24),

$$P_2 - P = \left[1 - (\alpha+\beta) \right] (p_x - b)(h^2 - 1)x$$

$$+ (\alpha+\beta) - \frac{2}{3} \frac{3}{2} cghx^{\frac{3}{2}} (h^3 - 1) + h^2 (p_x - b - cghx^{\frac{1}{2}})x$$

$$- h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} cghx^{\frac{1}{2}})x$$

For ease of later comparison, increased profit of the firm is converted into the following expression:

$$\begin{aligned}
& \frac{[1 - (\alpha + \beta)] \left[h^{\frac{2}{\alpha + \beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) - (p_x - b - \frac{3}{2} c g h^3 x^{\frac{1}{2}}) \right] x}{+ (h^3 - 1) \left[\frac{3}{2} (\alpha + \beta) - 1 \right] c g x^{\frac{3}{2}}} \\
& - \frac{1}{3} \left[h^{\frac{2}{\alpha + \beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) x - h^2 (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) x \right] \quad (5.25)
\end{aligned}$$

Net social cost is defined as subsidy cost (5.24) minus increased profit (5.25), which simplifies to:

$$\begin{aligned}
& \frac{(\alpha + \beta) \left[h^{\frac{2}{\alpha + \beta}} - 1 \right] (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) x}{- h^2 (p_x - b - c g h x^{\frac{1}{2}}) x + (p_x - b - c g x^{\frac{1}{2}}) x} \quad (5.26)
\end{aligned}$$

The next step is to compare subsidy cost, increased profit and net social cost from subsidizing line haul transport charges as against subsidizing the output price or the factor price of labour.

The subsidy cost from subsidizing line haul transport charges is shown in (5.24). This is exactly two-thirds of the subsidy cost incurred in subsidizing output price in (5.11). Under the model specifications, it is less expensive to achieve a given increase in output from subsidizing line haul transport charges than from subsidizing output price. This conclusion may not be intuitively obvious from micro-economic theory, which generally argues that it is better to apply subsidy to output in total rather than to specific inputs. Yet perhaps

this result is not really surprising. It is the marginal units of output with high transport costs which are most in need of subsidy; the line haul transport subsidy is directed more intensely to these units, while the output price subsidy operates equally and indiscriminately on all units of production.

The earlier discussion (p.188.) was inconclusive in the comparison of subsidy costs from subsidizing factor prices as against subsidizing the output price. However, it was later established that net social cost was always higher from the subsidy on factor price (pp.189-91). The firm's profit was also higher from the subsidy on factor price when there were increasing returns to scale, while there was no difference between profit from the two subsidy approaches under constant returns to scale (p.188). By definition, subsidy cost is equal to net social cost plus the increased profit of the firm. Hence, the subsidy cost must be greater from subsidizing factor price than from subsidizing output price under conditions of increasing or constant returns to scale. It is not possible to make a definitive comment in respect of diminishing returns to scale. The discussion below will show that net social cost and the increased profit of the firm are always less from subsidizing a factor price. Hence, the subsidy cost must be lower from subsidizing line haul transport charges than from subsidizing factor price, irrespective of the returns to scale in the production function.

The increased profit of the firm from a subsidy on line haul charges is shown in (5.25). This is easily compared with increased profit when output price is subsidized in (5.12). The increased profit of the firm is always less from the subsidy on line haul charges by an amount:

$$\frac{1}{3} \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) x - h^2 (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) x \right] \quad (5.27)$$

This is equivalent to one-third of the total cost paid to subsidize output price in (5.11). It is also the amount by which the subsidy cost on line haul charges in (5.24) falls short of the subsidy payment when output price is subsidized in (5.11). In other words, the saving in subsidy cost from subsidizing line haul charges rather than output price is matched exactly by the smaller increase in the firm's profits when the subsidy is applied to line haul charges.

The increased profit to the firm from subsidy to labour (5.18) minus the increased profit from subsidy on line haul transport charges (5.25) is:

$$(\alpha+\beta - \frac{2}{3}) \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - \frac{3}{2} c g x^{\frac{1}{2}}) x - h^2 (p_x - b - \frac{3}{2} c g h x^{\frac{1}{2}}) x \right] \quad (5.28)$$

This expression is positive for all values of $\alpha+\beta > \frac{2}{3}$, and the model is not calibrated for values of $\alpha+\beta < 0.8$. Hence, the profit of the firm is greater from a subsidy on the input price of labour than from a subsidy on line haul transport charges.

Subsidy cost is one-third less from subsidizing line haul transport charges than from subsidizing output price, but the increased profit of the firm is also reduced by an equivalent amount. Consequently, net social cost from subsidizing line haul charges in (5.26) is identical to net social cost from subsidizing output price in (5.13), and less than the net social cost incurred from subsidizing the price of labour. The subsidy on output price involves a larger transfer payment from taxpayers to the firm, offset by an equally larger increase in the firm's profit. *Ceteris paribus*, with net social cost the same for two alternative methods of subsidy, it was argued in Chapter IV, Section 2(e), that the method incurring the smaller transfer payment would be superior. Within the restrictions of the model, this additional criterion would suggest that subsidy on line haul transport charges would be preferred to subsidy on output price.

Apart from the equilibrium condition that no factor of production should become free or negatively priced, the algebraic presentation in this section has not been constrained to require, for example, that subsidy on transport charges should not exceed transport charges actually paid by the firm. Constraints of this type do not affect the algebraic analysis, but they limit the extent of output increase attainable for different combinations of transport charges and economies of scale. This is examined further in Section 4 which presents the model simulations.

3. INCREASED OUTPUT THROUGH SUBSIDIES APPLICABLE ONLY TO ADDITIONAL PRODUCTION OF FIRM

This section considers subsidy costs incurred by government when these are paid only in respect of the increase in output beyond that produced in equilibrium without subsidy, or alternatively only in respect of increased utilization of a subsidized factor of production beyond the amount already used in equilibrium without subsidy. If this procedure is administratively feasible, it is always less expensive in terms of subsidy costs to confine payments to incremental units of output or incremental factor utilization rather than pay in respect of the entire output or the entire factor utilization. In effect, a marginal subsidy scheme reduces the transfer payments by government to the firm with a corresponding reduction in the firm's profits. Net social cost, as defined in this paper, remains unchanged. As already explained, with net social cost the same for two alternative methods of subsidy, the method incurring the smaller transfer payment would normally be preferred. This is the basic justification for using marginal subsidies rather than subsidies applicable to the entire operations of the firm.

The discussion proceeds to consider the reduction in subsidy payments from a subsidy on output price applied only to units of output in excess of that produced in equilibrium

without subsidy; from a subsidy on labour applied only to units of labour used in excess of that used in equilibrium without subsidy; and from a subsidy on line haul transport charges applied only to additional shipments not made when the firm was in equilibrium without subsidy. Assuming that marginal type subsidies are administratively feasible, the equilibrium conditions for the firm under subsidy will continue to be the same as in Section 2. The examination below relates only to subsidy costs; as already stated, each reduction in subsidy cost is accompanied by an equal reduction in the firm's profit and net social cost does not change.

(a) *Marginal Subsidizing of Output Price*

Subsidy cost applied to the entire production of the firm was shown in the previous section in (5.11). It was subsequently shown that it was less expensive to subsidize output price than to subsidize the factor price of labour when constant or increasing returns to scale were operative; no clear conclusion was reached in respect of diminishing returns to scale and this has to await the arithmetical simulations. It was also shown that subsidy cost was always greater from subsidizing output price than from subsidizing line haul transport charges.

The subsidy cost in (5.11) was obtained by applying a subsidy of $p_{x_2} - p_x$ per unit of output to an output x_2 .

Under a marginal scheme of subsidy, this rate of subsidy would only be applied to the additional output $x_2 - x$ for a subsidy cost of $(p_{x2} - p_x) (x_2 - x)$.

The ratio of subsidy cost under a marginal scheme to subsidy cost applied to the entire output is:

$$\frac{(p_{x2} - p_x) (x_2 - x)}{(p_{x2} - p_x) x_2}$$

Substituting $x_2 = h^2 x$, the ratio becomes $1 - h^{-2}$. In other words, for a required 25% increase in output ($h^2 = 1.25$) application of subsidy to only the additional output would avoid 80% of the subsidy cost. If a 100% increase in output were required ($h^2 = 2.00$), 50% of the subsidy cost would be saved. These savings are clearly substantial.

(b) *Marginal Subsidizing of Input Price of Labour*

The subsidy cost incurred from subsidizing the entire labour input is given in (5.17). This is obtained by applying the subsidy s per unit of labour employed to the entire labour input l_2 . A marginal subsidy requires that subsidy s be applied only to the additional labour input $l_2 - l$.

The ratio of subsidy cost under a marginal scheme to subsidy cost applied to the entire output is $s(l_2 - l)/sl_2$,

i.e. $(1 - \frac{l}{l_2})$. From (5.5), $\frac{l}{l_2} = \frac{h^{-2} (p_l - s) (p_x^{-b-\frac{3}{2}} c g x^{\frac{1}{2}})}{p_l (p_x^{-b-\frac{3}{2}} c g h x^{\frac{1}{2}})}$

It can be shown that this expression is $< h^{-2}$.^{*} Therefore, the application of marginal subsidy to the labour input reduces the subsidy cost by a lower proportionate amount than the introduction of a marginal subsidy scheme to output price. Nevertheless, there are still substantial savings in subsidy cost by moving from a scheme applicable to all labour used to subsidy applicable only to the incremental usage of labour.

(c) *Marginal Subsidizing of Transport Line Haul Charges*

The subsidy cost incurred from subsidizing line haul charges over the entire output x_2 is given in (5.24). This is obtained by applying the subsidy $c - c_2$ per "output unit-mile" to the aggregate number of "output unit-miles" $gx_2^{\frac{3}{2}}$.

$$* \text{ From (5.14), } \ell/\ell_2 = h^{\frac{-2}{\alpha+\beta}} (p_\ell - s/p_\ell)^{\frac{\alpha}{\alpha+\beta}}$$

$$\therefore h^{\frac{-2}{\alpha+\beta}} (p_\ell - s/p_\ell)^{\frac{\alpha}{\alpha+\beta}} = \frac{h^{-2} (p_\ell - s) (p_x - b - \frac{3}{2}cgx^{\frac{1}{2}})}{p_\ell (p_x - b - \frac{3}{2}cghx^{\frac{1}{2}})}$$

$$\text{and } (p_\ell - s/p_\ell) = h^{\frac{-2(1-\alpha-\beta)}{\beta}} \left[\frac{p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}}{p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}} \right]^{\frac{-(\alpha+\beta)}{\beta}}$$

$$\therefore \frac{\ell}{\ell_2} = h^{-2} \left[h^{-2(1-\alpha-\beta)} \left(\frac{p_x - b - \frac{3}{2}cghx^{\frac{1}{2}}}{p_x - b - \frac{3}{2}cgx^{\frac{1}{2}}} \right)^\alpha \right]^{\frac{1}{\beta}}$$

The expression in the square brackets is < 1 for $h > 1$ and $\alpha+\beta \leq 1$. From arithmetical simulation, it is also < 1 for $1 < \alpha+\beta \leq 1.3$ within the range of values of h and line haul transport charges for which the model is calibrated.

A marginal subsidy would be applied only to the additional "output unit-miles" $gx_2^{\frac{3}{2}} - gx^{\frac{3}{2}}$.

The ratio of subsidy cost under a marginal scheme to subsidy cost applicable to all shipments is:

$$\frac{(c - c_2) (gx_2^{\frac{3}{2}} - gx^{\frac{3}{2}})}{(c - c_2) (gx_2^{\frac{3}{2}})}$$

Substituting $x_2 = h^2x$, the ratio becomes $1 - h^{-3}$. This ratio is higher than the ratio of $1 - h^{-2}$ established above in respect of a marginal subsidy scheme on output price. The output price subsidy applies equally to all units of output, while the line haul charge subsidy is applied less intensely to initial units of output. Hence, the introduction of a marginal subsidy scheme must have a relatively greater effect in respect of output price subsidy. Nevertheless, the effects are still substantial for the introduction of marginal subsidy on line haul charges as against subsidy on all shipments. If a 25% increase in output ($h^2 = 1.25$) is required, application of subsidy to only the additional output would reduce subsidy cost by 72%. For a 100% increase in output ($h^2 = 2.00$), 35% of the subsidy cost would be saved.

It has already been shown that, with subsidy applicable to all output, subsidy cost with respect to line haul charges (5.24) is two-thirds of subsidy cost with respect to output price (5.11). For a marginal subsidy scheme, the comparison is therefore $\frac{2}{3}(1 - h^{-3})$ for line haul charges, as against $1 - h^{-2}$ for output price. The line haul subsidy cost

is less for all values of $h > 1$. For equal net social cost, the subsidy scheme requiring the lowest actual subsidy payments is generally to be preferred; on this criterion, the line haul transport charges subsidy is again superior.

(d) Feasibility of Marginal Subsidies

Within the present model, net social cost, defined as subsidy cost minus the increased profit of the firm, is the same under a scheme of marginal subsidies as when subsidies are applied to the entire output or the entire factor utilization. The purpose of marginal subsidies is therefore to reduce the actual transfer payments that have to be met by government, recognizing that each reduction in subsidy cost will be matched by a corresponding reduction in the profit of the firm.

There are often appreciable administrative difficulties in achieving the savings in subsidy costs offered by marginal subsidy schemes. The present model has been developed in terms of comparative statics, but practical application is more complex in a dynamic economy characterized by changes in product prices, factor prices and transport charges. The correct criterion for the determination of marginal subsidy is comparison of desired output at time t with what equilibrium output would be at time t without subsidy. In practice, the comparison often tends to be between desired output at time t and equilibrium output without subsidy at time $t - 1$. Between

these two time periods, there can be changes in technology, tastes and prices.

At first blush, the subsidy on transport charges would seem to be the easiest to administer on a marginal basis. Subsidy on transport charges would be applied only in respect of shipments beyond a specific distance. This appears to avoid the problem of forecasting, on the basis of data for time $t - 1$, what output price without subsidy or labour utilization without subsidy would be at time t . However, this greater simplicity of a subsidy on transport charges may be more apparent than real. Between time $t - 1$ and time t , the distance that can be reached without subsidy may change not only in response to changes in transport charges, but also in response to changes in product and factor prices. In practice, a marginal subsidy scheme can only be applied approximately, regardless of whether subsidy relates to output price, factor price or transport charges. Nevertheless, even imperfect marginal subsidy schemes can yield considerable reductions in transfer payments and the marginal approach has considerable merit.

The marginal subsidy schemes developed in this chapter are not unique and it would be possible to use alternative criteria. For example, a subsidy on line haul charges means that the subsidy paid on each additional unit of output is always increasing as output has to be shipped longer distances; in principle, it would be possible to secure a similar

effect from subsidies on output price or labour if the marginal rate of subsidy were an increasing function of output. However, this would be administratively cumbersome and the scheme of marginal subsidies already examined appears to be more practical. In Section 4, arithmetical simulations are presented on subsidy cost, profit of the firm and net social cost when the various subsidy schemes are applied to the entire output of the firm. Simulations have not been developed to show subsidy cost in respect of marginal subsidy schemes, but the order of magnitude of the substantial savings offered has been outlined in the present section.

4. ARITHMETICAL SIMULATIONS

The algebraic analysis for this version of the model has now been completed. In this section, arithmetical simulations are developed in respect of subsidy schemes applicable to the entire output of the firm or the entire utilization of a factor of production. The main purpose of this section is to give a quantitative indication of the amount of subsidy cost, increased profit and net social cost from the different subsidy approaches.

(a) *Simulation Requirements*

Subsidy cost, increased profit of the firm and net social cost have been established from subsidizing output price in (5.11) to (5.13); input price of labour in (5.17) to (5.19); and line haul transport charges in (5.24) to (5.26). These expressions are now processed as follows:

(i) Divide each expression by h^2 so that subsidy cost, increased profit and net social cost are expressed per unit of that output which is achieved after application of subsidy.

(ii) The selling price of the product p_x is taken as the numéraire and is specified as equal to 100.

(iii) From (5.2), transport costs per unit of initial output x are terminal charges b and line haul charges $cqx^{\frac{1}{2}}$.

Following the earlier discussion (Chapter IV, Section 4), terminal charges are taken initially as one-third of total transport costs and line haul charges as the remaining two-

thirds. The model is renotated with $y = b + cgx^{\frac{1}{2}}$, $b = 0.3333y$, and $cgx^{\frac{1}{2}} = 0.6667y$.

The expressions below are per unit of output x_2 and are given in the order subsidy cost, increased profit, and net social cost. Net social cost is expressed as subsidy cost minus increased profit, rather than in algebraic terms; expressions in respect of line haul charges are given as proportions of measures under output price.

Subsidy on output price

1.
$$h \frac{2(1-\alpha-\beta)}{\alpha+\beta} (100 - 1.3333y) - (100 - .3333y - hy)$$
2.
$$(1 - \alpha - \beta) \left[h \frac{2(1-\alpha-\beta)}{\alpha+\beta} (100 - 1.3333y) - h^{-2} (100 - 1.3333y) + (h - h^{-2}) .3333y \right]$$
3. $(1 - 2)$

Subsidy on input price of labour

4.
$$\beta h \frac{2(1-\alpha-\beta)}{\beta} (100 - 1.3333y) \frac{\alpha+\beta}{\beta} (100 - .3333y - hy) \frac{-\alpha}{\beta} - \beta (100 - .3333y - hy)$$
5.
$$(1 - \alpha - \beta) (1 - h^{-2}) (100 - .3333y) + (\alpha + \beta - .6667) (h - h^{-2}) y$$
6. $(4 - 5)$

Subsidy on line haul transport charges

7. .6667 of (1)
8. (2) - (.3333 of (1))
9. (7 - 8), which equals (3)

From the discussion in the previous chapter (p. 174), the model is to be calibrated with the following combinations of values for the capital coefficient α and the labour coefficient β :

$\alpha + \beta$	α	β
0.8	0.3	0.5
0.9	0.3	0.6
1.0	0.3	0.7
1.1	0.3	0.8
1.1	0.4	0.7
1.2	0.4	0.8
1.3	0.4	0.9

The following range of output increases and values for h^2 and h were specified in the previous chapter (p. 141).

<u>Percentage Increase In Output</u>	<u>h^2</u>	<u>h</u>
5	1.05	1.025
25	1.25	1.118
50	1.50	1.225
100	2.00	1.414
300	4.00	2.000

As explained in the previous chapter (p. 152), the model is to be calibrated with seven values of y , namely 3%, 7%, 12%, 20%, 25%, 35%, and 42%. All seven values are to be used when $\alpha + \beta$ is equal to unity or less. In order to obtain a determinate equilibrium solution to the model, only the three highest values

can be used for $\alpha + \beta = 1.1$; only the two highest values for $\alpha + \beta = 1.2$; and only the highest value of 42% for $\alpha + \beta = 1.3$.

(b) Simulation Results

The results of the arithmetical simulations are contained in Appendix A. Tables IA - IG of this Appendix present simulations for $\alpha + \beta = 0.8$ in respect of each of the seven specified levels of transport costs before subsidy. Similar results are given for $\alpha + \beta = 0.9$ and $\alpha + \beta = 1.0$ in Tables II and III. As stated at the end of the previous sub-section, the calibration for $\alpha + \beta = 1.1$ has to be confined to the three highest values of transport costs and only Tables IVE - IVG are shown for this simulation. Similarly, for $\alpha + \beta = 1.2$, the calibration is confined to Tables VF - VG, and for $\alpha + \beta = 1.3$ to Table VIG.

The discussion of the simulations commences with some general statements and then proceeds to examine the results in respect of decreasing returns to scale. In the algebraic formulation of the model, the only constraint incorporated so far is the requirement that a factor of production should not be subsidized to the extent that its cost to the firm is zero or negative; otherwise there would not be a determinate equilibrium output after payment of subsidy. However, the model still allows payment of subsidy in excess of the selling price of the product, and payment of subsidy on transport charges in excess of the transport charges actually incurred

by the firm. The discussion therefore proceeds to consider imposition of constraints to prevent such excessively high levels of subsidy.

From the Appendix Tables of subsidy cost, increased profit and net social cost per unit of total output, the three following generalizations can be made.

(i) The higher the increase in output required, the greater are subsidy costs, increased profit and net social cost per unit of output. These three measures are therefore increasing functions of h^2 . This is hardly surprising; each additional unit of output has to be shipped a further distance, thus incurring an increasingly heavier burden of transport charges which must be offset by subsidy.

(ii) The higher the initial level of transport charges as a proportion of product price, the greater is the burden in terms of subsidy cost, increased profit and net social cost for a given increase in output. These three measures are therefore increasing functions of y . This result is to be expected as it obviously costs more to ship increased output when freight charges are already high.

(iii) The lower the returns to scale, the higher is the burden of subsidy cost, increased profit and net social cost per unit of output. These three measures are therefore decreasing functions of $\alpha + \beta$. Again, this result is not

surprising.* With increasing returns to scale, the firm needs less subsidy to expand output because production costs are also falling; similarly, constant returns to scale require less subsidy than diminishing returns to scale.

The Appendix Tables show subsidy cost, increased profit and net social cost on a per unit of output basis. This understates the extent to which these three measures increase for increasing values of h^2 and y and decreasing values of $\alpha + \beta$. From the specification of the model, initial output is a decreasing function of y and an increasing function of $\alpha + \beta$. The model formulation calls for equal ratios of output increase h^2 , but the absolute increase in output of $(h^2 - 1)x$ is clearly an increasing function of the initial output x . As transport charges are also an increasing function of output, the transport component to be overcome by subsidy is higher for the larger increases in output. Savings in subsidy cost shown for high values of $\alpha + \beta$ and low values of y would be even greater if the requirement had been equal absolute increases in output rather than the equal proportionate increases which are postulated. This is an important consideration to be borne in mind when interpreting the tables.

*There is one exception to this generalization in the arithmetical simulations. Where $h^2 = 4.00$ and $y = 42\%$, the cost of subsidizing capital is greater for higher values of $\alpha + \beta$. However, firstly this occurs at levels of subsidy which are far too high for practical application. (Cont'd. next page)

Decreasing returns to scale

The following conclusions emerge from the results for decreasing returns to scale in Tables I and II of Appendix A, where the $\alpha + \beta$ values are 0.8 and 0.9.

(i) Net social cost is the same for the subsidy on output price as for the subsidy on line haul transport charges and always less than for the subsidy on factor price. On the model assumption that capital, $\alpha = 0.3$, is used less intensively than labour, $\beta = 0.5$ or 0.6 , in the production process, the net social cost from subsidizing capital is greater than the net social cost from subsidizing labour. This difference is modest for low increases in output, but becomes very marked for large output increases and heavy burdens of transport charges.

(ii) With decreasing returns to scale, the increased profit of the firm is always highest for the subsidy on output price and lowest for the subsidy on transport charges. Subsidy on factor price produces an increase profit intermediate between the other two forms of subsidy, and increased profit from subsidizing factor price is the same regardless of which factor is subsidized.

Secondly, as explained in the next paragraph of the text above, the Appendix Tables have been estimated as average subsidy cost per unit of output. Initial output and the absolute size of the output increase are greater for higher values of $\alpha + \beta$ than for lower values; if the comparison were between equal absolute increases in output for different values of $\alpha + \beta$, the curiosum would disappear.

(iii) Subsidy cost is always lowest from subsidizing line haul transport charges. Subsidy cost is less from subsidizing output price than from subsidizing factor price when the output increase is at the highest specified level of 300%. However, for the lowest output increase of only 5%, subsidy cost is always less from subsidizing the input price. The results for the three intermediate levels of output increase are rather interesting. For output increases of 25%, the subsidy cost is always lower from subsidizing the factor price for values of $\alpha + \beta = 0.8$. This is also true of the subsidy on labour when $\alpha + \beta = 0.9$ but the subsidy cost on capital becomes greater than the subsidy cost on output price when the transport cost $y \geq 35\%$. For a 50% increase in output, the subsidy cost on labour is again lower than the subsidy cost on output price, but the cost of subsidizing capital edges above the cost of subsidizing output price at $y = 20\%$ for $\alpha + \beta = 0.9$, and at $y = 35\%$ for $\alpha + \beta = 0.8$. For an output increase of 100%, the labour subsidy ceases to be less expensive when $y = 42\%$ in Table I and $y = 35\%$ in Table II; subsidy cost for capital exceeds that for output price at $y = 20\%$ in Table I and $y = 7\%$ in Table II.

It is always less expensive in terms of subsidy cost to subsidize the factor of production which is used more intensively in the production process (i.e. labour in this example), than the factor of production used less intensively. Under

decreasing returns to scale, the subsidy cost from subsidizing a factor price can be less from subsidizing output price for modest output increases where transport charges are not too heavy a burden. This can give a superficial attraction to subsidizing a factor input, even although an output price subsidy scheme would be preferable in terms of net social cost. However, subsidy cost on line haul transport charges is less expensive than both the output price and factor price approaches; it also equals the lower net social cost achieved from the output price subsidy.

Constant returns to scale

The arithmetical simulations of constant returns to scale $\alpha + \beta = 1.0$ are given in Table III of Appendix A and the following conclusions emerge.

(i) Net social cost is the same for the subsidy on output price as for the subsidy on line haul transport charges and always less than the subsidy on factor price. Net social cost is greater from subsidizing capital than from subsidizing labour, as capital is the factor used less intensively. When the required increase in output is modest or the burden of transport charges low, the differences in net social cost between the various subsidy schemes are not too great; the differentials are much more pronounced for large increases in output where transport charges are also high.

(ii) The increased profit of the firm is always lowest

for the subsidy on transport charges. However, under constant returns to scale, the increased profit is identical between subsidy on output price and subsidy on factor input price.

(iii) Subsidy cost is always lowest from subsidizing line haul transport charges. Under constant returns to scale, subsidy cost is always less for subsidizing output price than for subsidizing a factor price; the saving in subsidy cost is normally slight comparing output price with the more intensive factor, labour, but the difference can become much more pronounced between output price and capital.

Increasing returns to scale

The arithmetical simulations of increasing returns to scale are given in Tables IV, V, and VI of Appendix A for $\alpha + \beta$ values of 1.1, 1.2 and 1.3. The following conclusions emerge.

(i) As under conditions of decreasing and constant returns to scale, net social cost is identical between subsidy on output price and subsidy on line haul transport charges. This is less than the net social cost from subsidizing a factor input price, with the highest net social cost incurred from subsidizing the factor which is used less intensively.

(ii) Under increasing returns to scale, the increased profit of the firm continues to be lowest when the subsidy is applied to transport charges. The increased profit of the firm is the same regardless of which factor input is

subsidized, but increased profit from subsidy on factor price is now larger than from subsidy on output price.

(iii) Subsidy cost continues to be lowest when line haul transport charges are subsidized. Under increasing returns to scale, subsidy cost is always less for output price than for factor price, and subsidy cost continues to be highest when applied to the less intensively used factor.

Constraints on subsidy cost

Some of the simulation results in the Appendix Tables show very high subsidy cost requirements per unit of output, in a few cases even in excess of 100% of the product price. The examination now proceeds to consider the effects of two types of restraint - firstly, that subsidy cost must not exceed 25% of the product price and, secondly, that subsidy cost on transport charges must not exceed the transport charges actually incurred by the firm.

Subsidy cost is heaviest when the production function shows decreasing returns to scale, as the subsidy has to cover not only increasing transport charges but also increasing costs of production. For $\alpha + \beta = 0.8$ in Table I, the constraint that subsidy cost must not exceed 25% effectively prevents the attainment of the highest output increase of 300%. When initial transport charges exceed 20% of product selling price, this constraint also eliminates the use of a capital subsidy to achieve a doubling of output. By the time initial trans-

port charges reach 42% of selling price, it is also impossible to achieve a doubling in output from subsidy on either output price or the input price of labour. The extent of diminishing returns to scale is less in Table II where $\alpha + \beta = 0.9$, but the constraint that subsidy cost must not exceed 25% of product price prevents the achievement of output increases of 300% from subsidies on output price or factor prices as transport charges increase beyond the 7% level.

The constraint that subsidy cost must not exceed 25% of product price has less effect for constant returns to scale in Table III. For increases of 300%, subsidy on capital becomes ineffective when initial transport charges reach 20% of product price. The subsidy on output price and on labour is inadequate when initial transport charges reach 25%. In respect of a 100% increase in output, the only subsidy not allowed by the constraint is that on capital when transport charges are at their highest level of 42%.

With increasing returns to scale in Tables IV, V and VI, the constraint that subsidy cost must not exceed 25% of product price does not affect output increases of 100%, except for the subsidy on capital where $\alpha + \beta = 1.1$ and transport charges amount to 42% of selling price. When transport charges are $\geq 35\%$ of initial product price, the constraint rules out output increases of 300% from subsidies on output price or factor prices.

The second constraint is that subsidy cost on transport charges must not exceed the transport charges actually incurred by the firm. Initial transport charges per unit of output are shown above as consisting of terminal charges of $b = 0.3333y$ and line haul charges of $cgx^{\frac{1}{2}} = 0.6667y$. When output increases from x to x_2 terminal charges per unit of output remain unchanged but line haul charges increase to $0.6667hy$. The requirement is therefore that subsidy cost per unit of output must not exceed $[1 + .6667 (h - 1)] y$.

This requirement is satisfied in respect of all simulations for constant and increasing returns to scale in Tables III - VI of Appendix A. Under decreasing returns to scale in Tables I and II, this condition is not satisfied when transport costs are a low proportion of product price and large increases in output are sought. Specifically, in Table I for $\alpha + \beta = 0.8$, the cost of subsidy on transport charges would exceed the transport charges actually incurred by the firm, when the initial transport costs are only 3% of selling price and an output increase of 25% or more is sought. The constraint also prevents output increases of 100% or more when transport charges before subsidy amount to 7% of product selling price; and output increases of 300% when initial transport charges amount to 12% or 20%. Turning to Table II where $\alpha + \beta = 0.9$, the constraint on subsidy cost for transport charges limits output increases to no more than 50% when initial transport

costs amount to only 3% of selling price; the 300% output increase is also not attainable, when initial transport charges amount to 7% of the product selling price.

(c) *Simulation Conclusions*

The net social cost of subsidizing increased output is the same for a subsidy scheme applied to output price as for a subsidy scheme applied to line haul transport charges. Net social cost is greater from a subsidy scheme applied to the factor price, particularly if applied to the factor used less intensively, i.e. capital in the present model. The net social cost may be regarded as the resource cost of achieving regional development in the present model and it can be argued, *ceteris paribus*, that it is this quantity that should be minimized. However, government does not raise tax revenue painlessly and, for similar levels of net social cost, the approach involving the lower actual transfer payments is to be preferred. In the present model, this second criterion is best satisfied by the subsidizing of transport charges.

The profit of the firm shows its smallest increases from subsidy on transport charges. Under decreasing returns to scale, subsidy on output price yields a larger increase in profit than subsidy on factor price; under constant returns to scale, the increased profit of the firm is identical from both types of subsidy; under increasing returns to scale, profit increases slightly more from a subsidy on factor price. Given the argument of the previous chapter that slightly increasing

returns to scale are more typical of manufacturing industry than decreasing or constant returns, it could be argued that the firm might have a preference for subsidy on a factor of production over other forms of subsidy.

The subsidy cost which has to be met by government is less from subsidy on output price than from subsidy on factor price under conditions of constant or increasing returns to scale. However, under decreasing returns to scale, the subsidy cost can be less from the factor price approach when the required increases in output are not overly large and transport charges do not represent a large part of the firm's costs.* If these conditions do not hold, the subsidy cost is also higher for the factor price approach under decreasing returns to scale.

The incorporation of a constraint on subsidy cost per unit of output made the attainment of very high output increases impossible, especially under conditions of decreasing returns to scale and a heavy burden of transport costs. Nevertheless, the requirement that subsidy cost per unit of output must not

*Of the subsidy approaches examined in the present model, the major thrust in Canadian regional development has probably been subsidies on capital, rather than on output price, transport charges or labour. This does not seem to be an optimal approach in terms of minimizing net social cost. However, in terms of the model, subsidy on factor prices would be favoured by subsidy-givers if they believed in diminishing returns to scale and the objective function were minimization of government transfer payments; conversely, subsidy-receivers would favour this approach for profit maximization if they believed in increasing returns to scale. But further pursuit of this intriguing possibility is beyond the present terms of reference.

exceed 25% of the product price only occasionally prevented the achievement of a doubling in output. A further constraint stated that subsidy payments in respect of the transport charges approach must not exceed the transport charges actually incurred by the firm. This had no effect under constant or increasing returns to scale, but it limited the output increases achievable under decreasing returns to scale when transport charges were only a small portion of product price. A subsidy on transport charges is not a feasible way to secure large increases in output for a firm faced with a low burden of transport costs together with decreasing returns to scale in its production process.

Marginal subsidies applicable only to output in excess of that which would be produced without subsidy can produce very large savings in subsidy costs. The transport charges subsidy continued to be the least expensive approach in terms of subsidy costs under the application of a marginal scheme. The reduction in subsidy cost achieved by a marginal scheme is matched by an equal reduction in the increased profit of the firm and leaves net social cost unchanged. However, these marginal schemes are still desirable in that they reduce the tax revenue to be raised by government in order to finance the subsidy schemes.

CHAPTER VI: DEVELOPMENT AND CALIBRATION OF THE MODEL: UNIFORM DISTRIBUTION OF DEMAND IN A BAND OF CONSTANT WIDTH

In this chapter, the model is developed on the assumption that demand is uniformly distributed in a band of constant width. This was the second assumption of the geographical distribution of demand outlined in Chapter IV. Output can be shipped only in two directions along the band, and not in the multiplicity of directions allowed in the previous chapter, when demand was distributed in an unbounded plane. Transport costs are therefore inevitably higher in this second model. The Canadian situation would seem to lie within these two limiting assumptions in respect of the geographical distribution of demand, although this still leaves the arbitrariness in the assumption of uniformity in the distribution. To facilitate comparison with the results of the previous chapter, equations are numbered to correspond with the comparable stages of development of the model of demand distributed in an unbounded plane.

The chapter commences with the equilibrium of the firm where no subsidy is paid. Section 2 develops the cost of achieving increased output through the various subsidy schemes and Section 3 the effects of confining subsidy to output in excess of that initially produced in equilibrium without subsidy. Arithmetical simulations are presented in Section 4 and the overall model is reviewed in Section 5.

1. EQUILIBRIUM WITHOUT SUBSIDY

From Chapter IV (p. 132) the production function is of the familiar Cobb-Douglas form.

$$x = ak^{\alpha}l^{\beta} \quad (6.1)$$

where x is output,

k is capital,

l is labour,

and, $0 < \alpha < 1$

$0 < \beta < 1$

$0 < a$

For demand uniformly distributed in a band of constant width, transport charges $TRANS$ paid by the firm are given in Chapter IV (p. 138).

$$TRANS = bx + cg*x^2 \quad (6.2)$$

where b is fixed terminal charges at origin

and destination per unit of output,

c is line haul rate per mile per unit of output,

g^* is a constant.

The firm receives a constant price p_x for each unit of output and revenue is $p_x x$. Production costs are

$p_k k + p_l l$ and the objective function of the firm is to maximize profits P , subject to the requirement that profits should not be negative. The next equation shows profits as revenue minus production costs and transport charges.

$$P = p_x x - (p_k k + p_l l) - (bx + cg*x^2) \quad (6.3)$$

where $P \geq 0$

Substituting for x from (6.1) and rearranging terms,

$$P = (p_x - b)ak^\alpha l^\beta - cg*(ak^\alpha l^\beta)^2 - p_k k - p_l l$$

From the requirement for profit maximization that each factor be employed to the point where factor price is equal to marginal product,

$$\frac{\partial P}{\partial k} = \alpha(p_x - b)ak^{\alpha-1}l^\beta - 2\alpha cg*(al^\beta)^2 k^{2\alpha-1} - p_k = 0$$

$$\therefore k = \alpha p_k^{-1} [p_x - b - 2cg*x] \quad (6.4)$$

$$\text{Similarly, } l = \beta p_l^{-1} [p_x - b - 2cg*x] \quad (6.5)$$

Profit maximization requires that profit must be decreasing with respect to further applications of either k or l separately, and of both k and l together. This condition is satisfied.¹

Returning to equation (6.3) and substituting for $p_k k$ and $p_l l$ from (6.4) and (6.5),

$$P = [1 - (\alpha + \beta)](p_x - b)x + [2(\alpha + \beta) - 1]cg*x^2 \quad (6.6)$$

¹ From (51, p. 68), profit maximization of P requires that the principal minors of the relevant Hessian determinant, f_{11} and f_{22} , be negative and that $f_{11}f_{22} - f_{12}f_{21} > 0$. After algebraic manipulation,

$$f_{11} = (\alpha - 1)k^{-2} (p_k k) - 2\alpha^2 cg*k^{-2}x^2$$

$$f_{22} = (\beta - 1)l^{-2} (p_l l) - 2\beta^2 cg*l^{-2}x^2$$

which are negative because $\alpha < 1$, $\beta < 1$.

continued....

where $P > 0$.

There is no problem in satisfying the requirement that $P \geq 0$ for values of $\alpha + \beta$ of 0.8, 0.9 and 1.0, but higher values require a further restraint. From (6.2), transport charges per unit of output are $b + cg^*x$. Terminal costs b are initially taken as equivalent to one-third of total transport charges (Chapter IV, p. 158). Now divide equation (6.6) by x , substitute $b = \frac{1}{3}cg^*x$, and the requirement that $P \geq 0$ implies:

$$(5\alpha + 5\beta - 3)\frac{1}{2}cg^*x \geq (\alpha + \beta - 1)p_x$$

$$\therefore \frac{3}{2}cg^*x/p_x > \frac{3\alpha + 3\beta - 3}{5\alpha + 5\beta - 3} \quad (6.7)$$

The expression $\frac{3}{2}cg^*x/p_x$ is simply transport charges per unit of output as a proportion of product selling price. To achieve the equilibrium requirement of $P \geq 0$, the following conditions must hold:

$$f_{12} = f_{21} = \beta(kl)^{-1}(p_k k) - 2\alpha\beta cg^*(kl)^{-1}x^2$$

$$= \alpha(kl)^{-1}(p_l l) - 2\alpha\beta cg^*(kl)^{-1}x^2$$

$$f_{11}f_{22} - f_{12}f_{21} = \beta p_k k(kl)^{-2} [(1-\alpha-\beta)(p_x - b)x + 2cg^*x^2(2(\alpha+\beta)-1)]$$

Substituting P from (6.6),

$$f_{11}f_{22} - f_{12}f_{21} = \beta p_k k(kl)^{-2} [P + cg^*x^2(2(\alpha+\beta)-1)]$$

This expression is positive because $\beta p_k k(kl)^{-2} > 0$, $P \geq 0$ from the requirement of (6.3), and $2(\alpha + \beta) > 1$ for all calibrations applied to this model. (In fact, further calculations have shown that $f_{11}f_{22} - f_{12}f_{21} > 0$ even when $\alpha + \beta < \frac{1}{2}$).

<u>$\alpha + \beta$</u>	<u>Transport costs as % of selling price</u>
1.1	≥ 12.0
1.2	≥ 20.0
1.3	≥ 25.7

It is not necessary to assume such high levels of transport charges to satisfy the $P \geq 0$ requirement as in the previous chapter. Marginal transport charges are a more rapidly increasing function of output when demand is distributed in a band of constant width than in the previous model of an unbounded plane. Hence, the gap between marginal and average transport charges is larger in the present model and equilibrium without subsidy can be achieved under increasing returns to scale without assuming quite such a large burden of transport charges. It should be noted, however, that the more rapid rate of increase in marginal transport charges in the present model means that, for each combination of values for α , β and transport charges, equilibrium output before subsidy x is always less than in the previous chapter.

Finally, from (6.4) and (6.5), the well-known Cobb-Douglas production function property is established:

$$\ell = \beta p_k k / \alpha p_\ell \quad (6.8)$$

2. INCREASED OUTPUT THROUGH SUBSIDIES APPLICABLE TO ENTIRE PRODUCTION OF FIRM

The approach here parallels that of the corresponding section of the previous chapter. The presentation has been abbreviated where the algebra is repetitive and this explains the omission of some equation numbers. As already mentioned, equilibrium output before subsidy is less in the present model than in the previous chapter for corresponding values of α , β and transport charges. Each model calls for a subsidy scheme to increase output from x to x_2 , where $x_2/x = h^2$, but in absolute terms an output increase of $(h^2 - 1)x$ is less in the present model than in the previous chapter.

(a) Subsidizing Output Price

From the same argument as in the previous chapter, Subsidy cost of $(p_{x_2} - p_x)h^2x$ is

$$\frac{h^{\frac{2}{\alpha+\beta}}}{h^{\frac{2}{\alpha+\beta}}} (p_x - b - 2cg*x)x - h^2(p_x - b - 2cg*h^2x)x \quad (6.11)$$

Increased profit of the firm is

$$\begin{aligned} & \frac{[1 - \alpha - \beta] [h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg*x) - (p_x - b - 2cg*h^4x)] x}{+ (h^4 - 1) [2(\alpha + \beta) - 1] cg*x^2} \quad (6.12) \end{aligned}$$

Net social cost is defined as subsidy cost (6.11) minus increased profit (6.12) and is:

$$\begin{aligned} & \frac{(\alpha + \beta) [h^{\frac{2}{\alpha+\beta}} - 1] (p_x - b - 2cg*x)x - h^2(p_x - b - cg*h^2x)x}{+ (p_x - b - cg*x)x} \quad (6.13) \end{aligned}$$

(b) *Subsidizing Factor Input Prices*(i) *Subsidizing Input Price of Labour*

A subsidy of s per unit of labour is paid to reduce the price of labour to the firm to $p_\ell - s$ in order to achieve the increased output of $x_2 = h^2 x$. It is specified that $s < p_\ell$; otherwise labour would become a free or negatively priced factor and the model would become indeterminate. The specification of $s < p_\ell$ also constrains the ratio h^2 of increased output to initial output. This was not a problem in the previous chapter. However, in the range of values for calibration of the present model, it is not possible to use a factor price subsidy to achieve an output increase of 300% ($h^2 = 4.0$) when transport charges as a ratio of product price are 20% or more; or an output increase of 100% ($h^2 = 2.0$) when the transport charges ratio is 35% or more.¹ (This restraint does not apply to subsidy on output price or subsidy on transport charges.)

Repeating the algebra of the previous chapter,

$$x_2 = x^{\frac{\alpha+\beta}{\beta}} h^{\frac{2}{\beta}} \left[p_\ell / h^2 \beta x (p_x - b - 2cg \cdot h^2 x) \right]^{\frac{\alpha}{\beta}} \quad (6.15)$$

¹ From the requirement $s < p_\ell$, it is necessary in equation (6.16) below that $(p_x - b - 2cg \cdot h^2 x) > 0$. Hence, it is required that $h^2 < (p_x - b)(2cg \cdot x)^{-1}$. From the discussion on page 228 of this chapter, the expression on the right of this inequality is (product price minus one-third of initial transport charges) divided by $(1\frac{1}{3}$ times total transport charges). The values of transport charges as a percentage of p_x used to calibrate the model (Chapter IV, p. 152) are listed below with the corresponding upper limits on h^2 .

Continued....

$$s = p_\ell - \ell_2^{-1} h^2 \beta x [p_x - b - 2cg \cdot h^2 x] \quad (6.16)$$

Subsidy cost $s\ell_2$ is then

$$\frac{\beta h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - 2cg \cdot x)^{\frac{\alpha+\beta}{\beta}} (p_x - b - 2cg \cdot h^2 x)^{-\frac{\alpha}{\beta}} x}{- \beta h^2 (p_x - b - 2cg \cdot h^2 x) x} \quad (6.17)$$

Increased profit of the firm is

$$\frac{(h^2 - 1) [1 - (\alpha + \beta)] (p_x - b)x + (h^4 - 1) [2(\alpha + \beta) - 1] cg \cdot x^2}{(6.18)}$$

Net social cost (6.17)-(6.18) is

$$\frac{\beta h^{\frac{2(1-\alpha)}{\beta}} (p_x - b - 2cg \cdot x)^{\frac{\alpha+\beta}{\beta}} (p_x - b - 2cg \cdot h^2 x)^{-\frac{\alpha}{\beta}} x}{- [(h^2 - 1)(1-\alpha) + \beta] (p_x - b)x - [(h^4 - 1)(2\alpha - 1) - 2\beta] cg \cdot x^2} \quad (6.19)$$

Subsidy cost, increased profit and net social cost are

Transport charges as % of p_x	Upper limit h^2
3	24.8
7	10.5
12	6.0
20	3.5
25	2.8
35	1.9
42	1.54

h^2 values of 4.0 and 2.0 are not achievable for all values of transport charges as % of p_x .

now compared from subsidizing the factor price of labour, as against subsidizing the output price. The first comparison shows the subsidy cost on labour (6.17) minus the subsidy cost on output price (6.11):

$$\begin{aligned}
 & h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg*x)x \\
 & \left[\beta \left((p_x - b - 2cg*x) / h^{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} (p_x - b - cg*h^2*x) \right)^{\frac{\alpha}{\beta}} - 1 \right] \\
 & + (1 - \beta) h^2 (p_x - b - 2cg*h^2*x)x \quad (6.20)
 \end{aligned}$$

The sign of (6.20) is not uniquely determined and depends upon the values of α , β , h and $cg*x$.

The next comparison shows the increased profit of the firm when labour is subsidized (6.18) minus the increased profit when output price is subsidized (6.12):

$$(\alpha + \beta - 1) \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg*x)x - h^2 (p_x - b - 2cg*h^2*x)x \right] \quad (6.21)$$

The expression in the square brackets is identical to (6.11) and therefore positive if $h > 1$.

Hence, (6.21) is positive if $\alpha + \beta > 1$,

zero if $\alpha + \beta = 1$,

negative if $\alpha + \beta < 1$.

If the production function shows increasing returns to scale, the profit of the firm increases more from a subsidy on labour than from a subsidy on output price. If there are constant returns to scale, both subsidy approaches have the same effect on the firm's profit. If there are decreasing

returns to scale, the firm's profit increases more from a subsidy on output price than from a subsidy on labour.

The net social cost from subsidizing labour (6.19) is now shown minus the net social cost from subsidizing the output price (6.13):

$$\begin{aligned} & \alpha h^{\frac{2}{\alpha+\beta}} \left[h^{\frac{2(\alpha+\beta-1)}{\alpha+\beta}} (p_x - b - 2cg \cdot h^2 x) - (p_x - b - 2cg \cdot x) \right] x \\ & + \beta h^{\frac{2}{\alpha+\beta}} \left[h^{\frac{2\alpha(1-\alpha-\beta)}{\beta(\alpha+\beta)}} (p_x - b - 2cg \cdot x)^{\frac{\alpha+\beta}{\beta}} (p_x - b - 2cg \cdot h^2 x)^{-\frac{\alpha}{\beta}} \right. \\ & \quad \left. - (p_x - b - 2cg \cdot x) \right] x \end{aligned} \quad (6.22)$$

Consider the value of (6.22) as h^2 approaches its limits.

As $h^2 \rightarrow 1$, (6.22) $\rightarrow 0$

As $h^2 \rightarrow (p_x - b)(2cg \cdot x)^{-1}$, (6.22) $\rightarrow \infty$

The first differential of (6.22) with respect to h is positive for all values of $\alpha + \beta$ used in the calibration.

(The lengthy proof follows, *pari passu*, from that given in the footnote, pp. 190-1 of the previous chapter.) Hence

(6.22) is an increasing function of h and always positive.

Net social cost is therefore higher from subsidizing factor price than from subsidizing output price.

Returning to subsidy cost, this is defined as increased profit plus net social cost. Net social cost is always greater from subsidizing the factor price; increased profit is higher from subsidizing the factor price under increasing returns to scale, equal to the increased profit of subsidizing the

output price under constant returns to scale, and lower under decreasing returns to scale. Hence, subsidy cost must be higher from subsidizing the factor price than the output price under increasing and constant returns to scale; the position under decreasing returns to scale will be clarified in the arithmetical simulations.

(ii) Subsidizing Input Price of Capital

The analysis parallels that already carried out for labour and the comments in the corresponding section of the previous chapter are again applicable.

(c) Subsidizing Transport Charges

The examination of transport terminal charges in the previous chapter showed that subsidy here was analytically no different from subsidy on product price. This also holds in respect of this second version of the model and the discussion below is confined to subsidy on transport line haul charges.

The line haul charge per mile per unit of output is subsidized from c to c_2 and subsidy cost of $(c-c_2)g^*h^4x^2$ is:

$$\frac{1}{2} \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg^*x)x - h^2(p_x - b - 2cg^*h^2x)x \right] \quad (6.24)$$

The increase in the firm's profit is

$$\begin{aligned}
 & \frac{(1 - \alpha - \beta) \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg*x) - (p_x - b - 2cg*h^4x) \right] x}{+ (h^4 - 1) [2(\alpha+\beta) - 1] cg*x^2} \\
 & - \frac{1}{2} \left[h^{\frac{2}{\alpha+\beta}} (p_x - b - 2cg*x)x - h^2 (p_x - b - 2cg*h^2x)x \right] \quad (6.25)
 \end{aligned}$$

Net social cost is:

$$\begin{aligned}
 & \frac{(\alpha + \beta) (h^{\frac{2}{\alpha+\beta}} - 1) (p_x - b - 2cg*x)x}{- h^2 (p_x - b - cg*h^2x)x + (p_x - b - cg*x)x} \quad (6.26)
 \end{aligned}$$

The subsidy cost from subsidizing line haul transport charges in (6.24) is exactly half the subsidy cost from subsidizing output price in (6.11). This is a greater saving in subsidy cost than in the previous chapter, where the saving was equivalent to one-third of subsidy cost. Transport charges rise more rapidly with distance in the present model so that the gap between marginal transport cost and average transport cost is also greater. The line haul transport subsidy is directed more intensely on the marginal units of output, while the output price subsidy operates equally and indiscriminately on all units of production. Hence, the saving in subsidy cost from the line haul transport charges approach must be greater for the pattern of demand postulated in the present chapter.

The increased profit of the firm is again less from subsidizing line haul transport charges (6.25) than from

subsidizing output price (6.12). The reduction in the increased profit is equal to the saving in subsidy cost. Consequently, net social cost (6.26) from subsidizing line haul transport charges is the same as from subsidizing output price (6.13). By the same argument as in the previous chapter, subsidy cost, increased profit of the firm, and net social cost are always less from subsidizing line haul transport charges than from subsidizing a factor price.

3. INCREASED OUTPUT THROUGH SUBSIDIES APPLICABLE ONLY TO ADDITIONAL PRODUCTION OF FIRM

The previous section has considered subsidy costs which are applicable to the entire output of the firm or the entire utilization of the subsidized factor. This section focusses on marginal subsidies which are paid only in respect of output additional to that produced in equilibrium without subsidy, or to factor employment additional to that employed before the introduction of a subsidy scheme. A marginal subsidy scheme does not affect net social cost as defined in this paper. In effect, it reduces the transfer payments by government to the firm with a corresponding reduction in the firm's profits. However, with net social cost the same for two alternative methods of subsidy, it has been explained earlier that the method incurring the smaller transfer payments would normally be preferred. This is the basic justification for marginal subsidies.

The section proceeds to examine the effects of marginal subsidizing of output price, input price of labour and transport line haul charges. The sub-section on the feasibility of marginal subsidies in the previous chapter is also applicable here and is not repeated.

(a) *Marginal Subsidizing of Output Price*

Subsidy cost applicable to the entire output of the firm is given in (6.11) and was calculated as $p_{x_2} - p_x$ per unit of output paid on output $x_2 = h^2 x$. Under a marginal subsidy

scheme this rate of subsidy would only be applied to the additional output $x_2 - x$, which is equivalent to $(h^2 - 1)x$.

The ratio of subsidy cost under a marginal scheme to subsidy cost applied to the entire output is:

$$\frac{(p_{x2} - p_x) (h^2 - 1) x}{(p_{x2} - p_x) h^2 x} = 1 - h^{-2}$$

The savings allowed by a marginal subsidy scheme are substantial. For an output increase of 25% ($h^2 = 1.25$), application of subsidy to only the additional output would avoid 80% of the subsidy cost. If a 100% increase in output were postulated ($h^2 = 2.00$), 50% of the subsidy cost would be saved.

(b) Marginal Subsidizing of Input Price of Labour

Subsidy cost applicable to the entire labour input is given in (6.17) and was calculated as sl_2 . Under a marginal subsidy scheme, only additional units of labour $l_2 - l$ would be subsidized for a cost of $s(l_2 - l)$. The ratio of subsidy cost under a marginal scheme to subsidy cost applied to the entire output is:

$$s(l_2 - l)/sl_2 = 1 - \frac{l}{l_2}$$

From (6.5),

$$\frac{l}{l_2} = \frac{h^{-2} (p_l - s) (p_x - b - 2cg*x)}{p_l (p_x - b - 2cg*h^2 x)}$$

Following the proof in the previous chapter (p. 203, footnote),

this expression is $< h^{-2}$ over the range of values used to estimate the model. Therefore, the application of marginal subsidy to the labour input reduces the subsidy cost proportionately less than the introduction of a marginal subsidy scheme to output price. However, there are still substantial savings in subsidy cost by moving from a scheme applicable to all labour used to a scheme applicable only to the additional units of labour employed.

(c) Marginal Subsidizing of Transport Line Haul Charges

Subsidy cost applicable to all transport line haul charges is given in (6.24) as $c - c_2$ per "output unit-mile" paid on the aggregate number of "output unit-miles" $g \cdot x_2^2 = g \cdot h^4 x^2$. Under a marginal scheme, subsidy would be applied only to the additional "output unit-miles" $g \cdot x_2^2 - g \cdot x^2$. The ratio of subsidy cost under a marginal scheme to subsidy cost applied to the entire output is:

$$\frac{(c - c_2) (h^4 - 1) g \cdot x^2}{(c - c_2) g \cdot h^4 x^2} = 1 - h^{-4}$$

The proportionate reduction in subsidy cost from using a marginal subsidy scheme is less at h^{-4} on the line haul charges approach than the h^{-2} of the output price approach. The output price subsidy applies equally to all units of output, while the line haul charge subsidy is applied less intensely to initial units of output. Hence, the introduction of a marginal subsidy scheme must have a relatively greater effect in respect of the output price subsidy. Nevertheless, the savings are

still substantial from the introduction of marginal subsidy on line haul charges. If a 25% increase in output ($h^2 = 1.25$) is required, application of subsidy to only the additional output would reduce subsidy cost by 64%. For a 100% increase in output ($h^2 = 2.00$), 25% of the subsidy cost would be saved.

With subsidy applicable to all output, it has been shown that subsidy cost with respect to line haul charges (6.24) is one-half of subsidy cost with respect to output price (6.11). For a marginal subsidy scheme, the comparison is therefore $\frac{1}{2}(1 - h^{-4})$ for line haul charges, as against $(1 - h^{-2})$ for output price. The line haul subsidy cost is less for all values of $h > 1$. With marginal subsidy schemes, the line haul subsidy cost continues lower than the output price subsidy cost and, from the earlier discussion, it is also less than the factor price subsidy cost. For equal net social cost, the subsidy scheme requiring the lowest actual subsidy payments is generally to be preferred; on this criterion, the line haul transport charges subsidy is superior both in respect of subsidy applicable to all output and subsidy applicable only to additional output.

4. ARITHMETICAL SIMULATIONS

In this section, arithmetical simulations are presented in respect of subsidy schemes applicable to the entire output of the firm or the entire utilization of a factor of production.

(a) *Simulation Requirements*

Subsidy cost, increased profit of the firm and net social cost have been established from subsidizing output price (6.11) to (6.13), input price of labour (6.17) to (6.19), and line haul transport charges (6.24) to (6.26). These expressions are now processed as follows:

- (i) Each expression is divided by h^2x so that subsidy cost, increased profit and net social cost are given on the basis of per unit of output after subsidy x_2 .
- (ii) The selling price of the product p_x is taken as the numéraire and specified as equal to 100.
- (iii) From (6.2), transport charges per unit of initial output were terminal charges b and line haul charges $cg*x$. Following the discussion in Chapter IV (p. 158), terminal charges are taken initially as one-third of total transport charges and line haul costs as the remaining two-thirds. The model is renotated with $y = b + cg*x$, $b = 0.3333y$ and $cg*x = 0.6667y$.

The expressions below are per unit of output x_2 and are given in the order subsidy cost, increased profit, and net

social cost. Net social cost is expressed as subsidy cost minus increased profit, rather than in algebraic terms; expressions in respect of line haul charges are given as proportions of measures under output price. .

Subsidy on output price

$$1. \quad h^{\frac{2(1-\alpha-\beta)}{\alpha+\beta}} (100 - 1.6667y) - (100 - .3333y - 1.3333h^2y)$$

$$2. \quad (1 - \alpha - \beta) (100 - 1.6667y) \left(h^{\frac{2(1-\alpha-\beta)}{\alpha+\beta}} - h^{-2} \right) + (h^2 - h^{-2}) .6667y$$

$$3. \quad (1 - 2)$$

Subsidy on input price of labour

$$4. \quad \beta h^{\frac{2(1-\alpha-\beta)}{\beta}} (100 - 1.6667y)^{\frac{\alpha+\beta}{\beta}} (100 - .3333y - 1.3333h^2y)^{\frac{-\alpha}{\beta}} - \beta (100 - .3333y - 1.3333h^2y)$$

$$5. \quad (1 - \alpha - \beta) (1 - h^{-2}) (100 - .3333y) + (2\alpha + 2\beta - 1) (h^2 - h^{-2}) .6667y$$

$$6. \quad (4 - 5)$$

Subsidy on line haul transport charges

$$7. \quad .5 \text{ of } (1)$$

$$8. \quad (2) - (.5 \text{ of } (1))$$

$$9. \quad (7 - 8), \text{ which equals } (3)$$

The values used to estimate the model are as summarized in the previous chapter (p. 210). Values for $\alpha + \beta$ range from 0.8 to 1.3 and h^2 values from 1.05 to 4.00.

The model is calibrated with six values of initial transport charges as a proportion of product price, namely y values of 3%, 7%, 12%, 20%, 25%, and 35%. The seventh value of 42%, which was used in the previous chapter, is not simulated in the present model, as it was not necessary to go as high as this to close the model. All six values are used when $\alpha + \beta$ is equal to unity or less. As explained above (pp. 227-8), the requirement for a determinate initial equilibrium solution to the model means that $\alpha + \beta = 1.1$ can only be calibrated for $y \geq 12\%$; $\alpha + \beta = 1.2$ for $y \geq 20\%$; and $\alpha + \beta = 1.3$ only for $y = 35\%$.

Finally, it has been shown above (pp. 230-1) that the requirement that labour and capital must not become free goods limits the maximum achievable output increase from subsidy on a factor price to $h^2 = 2.00$ for $y = 20\%$ and $y = 25\%$, and to $h^2 = 1.50$ for $y = 35\%$.

(b) Simulation Results

The results of the arithmetical simulations are contained in Appendix B. Tables IA - IF present the simulations for $\alpha + \beta = 0.8$ in respect of each of the six specified levels of transport charges before subsidy. Similar results are given for $\alpha + \beta = 0.9$ and $\alpha + \beta = 1.0$ in Tables II and III. The calibration for $\alpha + \beta = 1.1$ has to be confined to the four highest values of transport costs and only Tables IVC - IVF are shown for this simulation. Similarly, for $\alpha + \beta = 1.2$, the calibration is confined to Tables VD - VF, and for $\alpha + \beta = 1.3$ to Table VIF.

The examination of the simulations is very similar to that of the previous chapter and can therefore be given in abbreviated form. From Appendix B simulations of subsidy cost, increased profit and net social cost per unit of output, it is seen that:

(i) The higher the increase in output required, the greater are subsidy cost, increased profit and net social cost per unit of output.* These three measures are therefore increasing functions of h^2 .

(ii) The higher the initial level of transport charges as a proportion of product price, the greater is the burden in terms of subsidy cost, increased profit and net social cost for a given increase in output. These three measures are therefore increasing functions of y .

(iii) The lower the returns to scale, the higher is the burden of subsidy cost, increased profit and net social cost per unit of output.** These three measures are therefore decreasing functions of $\alpha + \beta$.

*There is one exception to this generalization. The increased profit per unit of output as a result of subsidizing line haul transport charges is less for $h^2 = 4.00$ than for $h^2 = 2.00$ in Tables IA - IB and Table IIA. However, in absolute terms, the firm's profit would be greater for $h^2 = 4.00$ because of the greater output produced. This exception was not found in the model developed in the previous chapter.

**There is also an exception to this generalization in the arithmetical simulations. Where ($y = 25\%$) and $h^2 = 2.00$, the cost per unit of output of subsidizing capital is greater for higher values of $\alpha + \beta$. Where $y = 35\%$, the cost of subsidizing capital is greater for higher values of $\alpha + \beta$ for all

The Appendix Tables show subsidy cost, increased profit and net social cost on a per unit of output basis. This understates the extent to which these three measures increase for increasing values of h^2 and y and decreasing values of $\alpha + \beta$. From the specification of the model, initial output is a decreasing function of y and an increasing function of $\alpha + \beta$. The model formulation calls for equal ratios of output increase h^2 , but the absolute increase in output of $(h^2 - 1)x$ is clearly an increasing function of the initial output x . As the relative burden of transport charges also increases with output, the transport component to be overcome by subsidy is higher for the larger increases in output. The savings in subsidy cost shown for high values of $\alpha + \beta$ and low values of y would be even greater if the requirement were equal absolute increases in output rather than the equal proportionate increases on which the model was calibrated.

those values of h^2 which can be attained from subsidy on capital. An exception similar to this was also noted in the previous chapter (pp. 212-3), but was not considered to be of practical importance. As explained in the next paragraph of the text above, the Appendix Tables are estimated as average subsidy cost per unit of output. Initial output and the absolute size of the output increase are greater for higher values of $\alpha + \beta$ than for lower values; if the comparison were between equal absolute increases in output for different values of $\alpha + \beta$, this curious result would no longer be present.

Subsidy cost, increased profit and net social cost per unit of output are always greater in Appendix B relating to this chapter than in Appendix A. However, this comparison underestimates the extent to which these three measures increase in the present version. Because transport charges rise more rapidly in this chapter, where demand is distributed in a band of constant width, than in the previous chapter, where demand is distributed in an unbounded plane, equilibrium output is less before subsidy for each given combination of $\alpha + \beta$ and y . Hence, paralleling the argument of the previous paragraph, similar proportionate increases in output of h^2 in the two versions of the model mean a smaller absolute increase in output in the present chapter. If the requirement had been equal absolute increases in output rather than the equal proportionate increases postulated, the excess burden per unit of output of subsidy cost, increased profit and net social cost would have been even greater in the present chapter.

The results in Appendix B are shown for decreasing returns to scale in Tables I - II, for constant returns to scale in Table III, and for increasing returns to scale in Tables IV - VI. The main conclusions are as follow:

- (i) *Net social cost* is the same for the subsidy on output price as for the subsidy on line haul transport charges

and always less than for the subsidy on factor price. The model assumes that capital is used less intensively than labour in the production process $\alpha < \beta$; hence, the net social cost for subsidizing capital is always greater than for subsidizing labour. These conclusions all hold regardless of the extent of returns to scale. When the required increase in output is modest or the burden of transport charges low, the differences in net social cost between the various subsidy schemes are not too great; the differentials are much more pronounced for large increases in output where transport charges are also high.

(ii) *The increased profit of the firm is always lowest for the subsidy on transport charges and this holds regardless of the returns to scale. Under decreasing returns to scale, the firm's profit increases more from subsidy on output price than from subsidy on factor price; with constant returns to scale, both forms of subsidy scheme produce the same increased profit; with increasing returns to scale, the profit of the firm is greater from the subsidy on factor price. The increased profit from the factor price approach is the same from subsidizing capital as from subsidizing labour.*

(iii) *The subsidy cost to be met by government must by definition cover the sum of net social cost and increased profit of the firm. As the sum of these two measures is always*

lowest from subsidizing line haul transport charges, it follows that subsidy cost is also lowest for this form of subsidy scheme. Net social cost is always less from subsidizing output price than from subsidizing factor price; under conditions of constant or increasing returns to scale, the increased profit of the firm from subsidizing output price is, respectively, equal to or less than the increased profit from subsidizing factor price; hence, subsidy cost is less from subsidizing output price.

With decreasing returns to scale in Tables I and II, the situation is more complicated. If output price is subsidized rather than factor price, net social cost is less but the increased profit of the firm is larger. Hence, the subsidy cost from subsidizing factor price can be less than from subsidizing output price. This is apparent for modest output increases where transport charges are not too heavy a burden. It occurs over a wider range of subsidy application to the factor of production which is used more intensively (i.e. labour), than to the factor of production used less intensively. Thus, the subsidy cost is less for labour than for output price for all output increases where initial transport charges as a proportion of product selling price are only 3%; for output increases up to 100% where the transport charges ratio is less than 20%; and for output increases up to 50% where the transport charges ratio does not exceed 25%. However, under all these conditions, subsidy cost on

line haul transport charges is still very much less expensive than subsidy on the factor price.

Constraints on subsidy cost

So far the only constraint on subsidy cost in the Appendix Tables is the requirement that subsidy on factor price must not equal or exceed the factor price itself. In the previous chapter, this constraint did not make any of the specified output increases unachievable. However, in the present model this prevents the use of subsidy on factor price to achieve output increases of 300% ($h^2 = 4.00$) when transport charges before subsidy are 20% or more of product selling price, and the achievement of output increases of 100% ($h^2 = 2.00$) when transport charges are as high as 35%. The examination now proceeds to consider the effects of two further restraints - firstly, that subsidy cost must not exceed 25% of the product selling price and, secondly, that subsidy cost on transport charges must not exceed the transport charges actually incurred by the firm.

The requirement that subsidy cost must not exceed 25% of the product selling price has its major effect under decreasing returns to scale in Tables I and II, where subsidy has to cover not only increasing transport charges but also increasing costs of production. Output increases of 300% are not achievable; increases of 100% are unachievable as transport charges pass 7% in Table I and 12% in Table II; by the time transport charges reach 35%, increases of 50%

are also too costly. This constraint has less effect for constant returns to scale in Table III. For increases of 300%, subsidy becomes too expensive when initial transport charges are 7% of product price, but increases of 100% are feasible until transport charges reach 20%.

With increasing returns to scale in Tables IV - VI, the constraint naturally operates more gradually. Nevertheless, an output increase of 300% is not achievable when transport charges reach 12% of initial selling price; when transport charges are 20%, only the output price and line haul transport schemes satisfy the constraint for increases of 100%.

The second constraint is that subsidy cost on transport charges must not exceed the transport charges actually incurred by the firm. Initial transport charges per unit of output consist of terminal charges $b = 0.3333y$ and line haul charges $cg*x = 0.6667y$. When output increases to x_2 terminal charges per unit of output remain unchanged but line haul charges increase to $0.6667h^2y$. Subsidy cost per unit of output must therefore not exceed $[1 + 0.6667(h^2 - 1)]y$.

This requirement is satisfied in respect of all simulations for constant and increasing returns to scale in Appendix B Tables III - VI. Under decreasing returns to scale, there are problems where initial transport charges amount to only a small percentage of product selling price. Thus, in Table IA where transport charges before subsidy amount to only 3% of product selling price, the cost of subsidy on transport charges

would exceed the transport charges actually incurred by the firm for output increases of 50% or more. Where initial transport charges amount to 7% and 12% of selling price in Tables IB and IC, this constraint prevents output increases of 300%. Turning to Table IIA, the constraint means that an output increase of 100% is not achievable where initial transport charges amount to only 3% of product price. Similarly, in Table IIB, an output increase of 300% is not achievable where transport charges are equivalent to 7% of product price. The general conclusion from examination of this second restraint is rather obvious - a subsidy on transport charges is not a feasible way to secure large increases in output from a firm faced with low burden of transport costs together with increasing costs in its production process.

The question of marginal subsidies has already been discussed earlier (pp. 237-40) and the examination is not repeated. Considerable economies can be achieved in subsidy cost if payments can be confined only to output in excess of that produced under equilibrium without subsidy.

(c) Simulation Conclusions

The conclusions from the simulations for demand uniformly distributed in a band of constant width are therefore very similar to those already established in the previous chapter, where demand was uniformly distributed in an unbounded plane. Between these two extremes lies a whole gamut of possible assumptions on the geographical distribution of demand and

the results within this range would conform to the common pattern established for the two extremes.

The net social cost of subsidizing increased output is the same for a subsidy scheme applied to output price as for a subsidy scheme applied to line haul transport charges. Net social cost is greater from a subsidy scheme applied to factor price, particularly if this is applied to the factor used less intensively, i.e. capital in the present model.

The profit of the firm shows its smallest increase from subsidy on transport charges. Under decreasing returns to scale, subsidy on output price means a larger increase in profit than subsidy on factor price; under constant returns to scale, the increased profit of the firm is identical from both types of subsidy; under increasing returns to scale, profit increases more from a subsidy on factor price.

The subsidy cost which has to be met by government is always least from the subsidy on line haul transport charges. Under conditions of constant or increasing returns to scale, subsidy cost is less from the output price approach than from the factor price approach. However, under decreasing returns to scale, the subsidy cost can be less from the factor price approach than from subsidizing output price. This occurs when the required increases in production are not overly large and transport charges do not represent a large part of the firm's costs. If these conditions do not hold, the subsidy cost is also higher from the factor price approach under decreasing returns to scale.

The model necessarily postulated that subsidy on factor price must never be so large as to make a factor a free or negatively priced good. Consequently, it was not possible to achieve very large increases in output from subsidy on factor price when the burden of transport charges was also high. The incorporation of a further restraint that subsidy cost per unit of output must not exceed 25% of the product price prevented large increases in output from the other subsidy approaches when transport charges were high. A final constraint stated that subsidy payments in respect of transport charges must not exceed the transport charges actually incurred. This had no effect under constant or increasing returns to scale, but under decreasing returns it limited the extent of output increases that could be achieved when transport charges were only a small portion of product price.

The transport charges subsidy continued to be the least expensive approach when marginal schemes were applied. The reduction in subsidy cost achieved by a marginal scheme is matched by an equal reduction in the increased profit of the firm and leaves net social cost unchanged. However, these marginal schemes are still desirable in that they substantially reduce the tax payments to be made by government.

5. THE MODEL IN RETROSPECT

The examination of the versions of the model in this chapter and the previous chapter has yielded conclusions which are to some extent surprising. The model has postulated a single-plant firm with a regional development objective to achieve a specified increase in output, where this can be obtained only by expanding the geographical area in which the firm sells. Three alternative subsidy approaches have been examined in detail. On the criterion of minimizing net social cost, which is defined as subsidy cost borne by government minus the increased profit of the firm, the alternative approaches of subsidizing output price or subsidizing line haul transport charges are equally efficient and less costly than subsidizing factor price. Government does not raise taxes painlessly and, on the further criterion that *ceteris paribus* the actual subsidy cost paid by government should be minimized, the subsidy on line haul transport charges is the most efficient.

In practice, it may not be feasible to direct a transport subsidy exclusively to line haul charges and part of the subsidy may inevitably relate to terminal charges. However, it has been shown that subsidy on the terminal charges component has exactly the same effects as subsidy on output price. Hence, if a transport subsidy is directed towards a blend of terminal and line haul charges, the advantages of a transport subsidy vis-a-vis an output price subsidy will be diluted but not eliminated.

These conclusions as to the efficiency of transport subsidies are surprising in the light of frequent questioning - perhaps more by carriers and academic economists than by regional development policy advisors - of the relevance of transport subsidies to regional development. Thus, in a recent article on this subject, Straszheim concluded that "The weight of current evidence concerning the usefulness of using transportation investment or rate regulation as a regional development tool would appear to be on the side of the skeptics" (88,p. 219). In the context of this statement, the term "transportation investment or rate regulation" would appear to embrace transport subsidies. The conclusions to the model developed in the present paper are therefore somewhat at variance with accepted opinion.

Under these circumstances, the next step is obviously to re-question the assumptions on which the model is built. However, in many respects, the present model stands up well to scrutiny. The Cobb-Douglas production function is a respectable assumption in micro-economic analysis and it has been explained why this was preferred to the more generalized CES function. Of more importance, the relationship between subsidy on output price applied uniformly to all units of output and subsidy on transport charges applied more intensively to incremental units of output would hold regardless of assumptions of the form of the production function. Similarly, if some substitution is assumed between factors of production - regardless of the precise relationship - it is clear that additional

net social cost is incurred from subsidizing factor price as a result of sub-optimal factor combinations in the production process.

The model has been developed for two factor inputs and has not dealt explicitly with other production costs, such as raw materials, inbound transport costs, public utilities and taxes. However, it was argued at the beginning of Chapter IV (pp. 122-4) that this was not a serious omission as the subsidies on these other costs were analytically either comparable to subsidy on output price or factor price, or alternatively a subsidy on fixed costs which had no effect on output. The model has been developed in two versions on widely different assumptions in respect of the geographical distribution of demand; the major results have been similar for both of these assumptions. Finally, the model has been calibrated over a range of values which has been established as realistically as possible.

The model is therefore reasonably robust as a means of examining subsidy payments and net social cost incurred to secure a specified increase in a firm's output, where this increased output has to be transported to more distant markets. The model is realistic, but it is not all-embracing. In particular, the increased output has been taken as a regional development desideratum and the basic objectives of regional development policy are not examined. There is no in-depth discussion of income redistribution effects of subsidies or analysis in respect of unemployment conditions where the

shadow price of labour is far below the wage rate. The model also precludes consideration of the achievement of regional development objectives from subsidizing economic and social infrastructure investment, and from using resources to improve the quality of technology and labour productivity. It has been argued that the interrelationships between transport and regional development are so subtle and complex that large scale systems simulation models are needed (88, p. 219). However, the development of such models can prove to be very intractable, the results have been far from conclusive*, and the practical usefulness of such comprehensive approaches has generally fallen far short of the theoretical expectations.

*Straszheim has enumerated the limitations to large-scale systems simulation models (88). These include the vast number of variables and functions which make only the simplest of applications soluble; the unrealistic nature of the assumption of "rational" behavior in location decision; the problem in representing a region's comparative advantages and the sources of regional differences in income, productivity and growth; the simulation of markets and the determination of prices and income distribution; the problem of dynamic feedback effects; and the treatment of linkages between a region and the "outside world". The Canadian Transport Commission has recently sponsored an attempt to apply general equilibrium analysis to the problem of transport subsidies. The first publication on this project (25) has dealt with subsidies on capital and labour and reached the expected theoretical conclusion that labour in a depressed area will benefit more from a direct subsidy on wages than from a subsidy on capital. Work is currently underway to integrate transport subsidies into a general equilibrium model, although still at a very theoretical level. A recent paper by Hartwick (44) has applied international trade theory to the problem of transport

Cont'd....

Chapters IV - VI have shown that, if transport charges incurred in reaching more distant markets are the main hindrance to increasing a firm's output, the most economic subsidy approach should be related directly to transport charges rather than indirectly to product or factor prices. This conclusion may not accord with the expectations of micro-economics, where it is generally argued that subsidy should be applied to output in total rather than to specific inputs. Yet, a subsidy on transport charges is clearly the most direct means of dealing with a problem created by transport charges, so perhaps the effectiveness of this approach is theoretically less surprising than it may at first appear.*

subsidies. The main conclusions confirm that transport subsidies impose a cost on an economy and have income redistribution effects, but the numerical illustrations are somewhat misleading.

*A rather interesting example of the advantages of the direct approach in urban transport problems was given at the 1975 Joint Annual Meeting of the Canadian Transportation Research Forum and the (American) Transportation Research Forum. In a session of urban transport demand, Gillen (40) argued that parking fees were the most effective way to reduce parking congestion, while Dunbar (29) claimed that parking controls were less effective than taxes on emissions or gasoline if the objective were to reduce pollution. Although it was suggested in the subsequent seminar discussion that these two findings were not reconcilable, each author appears to be correct in advocating the most direct approach to the problem in hand; the apparent confusion arose because the policy objectives of reducing congestion and reducing pollution are similar, but are not identical.

CHAPTER VII: CONCLUSIONS

1. SUMMARY

The major objective of this dissertation is to make a contribution towards resolution of the role of transport subsidies in regional development. In contrast to negative views frequently expressed by carriers and economists on the relevance of transport subsidies to regional development, the present study shows that, under certain circumstances, transport subsidies can be an efficient tool to promote increased output in the slow growth regions of Canada.

Chapter I starts with a description of the transport problem and the regional development problem as perceived in the Atlantic Region and the Western Provinces of Canada. It is shown that there is a tendency to synthesize these two problems; freight rates cease to be regarded merely as one of the factors causing regional disparities and become symbolic of the entire regional disparity problem.

Chapter II examines the extent to which allegations of disparities are factually justified. From the standpoint of economic disparities, income per head in the Atlantic Region is substantially below the Canadian average, unemployment is high and the growth in employment opportunities has been unimpressive. In Western Canada, regional economic disparities are confined to Saskatchewan and Manitoba, where the growth in employment opportunities has been extremely slow. However, these two provinces do not suffer from high

unemployment and the income problem, which is confined to Saskatchewan, is mainly instability as a result of fluctuations in agricultural prosperity.

In respect of freight rate disparities, specific examples of high freight rates are documented for the Prairie Provinces in respect of finished goods versus raw materials and the short-haul long-haul differential. Investigation of the existence of overall freight rate disparities gives inconclusive results. Grain movements under the statutory rates do not cover the variable costs of movement and this shortfall and the burden of railway fixed costs are borne mainly by traffic in the manufacturing and miscellaneous group. In terms of geographical origin of traffic, this means that railway revenue per ton-mile is highest on traffic originating in Quebec and Ontario.

Regression analysis has long been applied to determining the allocation of costs on different rail traffic movements, but the use of regression analysis to compare revenue per ton-mile on different movements is a new departure in the present study. Considering only traffic in the manufacturing and miscellaneous group, it appears from the regression analysis that over seventy per cent of the variation in railway revenue per ton-mile between different movements can be explained in terms of differences in carload weights and differences in the length of haul. There does not seem to be evidence of overall higher freight rates

on traffic originating in the Prairie Provinces, but average revenue per ton-mile does tend to be higher on products destined for this region and this would be the expected result of short-haul long-haul discrimination. The evidence for specific freight rate disparities is reasonably strong, but the evidence for general freight rate disparities against the Prairie Provinces is much less convincing. However, more definitive conclusions for the Prairies and for the Atlantic Region require more detailed traffic data to reduce the inevitable heterogeneity of groups as wide as manufacturing and miscellaneous.

The last section of Chapter II examines the difficult concept of equity in freight rates. While there are clearly some instances where the correction of freight rate disparities could stimulate economic activity in the slow growth areas of Canada, across-the-board reductions in freight rates towards closer conformity with variable costs would not necessarily benefit the Atlantic Region and the Western Provinces more than Central Canada. If transport is to be used to promote regional economic development, there would seem to be a need for selective reductions in freight rates on shipments of finished products from the slow growth areas. Fortunately, the model developed in the later chapters of the dissertation only requires that transport subsidies reduce the burden of freight charges borne by a manufacturer; it is not necessary to make the more difficult determination

of whether these transport subsidies are given to offset freight rate inequities or to reduce freight rates below the level required to meet transport costs.

Chapter III examines the general economic basis for transport subsidies. From a discussion of Pareto-optimality requirements, it is shown that the transport industry does not satisfy the conditions necessary to ensure an efficient allocation of resources. Where increasing returns to scale prevail in the supply of transport services, there is a case for subsidy on the grounds that the additional benefits would exceed the subsidy costs. Returns to scale are not identical for all transport modes; subsidy payments should generally be selective of modes showing the greatest extent of increasing returns to scale and this denies the argument that all modes should necessarily received equal subsidy treatment.

The use of transport subsidies to offset the vestigial monopoly powers of carriers is examined, firstly, on the assumption of no price discrimination and, secondly, on the more realistic assumption of price discrimination. Additional increments of transport infrastructure would not generally exercise a strategic role in the development of the non-isolated parts of Canada today. However, a number of other social benefits are claimed for transport which must be considered on their individual merits. Finally, transport subsidies can be justified if transport is to be used as a

means of securing non-transport public policy goals such as income redistribution and regional economic development.

Chapters IV-VI are concerned with the relative efficiency of transport subsidies as a means of promoting increased output in the slow growth areas of Canada. The regional development objective of increased output is assumed exogenously and it is specified that this can be achieved only by expanding the geographical area in which the firm sells. Three alternative subsidy approaches are examined in detail -- subsidy on output price, subsidy on the prices of factors employed by the firm, and subsidy on transport charges -- and it is argued that analytically these three alternative subsidy approaches also provided a basic framework for examination of subsidy on other inputs such as raw material costs. The most efficient subsidy system is specified as that which minimizes net social cost, which is defined as subsidy cost borne by government minus the increased profit of the firm. However, government does not raise taxes painlessly and it is also desirable to minimize the actual subsidy cost paid by government.

Chapter IV develops the framework of the model under assumptions of perfect competition modified by the existence of transport charges which increase at an accelerating rate as output increases and has to be transported further distances. Empirical data are developed to calibrate the model in respect of extent of output increases that might be sought, the

burden of transport charges in relation to product selling price, the division of transport charges into terminal and line haul components, and the form of production function used by the firm.

The geographical distribution of the firm's shipments are specified under two alternative assumptions. The first assumption postulates that the demand for the firm's product is uniformly distributed in an unbounded plane; as the firm increases output, it has to tap more distant markets but these are available in every direction from where the firm is situated. The second assumption is that demand is uniformly distributed in a band of constant width; ignoring exports to the south, this assumption could be applied as a rough approximation for those parts of Canada where population is distributed in a line along the U.S. boundary so that increased shipments cannot be delivered in all directions, but roughly only due east or due west. The real world situation is, of course, intermediate between these two alternatives.

In Chapters V and VI, the model is developed in two versions, corresponding to these two demand patterns. Output is established for equilibrium conditions without subsidy and the effects of the three forms of subsidy are examined. The burden of transport charges is naturally higher in the version of the model developed in Chapter VI, where new markets are only available due east or due west rather than in all directions. However, the conclusions from the two versions

of the model are basically similar and to some extent surprising against a background of conventional wisdom which questions the use of transport as a tool to promote regional economic development.

On the criterion of minimizing net social cost, subsidy on transport charges and subsidy on output price are equally efficient, and less costly than subsidizing either the labour or the capital used by the firm. Net social cost is defined as subsidy cost borne by government minus the increased profit of the firm. On the further criterion that the subsidy cost borne by government should also be minimized, the subsidy on transport charges is the most efficient approach.

Each version of the model is also developed in respect of marginal subsidies, applied only to additional output or additional utilization of a factor over and beyond what was the equilibrium position before subsidy. The effect of marginal subsidies is to reduce, to an equal extent, the subsidy cost borne by government and the increased profit enjoyed by the firm, so that there is no effect on net social cost. Nevertheless, marginal subsidy schemes are valuable in that they reduce the subsidy payments to be made by government out of general taxation. The savings in subsidy costs from marginal schemes are very substantial in the models and expenditure was again lowest for the subsidy on

transport charges. The practical feasibility of marginal subsidies is examined; inevitably, it is easier to design a marginal subsidy scheme applicable in terms of comparative statics than to the real world of continuous dynamic change.

Finally, the models are constrained by specifying maximum levels of subsidy payment per unit of output. These constraints generally have their greatest effect on subsidy schemes related to factor prices. A further constraint that subsidy payments on transport charges should not exceed the transport charges actually incurred by the firm shows, not surprisingly, that transport subsidies are not very effective when transport charges are only a small proportion of product price.

The conclusions of this dissertation as to the efficiency of transport subsidies in securing increased regional output are somewhat at variance with accepted opinion. The assumptions on which the model is built have been re-questioned but in many respects the model stands up well to scrutiny. The Cobb-Douglas production function is commonly used in micro-economic analysis, but the form of production function is not crucial to the general conclusions. If subsidy on output price is applied uniformly to all units of output while subsidy on transport charges is applied more intensively to incremental units of output, subsidy cost must be incurred at a greater rate when output price is subsidized. The transport subsidy meets only the costs necessary to overcome

distance on each specific unit of output, while the output price subsidy dissipates resources by paying the same rate of subsidy on product moving short distances as on product moving long distances. Furthermore, if some substitution is assumed between factors of production--regardless of the precise relationship--additional net social cost is incurred from subsidizing factor price, as compared to output price or transport charges, because of heavy use of the subsidized factor and the resultant diseconomies from the sub-optimal factor combinations in the production process.

Although the model is not developed in respect of other production costs, such as raw materials, public utilities and taxes, it is argued that subsidies on these other costs are analytically either comparable to subsidy on output price or subsidy on factor price, or alternatively they constitute a subsidy on fixed costs which has no effect on output. Hence, the advantages of subsidizing transport charges still hold. The model is developed on two widely different assumptions in respect of the geographical distribution of demand, yet the major results are very similar in both versions. Finally, the model has been calibrated over a range of values established as realistically as possible.

The model is reasonably robust as a means of examining subsidy payments and net social cost incurred to secure a specified increase in a firm's output, where this increased

output has to be transported to more distant markets. If transport charges are the main hindrance to increasing a firm's output, the most economic subsidy approach should be related directly to transport charges rather than indirectly to product or factor prices. Although this seems to go against conventional wisdom, nevertheless a subsidy on transport charges is clearly the most direct means of dealing with a problem created by transport charges, so perhaps the effectiveness of this approach is really less surprising than it may appear. However, although the model is realistic, it is not all-embracing and the limitations will be considered in the next section.

2. IMPLICATIONS, LIMITATIONS, AND FURTHER RESEARCH

The implications to the present study are reasonably self-evident. From Chapters IV-VI, if the regional development objective is to secure increased output from a firm located in a slow growth area and this involves an increasing burden of transport charges, then a subsidy on transport charges may be the most efficient method of achieving the required output increase. If the subsidy scheme can be operated on a marginal basis, applicable only to incremental output, then the saving in the subsidy cost borne by government will be substantial. In terms of current transport issues, these conclusions would seem to provide some theoretical justification for the additional selective subsidy operative since

1974 on westbound shipments from the Select Territory. The verdict is not proven in respect of the Chapter II examination of Western Canadian complaints in respect of overall freight rate discrimination, but transport subsidies to reach more distant markets may have merit in some cases in the light of the later part of the dissertation.

The examination in Chapter III suggests that, *ceteris paribus*, transport subsidies should be concentrated on those modes showing increasing returns to scale. It seems probable that returns to scale are greatest in rail, especially in those regions where traffic is less dense, namely the Prairies and the Atlantic Provinces, but this is an issue where much more research is needed. Superficially, subsidy rates in the Select Territory may seem to be similar for rail and highway traffic. However, in fact the rate of subsidy is higher for rail; for example, a 30% westbound subsidy on highway transport is interpreted as 30% of what the shipper pays on that part of the movement which occurs in the Select Territory, while a 30% subsidy on rail transport is related to the larger base of shipper payments plus subsidy payments, making it effectively 43% of what the shipper pays. Again, the direction of this differential although not necessarily its size might be justified in terms of differences in economies of scale. The Chapter III analysis also suggests that, under conditions of carrier monopoly, subsidy given

as a flat rate per unit of output is less expensive than the practice followed at present of paying subsidy on a percentage basis. However, the percentage basis for subsidy is administratively more convenient in an economy subject to inflationary pressures and may be justified on these grounds.

The conclusions to any research study are partly a function of the assumptions on which the research is developed. It has been argued that the model used in Chapters IV - VI is reasonably robust, but it is subject to limitations. The major qualifications are as follow:

(i) Increased output is taken as a regional development desideratum and it is specified that this output must be sold in more distant markets. It is assumed that an exogenous policy decision has been made that this increased output is desirable -- based upon analysis of such factors as direct employment and income generating potential, and backward and forward linkages in the regional economy. There is no examination in the dissertation of the desirability of this objective or of the basic goals of regional development policy. The model also precludes consideration of the achievement of regional development objectives from subsidizing economic and social infrastructure investment, and from using resources to improve the quality of technology and labour productivity.

(ii) The micro-economic analysis of a firm in the

present study cannot necessarily be extended to apply to all economic activity in a regional economy. There are theoretical reasons for arguing the superiority of the general equilibrium approach with its claims to measure complex interrelationships, to examine income redistribution effects, and to analyse in respect of unemployment conditions where the opportunity cost of labour is below the wage rate. However, it has already been argued that general equilibrium theory is also limited in its generality and that no systems analysis is ever all-embracing.

(iii) The model has been developed in terms of comparative statics and this cannot allow for the effects of dynamic change. For example, subsidies given to a firm at time t may become less effective at time $t + 1$, if the firm has become accustomed to subsidy and incorporated this revenue in its cost structure either in the form of inefficiencies or capitalized quasi-rents.

The main suggestions for further research which arise from this dissertation are:

(i) Extension of the model developed in Chapters IV-VI to apply to a generalized production function and a generalized distribution of demand, perhaps incorporating such refinements as monopolistic competition and objective functions for the firm other than profit maximization. However, the algebra would be more difficult and the model would be further removed from possibilities of calibration.

(ii) In respect of the theoretical case for subsidizing industries with increasing returns to scale, more needs to be known of production functions and returns to scale in the transport modes. A study is currently underway in the Canadian Transport Commission in respect of the air mode.

(iii) Further work is desirable in the measurement of freight rate disparities but this requires more disaggregated information than is presently available.

(iv) Virtually no research studies have been made of the likely effects of a reduction in transport charges relative to manufacturing production costs on the amount of industry located in the Atlantic Region and the Western Provinces.

(v) Finally, in spite of skepticism on general equilibrium theory, perhaps more work needs to be done on the ripple effects of transport subsidies.

The final conclusion to this dissertation is to recapitulate that, when the smallness of the regional market is the major problem in securing increased output, transport subsidies may be the most efficient incentive towards increased production. However, transport policies cannot provide universal solutions to problems of regional development and it is well to be aware of the dangers of undue concentration on any one issue -- be it entrepreneurial abilities, quality of labour, availability and cost of capital, infrastructure, or transportation.

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APPENDIX A

This contains Appendix Tables to Chapter V relating to simulations of alternative subsidy schemes in respect of Subsidy Cost, Increased Profit and Net Social Cost, all expressed on a per unit of output basis. In the Cobb-Douglas production function, (α) is the capital coefficient and (β) the labour coefficient. Each table number relates to a different ($\alpha + \beta$) combination. The letters attached to each table relate to different burdens of transport costs before operation of the subsidy scheme; as explained in Chapter V, it is not possible to simulate for low burdens of transport costs where ($\alpha + \beta$) ≥ 1.1 . The tables are as follow:

Tables IA - IG	($\alpha + \beta = 0.8$)
Tables IIA - IIG	($\alpha + \beta = 0.9$)
Tables IIIA - IIIG	($\alpha + \beta = 1.0$)
Tables IVE - IVG	($\alpha + \beta = 1.1$)
Tables VF - VG	($\alpha + \beta = 1.2$)
Table VIG	($\alpha + \beta = 1.3$)

APPENDIX TABLE IA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 3% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.27	1.24	0.03
Input price: $\alpha = 0.3$	1.02	0.98	0.04
$\beta = 0.5$	1.02	0.98	0.04
Line haul transport	0.84	0.81	0.03
<u>$h^2 = 1.25$</u>			
Output price	5.86	5.26	0.60
Input price: $\alpha = 0.3$	4.93	4.09	0.84
$\beta = 0.5$	4.77	4.09	0.68
Line haul transport	3.91	3.31	0.60
<u>$h^2 = 1.50$</u>			
Output price	10.93	9.02	1.91
Input price: $\alpha = 0.3$	9.60	6.83	2.77
$\beta = 0.5$	9.04	6.83	2.21
Line haul transport	7.28	5.37	1.91
<u>$h^2 = 2.00$</u>			
Output price	19.40	14.14	5.26
Input price: $\alpha = 0.3$	18.28	10.26	8.02
$\beta = 0.5$	16.44	10.26	6.18
Line haul transport	12.93	7.68	5.26
<u>$h^2 = 4.00$</u>			
Output price	42.76	24.10	18.66
Input price: $\alpha = 0.3$	48.62	15.55	33.07
$\beta = 0.5$	38.68	15.55	23.13
Line haul transport	28.51	9.85	18.66

APPENDIX TABLE IB

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.30	1.27	0.03
Input price: $\alpha = 0.3$	1.05	1.01	0.04
$\beta = 0.5$	1.05	1.01	0.04
Line haul transport	0.87	0.84	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.03	5.41	0.62
Input price: $\alpha = 0.3$	5.09	4.20	0.89
$\beta = 0.5$	4.92	4.20	0.72
Line haul transport	4.02	3.40	0.62
<u>$h^2 = 1.50$</u>			
Output price	11.26	9.29	1.97
Input price: $\alpha = 0.3$	9.98	7.04	2.94
$\beta = 0.5$	9.34	7.04	2.30
Line haul transport	7.51	5.54	1.97
<u>$h^2 = 2.00$</u>			
Output price	20.05	14.63	5.42
Input price: $\alpha = 0.3$	19.24	10.62	8.62
$\beta = 0.5$	17.11	10.62	6.49
Line haul transport	13.36	7.94	5.42
<u>$h^2 = 4.00$</u>			
Output price	44.55	25.19	19.36
Input price: $\alpha = 0.3$	53.26	16.28	36.98
$\beta = 0.5$	41.00	16.28	24.72
Line haul transport	29.70	10.34	19.36

APPENDIX TABLE IC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.34	1.31	0.03
Input price: $\alpha = 0.3$	1.09	1.04	0.05
$\beta = 0.5$	1.08	1.04	0.04
Line haul transport	0.89	0.86	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.23	5.59	0.64
Input price: $\alpha = 0.3$	5.31	4.35	0.96
$\beta = 0.5$	5.10	4.35	0.75
Line haul transport	4.16	3.52	0.64
<u>$h^2 = 1.50$</u>			
Output price	11.67	9.63	2.04
Input price: $\alpha = 0.3$	10.49	7.30	3.19
$\beta = 0.5$	9.73	7.30	2.43
Line haul transport	7.78	5.74	2.04
<u>$h^2 = 2.00$</u>			
Output price	20.85	15.23	5.62
Input price: $\alpha = 0.3$	20.56	11.06	9.50
$\beta = 0.5$	17.96	11.06	6.90
Line haul transport	13.90	8.28	5.62
<u>$h^2 = 4.00$</u>			
Output price	46.80	26.56	20.24
Input price: $\alpha = 0.3$	60.50	17.20	43.30
$\beta = 0.5$	44.21	17.20	27.01
Line haul transport	31.20	10.96	20.24

APPENDIX TABLE ID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.41	1.38	0.03
Input price: $\alpha = 0.3$	1.15	1.10	0.05
$\beta = 0.5$	1.14	1.10	0.04
Line haul transport	0.94	0.91	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.56	5.89	0.67
Input price: $\alpha = 0.3$	5.67	4.58	1.09
$\beta = 0.5$	5.40	4.58	0.82
Line haul transport	4.38	3.71	0.67
<u>$h^2 = 1.50$</u>			
Output price	12.33	10.18	2.15
Input price: $\alpha = 0.3$	11.40	7.72	3.68
$\beta = 0.5$	10.38	7.72	2.66
Line haul transport	8.22	6.07	2.15
<u>$h^2 = 2.00$</u>			
Output price	22.15	16.20	5.95
Input price: $\alpha = 0.3$	23.12	11.77	11.35
$\beta = 0.5$	19.46	11.77	7.69
Line haul transport	14.77	8.82	5.95
<u>$h^2 = 4.00$</u>			
Output price	50.38	28.74	21.64
Input price: $\alpha = 0.3$	78.26	18.67	59.59
$\beta = 0.5$	50.62	18.67	31.95
Line haul transport	33.59	11.95	21.64

APPENDIX TABLE IE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.45	1.42	0.03
Input price: $\alpha = 0.3$	1.18	1.13	0.05
$\beta = 0.5$	1.17	1.13	0.04
Line haul transport	0.97	0.94	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.77	6.08	0.69
Input price: $\alpha = 0.3$	5.91	4.73	1.18
$\beta = 0.5$	5.59	4.73	0.86
Line haul transport	4.51	3.82	0.69
<u>$h^2 = 1.50$</u>			
Output price	12.75	10.53	2.22
Input price: $\alpha = 0.3$	12.05	7.98	4.07
$\beta = 0.5$	10.82	7.98	2.84
Line haul transport	8.50	6.28	2.22
<u>$h^2 = 2.00$</u>			
Output price	22.96	16.80	6.16
Input price: $\alpha = 0.3$	25.15	12.21	12.94
$\beta = 0.5$	20.51	12.21	8.30
Line haul transport	15.31	9.15	6.16
<u>$h^2 = 4.00$</u>			
Output price	52.61	30.10	22.51
Input price: $\alpha = 0.3$	97.81	19.58	78.23
$\beta = 0.5$	56.11	19.58	36.53
Line haul transport	35.08	12.57	22.51

APPENDIX TABLE IF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.54	1.50	0.04
Input price: $\alpha = 0.3$	1.26	1.19	0.07
$\beta = 0.5$	1.24	1.19	0.05
Line haul transport	1.03	0.99	0.04
<u>$h^2 = 1.25$</u>			
Output price	7.19	6.45	0.74
Input price: $\alpha = 0.3$	6.47	5.02	1.45
$\beta = 0.5$	6.00	5.02	0.98
Line haul transport	4.79	4.05	0.74
<u>$h^2 = 1.50$</u>			
Output price	13.57	11.21	2.36
Input price: $\alpha = 0.3$	13.73	8.50	5.23
$\beta = 0.5$	11.79	8.50	3.29
Line haul transport	9.05	6.69	2.36
<u>$h^2 = 2.00$</u>			
Output price	24.58	18.01	6.57
Input price: $\alpha = 0.3$	31.42	13.09	18.33
$\beta = 0.5$	23.13	13.09	10.04
Line haul transport	16.39	9.82	6.57
<u>$h^2 = 4.00$</u>			
Output price	57.09	32.83	24.26
Input price: $\alpha = 0.3$	233.50	21.41	212.09
$\beta = 0.5$	78.95	21.41	57.54
Line haul transport	38.06	13.80	24.26

APPENDIX TABLE IG

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.60	1.56	0.04
Input price: $\alpha = 0.3$	1.32	1.24	0.08
$\beta = 0.5$	1.29	1.24	0.05
Line haul transport	1.07	1.03	0.04
<u>$h^2 = 1.25$</u>			
Output price	7.48	6.72	0.76
Input price: $\alpha = 0.3$	6.98	5.22	1.76
$\beta = 0.5$	6.32	5.22	1.10
Line haul transport	4.98	4.22	0.76
<u>$h^2 = 1.50$</u>			
Output price	14.15	11.70	2.45
Input price: $\alpha = 0.3$	15.52	8.86	6.66
$\beta = 0.5$	12.64	8.86	3.78
Line haul transport	9.43	6.98	2.45
<u>$h^2 = 2.00$</u>			
Output price	25.71	18.86	6.85
Input price: $\alpha = 0.3$	40.45	13.71	26.74
$\beta = 0.5$	25.94	13.71	12.23
Line haul transport	17.14	10.29	6.85
<u>$h^2 = 4.00$</u>			
Output price	60.22	34.74	25.48
Input price: $\alpha = 0.3$	57.38	22	57.16
$\beta = 0.5$	24.3	22	22.1
Line haul transport	40.15	14.67	25.48

APPENDIX TABLE IIA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 3 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.60	0.59	0.01
Input price: $\alpha = 0.3$	0.55	0.53	0.02
$\beta = 0.6$	0.54	0.53	0.01
Line haul transport	0.40	0.39	0.01
<u>$h^2 = 1.25$</u>			
Output price	2.76	2.48	0.28
Input price: $\alpha = 0.3$	2.56	2.20	0.36
$\beta = 0.6$	2.50	2.20	0.30
Line haul transport	1.84	1.56	0.28
<u>$h^2 = 1.50$</u>			
Output price	5.10	4.20	0.90
Input price: $\alpha = 0.3$	4.84	3.69	1.15
$\beta = 0.6$	4.65	3.69	0.96
Line haul transport	3.40	2.50	0.90
<u>$h^2 = 2.00$</u>			
Output price	8.92	6.48	2.44
Input price: $\alpha = 0.3$	8.81	5.59	3.22
$\beta = 0.6$	8.22	5.59	2.63
Line haul transport	5.95	3.51	2.44
<u>$h^2 = 4.00$</u>			
Output price	18.99	10.55	8.44
Input price: $\alpha = 0.3$	20.81	8.65	12.16
$\beta = 0.6$	17.93	8.65	9.28
Line haul transport	12.66	4.22	8.44

APPENDIX TABLE IIB

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.68	0.66	0.02
Input price: $\alpha = 0.3$	0.61	0.59	0.02
$\beta = 0.6$	0.61	0.59	0.02
Line haul transport	0.45	0.43	0.02
<u>$h^2 = 1.25$</u>			
Output price	3.10	2.78	0.32
Input price: $\alpha = 0.3$	2.89	2.47	0.42
$\beta = 0.6$	2.82	2.47	0.35
Line haul transport	2.07	1.75	0.32
<u>$h^2 = 1.50$</u>			
Output price	5.76	4.75	1.01
Input price: $\alpha = 0.3$	5.52	4.17	1.35
$\beta = 0.6$	5.26	4.17	1.09
Line haul transport	3.84	2.83	1.01
<u>$h^2 = 2.00$</u>			
Output price	10.15	7.39	2.76
Input price: $\alpha = 0.3$	10.24	6.37	3.87
$\beta = 0.6$	9.40	6.37	3.03
Line haul transport	6.77	4.01	2.76
<u>$h^2 = 4.00$</u>			
Output price	22.10	12.39	9.71
Input price: $\alpha = 0.3$	25.60	10.18	15.42
$\beta = 0.6$	21.15	10.18	10.97
Line haul transport	14.73	5.02	9.71

APPENDIX TABLE IIC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.76	0.74	0.02
Input price: $\alpha = 0.3$	0.69	0.67	0.02
$\beta = 0.6$	0.69	0.67	0.02
Line haul transport	0.51	0.49	0.02
<u>$h^2 = 1.25$</u>			
Output price	3.52	3.16	0.36
Input price: $\alpha = 0.3$	3.31	2.81	0.50
$\beta = 0.6$	3.21	2.81	0.40
Line haul transport	2.35	1.99	0.36
<u>$h^2 = 1.50$</u>			
Output price	6.57	5.42	1.15
Input price: $\alpha = 0.3$	6.41	4.77	1.64
$\beta = 0.6$	6.04	4.77	1.27
Line haul transport	4.38	3.23	1.15
<u>$h^2 = 2.00$</u>			
Output price	11.69	8.53	3.16
Input price: $\alpha = 0.3$	12.15	7.35	4.80
$\beta = 0.6$	10.90	7.35	3.55
Line haul transport	7.79	4.63	3.16
<u>$h^2 = 4.00$</u>			
Output price	25.99	14.70	11.29
Input price: $\alpha = 0.3$	32.85	12.10	20.75
$\beta = 0.6$	25.39	12.10	13.29
Line haul transport	17.33	6.04	11.29

APPENDIX TABLE IID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIALAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (px).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.9090	0.8888	0.0202
Input price: $\alpha = 0.3$	0.8282	0.7979	0.0303
$\beta = 0.6$	0.8181	0.7979	0.0202
Line haul transport	0.6060	0.5858	0.0202
<u>$h^2 = 1.25$</u>			
Output price	4.2020	3.7777	0.4343
Input price: $\alpha = 0.3$	4.0101	3.3535	0.6666
$\beta = 0.6$	3.8434	3.3535	0.4949
Line haul transport	2.8080	2.3737	0.4343
<u>$h^2 = 1.50$</u>			
Output price	7.8888	6.5151	1.3737
Input price: $\alpha = 0.3$	7.9499	5.7272	2.2222
$\beta = 0.6$	7.2929	5.7272	1.5757
Line haul transport	5.2525	3.8888	1.3737
<u>$h^2 = 2.00$</u>			
Output price	14.1515	10.3535	3.8080
Input price: $\alpha = 0.3$	15.1707	8.9393	6.7777
$\beta = 0.6$	13.4040	8.9393	4.4747
Line haul transport	9.4343	5.6363	3.8080
<u>$h^2 = 4.00$</u>			
Output price	32.2121	18.3838	13.8383
Input price: $\alpha = 0.3$	50.0303	15.1717	34.8686
$\beta = 0.6$	33.0101	15.1717	17.8484
Line haul transport	21.4848	7.6565	13.8383

APPENDIX TABLE IIE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.99	0.97	0.02
Input price: $\alpha = 0.3$	0.91	0.87	0.04
$\beta = 0.6$	0.90	0.87	0.03
Line haul transport	0.66	0.64	0.02
<u>$h^2 = 1.25$</u>			
Output price	4.62	4.15	0.47
Input price: $\alpha = 0.3$	4.47	3.69	0.78
$\beta = 0.6$	4.24	3.69	0.55
Line haul transport	3.08	2.61	0.47
<u>$h^2 = 1.50$</u>			
Output price	8.70	7.19	1.51
Input price: $\alpha = 0.3$	9.00	6.32	2.68
$\beta = 0.6$	8.10	6.32	1.78
Line haul transport	5.80	4.29	1.51
<u>$h^2 = 2.00$</u>			
Output price	15.68	11.48	4.20
Input price: $\alpha = 0.3$	18.41	9.91	8.50
$\beta = 0.6$	15.06	9.91	5.15
Line haul transport	10.45	6.25	4.20
<u>$h^2 = 4.00$</u>			
Output price	36.10	20.69	15.41
Input price: $\alpha = 0.3$	68.77	17.08	51.69
$\beta = 0.6$	38.75	17.08	21.67
Line haul transport	24.07	8.66	15.41

APPENDIX TABLE IIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.17	1.14	0.03
Input price: $\alpha = 0.3$	1.07	1.02	0.05
$\beta = 0.6$	1.06	1.02	0.04
Line haul transport	0.78	0.75	0.03
<u>$h^2 = 1.25$</u>			
Output price	5.47	4.91	0.56
Input price: $\alpha = 0.3$	5.49	4.36	1.13
$\beta = 0.6$	5.05	4.36	0.69
Line haul transport	3.65	3.09	0.56
<u>$h^2 = 1.50$</u>			
Output price	10.33	8.54	1.79
Input price: $\alpha = 0.3$	11.58	7.51	4.07
$\beta = 0.6$	9.81	7.51	2.30
Line haul transport	6.89	5.10	1.79
<u>$h^2 = 2.00$</u>			
Output price	18.76	13.76	5.00
Input price: $\alpha = 0.3$	26.35	11.88	14.47
$\beta = 0.6$	18.78	11.88	6.90
Line haul transport	12.50	7.50	5.00
<u>$h^2 = 4.00$</u>			
Output price	43.88	25.30	18.58
Input price: $\alpha = 0.3$	209.43	20.92	188.51
$\beta = 0.6$	57.77	20.92	36.85
Line haul transport	29.26	10.68	18.58

APPENDIX TABLE IIG

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.29	1.26	0.03
Input price: $\alpha = 0.3$	1.20	1.13	0.07
$\beta = 0.6$	1.17	1.13	0.04
Line haul transport	0.86	0.83	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.06	5.44	0.62
Input price: $\alpha = 0.3$	6.34	4.83	1.51
$\beta = 0.6$	5.66	4.83	0.83
Line haul transport	4.04	3.42	0.62
<u>$h^2 = 1.50$</u>			
Output price	11.48	9.49	1.99
Input price: $\alpha = 0.3$	14.14	8.34	5.80
$\beta = 0.6$	11.15	8.34	2.81
Line haul transport	7.65	5.66	1.99
<u>$h^2 = 2.00$</u>			
Output price	20.91	15.34	5.57
Input price: $\alpha = 0.3$	37.47	13.25	24.22
$\beta = 0.6$	22.13	13.25	8.88
Line haul transport	13.94	8.37	5.57
<u>$h^2 = 4.00$</u>			
Output price	49.33	28.53	20.80
Input price: $\alpha = 0.3$	10,128	24	10,104
$\beta = 0.6$	155	24	131
Line haul transport	32.89	12.09	20.80

APPENDIX TABLE IIIA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 3% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.075	0.073	0.002
Input price: $\alpha = 0.3$	0.075	0.073	0.002
$\beta = 0.7$	0.075	0.073	0.002
Line haul transport	0.050	0.048	0.002
<u>$h^2 = 1.25$</u>			
Output price	0.354	0.318	0.036
Input price: $\alpha = 0.3$	0.356	0.318	0.038
$\beta = 0.7$	0.354	0.318	0.036
Line haul transport	0.236	0.200	0.036
<u>$h^2 = 1.50$</u>			
Output price	0.675	0.559	0.116
Input price: $\alpha = 0.3$	0.681	0.559	0.122
$\beta = 0.7$	0.676	0.559	0.117
Line haul transport	0.450	0.334	0.116
<u>$h^2 = 2.00$</u>			
Output price	1.24	0.91	0.33
Input price: $\alpha = 0.3$	1.26	0.91	0.35
$\beta = 0.7$	1.24	0.91	0.33
Line haul transport	0.83	0.50	0.33
<u>$h^2 = 4.00$</u>			
Output price	3.00	1.75	1.25
Input price: $\alpha = 0.3$	3.11	1.75	1.36
$\beta = 0.7$	3.02	1.75	1.27
Line haul transport	2.00	0.75	1.25

APPENDIX TABLE IIIB

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.175	0.171	0.004
Input price: $\alpha = 0.3$	0.175	0.171	0.004
$\beta = 0.7$	0.175	0.171	0.004
Line haul transport	0.116	0.112	0.004
<u>$h^2 = 1.25$</u>			
Output price	0.826	0.742	0.084
Input price: $\alpha = 0.3$	0.835	0.742	0.093
$\beta = 0.7$	0.828	0.742	0.086
Line haul transport	0.551	0.467	0.084
<u>$h^2 = 1.50$</u>			
Output price	1.57	1.30	0.27
Input price: $\alpha = 0.3$	1.61	1.30	0.31
$\beta = 0.7$	1.58	1.30	0.28
Line haul transport	1.05	0.78	0.27
<u>$h^2 = 2.00$</u>			
Output price	2.90	2.13	0.77
Input price: $\alpha = 0.3$	3.01	2.13	0.88
$\beta = 0.7$	2.92	2.13	0.79
Line haul transport	1.93	1.16	0.77
<u>$h^2 = 4.00$</u>			
Output price	7.00	4.08	2.92
Input price: $\alpha = 0.3$	7.71	4.08	3.63
$\beta = 0.7$	7.12	4.08	3.04
Line haul transport	4.67	1.75	2.92

APPENDIX TABLE IIIC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.300	0.293	0.007
Input price: $\alpha = 0.3$	0.301	0.293	0.008
$\beta = 0.7$	0.300	0.293	0.007
Line haul transport	0.200	0.193	0.007
<u>$h^2 = 1.25$</u>			
Output price	1.41	1.27	0.14
Input price: $\alpha = 0.3$	1.44	1.27	0.17
$\beta = 0.7$	1.42	1.27	0.15
Line haul transport	0.94	0.80	0.14
<u>$h^2 = 1.50$</u>			
Output price	2.70	2.23	0.47
Input price: $\alpha = 0.3$	2.80	2.23	0.57
$\beta = 0.7$	2.72	2.23	0.49
Line haul transport	1.80	1.33	0.47
<u>$h^2 = 2.00$</u>			
Output price	4.97	3.66	1.31
Input price: $\alpha = 0.3$	5.34	3.66	1.68
$\beta = 0.7$	5.03	3.66	1.37
Line haul transport	3.31	2.00	1.31
<u>$h^2 = 4.00$</u>			
Output price	12.00	7.00	5.00
Input price: $\alpha = 0.3$	14.51	7.00	7.51
$\beta = 0.7$	12.42	7.00	5.42
Line haul transport	8.00	3.00	5.00

APPENDIX TABLE IIID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.500	0.488	0.012
Input price: $\alpha = 0.3$	0.504	0.488	0.016
$\beta = 0.7$	0.501	0.488	0.013
Line haul transport	0.333	0.321	0.012
<u>$h^2 = 1.25$</u>			
Output price	2.36	2.12	0.24
Input price: $\alpha = 0.3$	2.45	2.12	0.33
$\beta = 0.7$	2.38	2.12	0.26
Line haul transport	1.57	1.33	0.24
<u>$h^2 = 1.50$</u>			
Output price	4.50	3.72	0.78
Input price: $\alpha = 0.3$	4.85	3.72	1.13
$\beta = 0.7$	4.56	3.72	0.84
Line haul transport	3.00	2.22	0.78
<u>$h^2 = 2.00$</u>			
Output price	8.28	6.09	2.19
Input price: $\alpha = 0.3$	9.58	6.09	3.49
$\beta = 0.7$	8.50	6.09	2.41
Line haul transport	5.52	3.33	2.19
<u>$h^2 = 4.00$</u>			
Output price	20.00	11.67	8.33
Input price: $\alpha = 0.3$	30.25	11.67	18.58
$\beta = 0.7$	21.51	11.67	9.84
Line haul transport	13.33	5.00	8.33

APPENDIX TABLE III E

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.625	0.610	0.015
Input price: $\alpha = 0.3$	0.632	0.610	0.022
$\beta = 0.7$	0.626	0.610	0.016
Line haul transport	0.417	0.402	0.015
<u>$h^2 = 1.25$</u>			
Output price	2.95	2.65	0.30
Input price: $\alpha = 0.3$	3.11	2.65	0.46
$\beta = 0.7$	2.98	2.65	0.33
Line haul transport	1.97	1.67	0.30
<u>$h^2 = 1.50$</u>			
Output price	5.62	4.65	0.97
Input price: $\alpha = 0.3$	6.25	4.65	1.60
$\beta = 0.7$	5.73	4.65	1.08
Line haul transport	3.75	2.78	0.97
<u>$h^2 = 2.00$</u>			
Output price	10.35	7.61	2.74
Input price: $\alpha = 0.3$	12.75	7.61	5.14
$\beta = 0.7$	10.74	7.61	3.13
Line haul transport	6.90	4.16	2.74
<u>$h^2 = 4.00$</u>			
Output price	25.00	14.58	10.42
Input price: $\alpha = 0.3$	47.38	14.58	32.80
$\beta = 0.7$	27.91	14.58	13.33
Line haul transport	16.67	6.25	10.42

APPENDIX TABLE IIIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.875	0.854	0.021
Input price: $\alpha = 0.3$	0.892	0.854	0.038
$\beta = 0.7$	0.878	0.854	0.024
Line haul transport	0.583	0.562	0.021
<u>$h^2 = 1.25$</u>			
Output price	4.13	3.71	0.42
Input price: $\alpha = 0.3$	4.55	3.71	0.84
$\beta = 0.7$	4.20	3.71	0.49
Line haul transport	2.75	2.33	0.42
<u>$h^2 = 1.50$</u>			
Output price	7.88	6.52	1.36
Input price: $\alpha = 0.3$	9.59	6.52	3.07
$\beta = 0.7$	8.16	6.52	1.64
Line haul transport	5.25	3.89	1.36
<u>$h^2 = 2.00$</u>			
Output price	14.49	10.66	3.83
Input price: $\alpha = 0.3$	21.87	10.66	11.21
$\beta = 0.7$	15.58	10.66	4.92
Line haul transport	9.66	5.83	3.83
<u>$h^2 = 4.00$</u>			
Output price	35.00	20.41	14.59
Input price: $\alpha = 0.3$	187.78	20.41	167.37
$\beta = 0.7$	46.17	20.41	25.76
Line haul transport	23.34	8.75	14.59

APPENDIX TABLE III G

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.05	1.02	0.03
Input price: $\alpha = 0.3$	1.08	1.02	0.06
$\beta = 0.7$	1.05	1.02	0.03
Line haul transport	0.70	0.67	0.03
<u>$h^2 = 1.25$</u>			
Output price	4.96	4.45	0.51
Input price: $\alpha = 0.3$	5.73	4.45	1.28
$\beta = 0.7$	5.09	4.45	0.64
Line haul transport	3.31	2.80	0.51
<u>$h^2 = 1.50$</u>			
Output price	9.45	7.82	1.63
Input price: $\alpha = 0.3$	12.84	7.82	5.02
$\beta = 0.7$	9.98	7.82	2.16
Line haul transport	6.30	4.67	1.63
<u>$h^2 = 2.00$</u>			
Output price	17.39	12.79	4.60
Input price: $\alpha = 0.3$	34.68	12.79	21.89
$\beta = 0.7$	19.58	12.79	6.79
Line haul transport	11.60	7.00	4.60
<u>$h^2 = 4.00$</u>			
Output price	42.00	24.50	17.50
Input price: $\alpha = 0.3$	17,874	24.50	17,850
$\beta = 0.7$	114	24.50	90
Line haul transport	28.00	10.50	17.50

APPENDIX TABLE IVE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 25 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.326	0.318	0.008
Input price: $\alpha = 0.3$	0.361	0.351	0.010
$\beta = 0.8$	0.359		0.008
$\alpha = 0.4$	0.360		0.009
$\beta = 0.7$	0.359		0.008
Line haul transport	0.218	0.210	0.008
<u>$h^2 = 1.25$</u>			
Output price	1.61	1.45	0.16
Input price: $\alpha = 0.3$	1.83	1.61	0.22
$\beta = 0.8$	1.78		0.17
$\alpha = 0.4$	1.81		0.20
$\beta = 0.7$	1.78		0.17
Line haul transport	1.07	0.91	0.16
<u>$h^2 = 1.50$</u>			
Output price	3.21	2.67	0.54
Input price: $\alpha = 0.3$	3.79	2.99	0.80
$\beta = 0.8$	3.56		0.57
$\alpha = 0.4$	3.70		0.71
$\beta = 0.7$	3.58		0.59
Line haul transport	2.14	1.60	0.54
<u>$h^2 = 2.00$</u>			
Output price	6.28	4.69	1.59
Input price: $\alpha = 0.3$	8.00	5.32	2.68
$\beta = 0.8$	7.05		1.73
$\alpha = 0.4$	7.60		2.28
$\beta = 0.7$	7.13		1.81
Line haul transport	4.19	2.60	1.59
<u>$h^2 = 4.00$</u>			
Output price	17.10	10.37	6.73
Input price: $\alpha = 0.3$	31.62	12.08	19.54
$\beta = 0.8$	20.16		8.08
$\alpha = 0.4$	26.25		14.17
$\beta = 0.7$	20.91		8.83
Line haul transport	11.40	4.67	6.73

APPENDIX TABLE IVF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.636	0.621	0.015
Input price: $\alpha = 0.3$	0.711	{ 0.684	0.027
$\beta = 0.8$	0.701		0.017
$\alpha = 0.4$	0.707		0.023
$\beta = 0.7$	0.702		0.018
Line haul transport	0.424	0.409	0.015
<u>$h^2 = 1.25$</u>			
Output price	3.06	2.75	0.31
Input price: $\alpha = 0.3$	3.66	{ 3.06	0.60
$\beta = 0.8$	3.40		0.34
$\alpha = 0.4$	3.55		0.49
$\beta = 0.7$	3.43		0.37
Line haul transport	2.04	1.73	0.31
<u>$h^2 = 1.50$</u>			
Output price	5.94	4.93	1.01
Input price: $\alpha = 0.3$	7.76	{ 5.52	2.24
$\beta = 0.8$	6.69		1.17
$\alpha = 0.4$	7.31		1.79
$\beta = 0.7$	6.78		1.26
Line haul transport	3.96	2.95	1.01
<u>$h^2 = 2.00$</u>			
Output price	11.23	8.32	2.91
Input price: $\alpha = 0.3$	17.92	{ 9.44	8.48
$\beta = 0.8$	12.99		3.55
$\alpha = 0.4$	15.70		6.26
$\beta = 0.7$	13.34		3.90
Line haul transport	7.49	4.58	2.91
<u>$h^2 = 4.00$</u>			
Output price	28.69	17.05	11.64
Input price: $\alpha = 0.3$	168.31	{ 19.91	148.40
$\beta = 0.8$	38.88		18.97
$\alpha = 0.4$	90.41		70.50
$\beta = 0.7$	43.54		23.63
Line haul transport	19.12	7.48	11.64

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.853	0.832	0.021
Input price: $\alpha = 0.3$	0.963	{ 0.917	0.046
$\beta = 0.8$	0.942		0.025
$\alpha = 0.4$	0.954		0.037
$\beta = 0.7$	0.943		0.026
Line haul transport	0.569	0.548	0.021
<u>$h^2 = 1.25$</u>			
Output price	4.07	3.66	0.41
Input price: $\alpha = 0.3$	5.14	{ 4.07	1.07
$\beta = 0.8$	4.57		0.50
$\alpha = 0.4$	4.90		0.83
$\beta = 0.7$	4.61		0.54
Line haul transport	2.71	2.30	0.41
<u>$h^2 = 1.50$</u>			
Output price	7.86	6.51	1.35
Input price: $\alpha = 0.3$	11.61	{ 7.30	4.31
$\beta = 0.8$	9.00		1.70
$\alpha = 0.4$	10.46		3.16
$\beta = 0.7$	9.19		1.89
Line haul transport	5.24	3.89	1.35
<u>$h^2 = 2.00$</u>			
Output price	14.70	10.86	3.84
Input price: $\alpha = 0.3$	32.06	{ 12.33	19.73
$\beta = 0.8$	17.69		5.36
$\alpha = 0.4$	25.03		12.70
$\beta = 0.7$	18.55		6.22
Line haul transport	9.80	5.96	3.84
<u>$h^2 = 4.00$</u>			
Output price	36.79	21.72	15.07
Input price: $\alpha = 0.3$	31,544	{ 25.40	31,519
$\beta = 0.8$	93		67
$\alpha = 0.4$	2,777		2,752
$\beta = 0.7$	146		121
Line haul transport	24.53	9.46	15.07

APPENDIX TABLE VF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.2, \alpha = 0.4, \beta = 0.8$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.438	0.427	0.011
Input price: $\alpha = 0.4$	0.530	0.515	0.015
$\beta = 0.8$	0.526	0.515	0.011
Line haul transport	0.292	0.281	0.011
<u>$h^2 = 1.25$</u>			
Output price	2.18	1.96	0.22
Input price: $\alpha = 0.4$	2.74	2.40	0.34
$\beta = 0.8$	2.65	2.40	0.25
Line haul transport	1.46	1.24	0.22
<u>$h^2 = 1.50$</u>			
Output price	4.39	3.66	0.73
Input price: $\alpha = 0.4$	5.79	4.53	1.26
$\beta = 0.8$	5.39	4.53	0.86
Line haul transport	2.92	2.19	0.73
<u>$h^2 = 2.00$</u>			
Output price	8.67	6.49	2.18
Input price: $\alpha = 0.4$	12.91	8.23	4.68
$\beta = 0.8$	10.97	8.23	2.74
Line haul transport	5.78	3.60	2.18
<u>$h^2 = 4.00$</u>			
Output price	24.00	14.62	9.38
Input price: $\alpha = 0.4$	82.93	19.41	63.52
$\beta = 0.8$	36.79	19.41	17.38
Line haul transport	16.00	6.62	9.38

APPENDIX TABLE VG

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.2, \alpha = 0.4, \beta = 0.8$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.689	0.673	0.016
Input price: $\alpha = 0.4$	0.840	0.810	0.030
$\beta = 0.8$	0.830	0.810	0.020
Line haul transport	0.459	0.443	0.016
<u>$h^2 = 1.25$</u>			
Output price	3.35	3.01	0.34
Input price: $\alpha = 0.4$	4.37	3.68	0.69
$\beta = 0.8$	4.10	3.68	0.42
Line haul transport	2.23	1.89	0.34
<u>$h^2 = 1.50$</u>			
Output price	6.57	5.46	1.11
Input price: $\alpha = 0.4$	9.48	6.77	2.71
$\beta = 0.8$	8.25	6.77	1.48
Line haul transport	4.38	3.27	1.11
<u>$h^2 = 2.00$</u>			
Output price	12.59	9.35	3.24
Input price: $\alpha = 0.4$	23.38	11.87	11.51
$\beta = 0.8$	16.77	11.87	4.90
Line haul transport	8.40	5.16	3.24
<u>$h^2 = 4.00$</u>			
Output price	32.92	19.71	13.21
Input price: $\alpha = 0.4$	4,253	26.30	4,227
$\beta = 0.8$	115.1	26.30	88.81
Line haul transport	21.95	8.74	13.21

APPENDIX TABLE VIG

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.3, \alpha = 0.4, \beta = 0.9$$

Transport costs before subsidy (y) = 42% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.551	0.538	0.013
Input price: $\alpha = 0.4$	0.727	0.703	0.024
$\beta = 0.9$	0.719	0.703	0.016
Line haul transport	0.367	0.354	0.013
<u>$h^2 = 1.25$</u>			
Output price	2.75	2.47	0.28
Input price: $\alpha = 0.4$	3.86	3.30	0.56
$\beta = 0.9$	3.63	3.30	0.33
Line haul transport	1.83	1.55	0.28
<u>$h^2 = 1.50$</u>			
Output price	5.52	4.60	0.92
Input price: $\alpha = 0.4$	8.54	6.25	2.29
$\beta = 0.9$	7.42	6.25	1.17
Line haul transport	3.68	2.76	0.92
<u>$h^2 = 2.00$</u>			
Output price	10.89	8.15	2.74
Input price: $\alpha = 0.4$	21.80	11.41	10.39
$\beta = 0.9$	15.35	11.41	3.94
Line haul transport	7.26	4.52	2.74
<u>$h^2 = 4.00$</u>			
Output price	29.95	18.21	11.74
Input price: $\alpha = 0.4$	6,512	27.20	6,485
$\beta = 0.9$	96.72	27.20	69.52
Line haul transport	19.97	8.23	11.74

APPENDIX B

This contains Appendix Tables to Chapter VI relating to simulations of alternative subsidy schemes in respect of Subsidy Cost, Increased Profit and Net Social Cost, all expressed on a per unit of output basis. In the Cobb-Douglas production function, (α) is the capital coefficient and (β) the labour coefficient. Each table number relates to a different $(\alpha + \beta)$ combination. The letters attached to each table relate to different burdens of transport costs before operation of the subsidy scheme; as explained in Chapter VI, it is not possible to simulate for low burdens of transport costs where $(\alpha + \beta) \geq 1.1$. The tables are as follow:

Tables IA - IF	$(\alpha + \beta = 0.8)$
Tables IIA - IIF	$(\alpha + \beta = 0.9)$
Tables IIIA - IIIF	$(\alpha + \beta = 1.0)$
Tables IVC - IVF	$(\alpha + \beta = 1.1)$
Tables VD - VF	$(\alpha + \beta = 1.2)$
Table VIF	$(\alpha + \beta = 1.3)$

APPENDIX TABLE IA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 3 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.38	1.35	0.03
Input price: $\alpha = 0.3$	1.12	1.07	0.05
$\beta = 0.5$	1.11	1.07	0.04
Line haul transport	0.69	0.66	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.45	5.79	0.66
Input price: $\alpha = 0.3$	5.46	4.50	0.96
$\beta = 0.5$	5.26	4.50	0.76
Line haul transport	3.22	2.56	0.66
<u>$h^2 = 1.50$</u>			
Output price	12.15	10.04	2.11
Input price: $\alpha = 0.3$	10.81	7.61	3.20
$\beta = 0.5$	10.09	7.61	2.48
Line haul transport	6.07	3.96	2.11
<u>$h^2 = 2.00$</u>			
Output price	21.96	16.09	5.87
Input price: $\alpha = 0.3$	21.29	11.70	9.59
$\beta = 0.5$	18.81	11.70	7.11
Line haul transport	10.98	5.11	5.87
<u>$h^2 = 4.00$</u>			
Output price	51.35	29.62	21.73
Input price: $\alpha = 0.3$	65.04	19.35	45.69
$\beta = 0.5$	48.18	19.35	28.83
Line haul transport	25.67	3.94	21.73

APPENDIX TABLE 1B

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
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$h^2 = 1.05$

Output price	1.57	1.53	0.04
Input price: $\alpha = 0.3$	1.27	1.22	0.05
$\beta = 0.5$	1.26	1.22	0.04
Line haul transport	0.78	0.74	0.04

$h^2 = 1.25$

Output price	7.40	6.65	0.75
Input price: $\alpha = 0.3$	6.35	5.16	1.19
$\beta = 0.5$	6.07	5.16	0.91
Line haul transport	3.70	2.95	0.75

$h^2 = 1.50$

Output price	14.10	11.67	2.43
Input price: $\alpha = 0.3$	12.93	8.85	4.08
$\beta = 0.5$	11.84	8.85	2.99
Line haul transport	7.05	4.62	2.43

$h^2 = 2.00$

Output price	26.03	19.17	6.86
Input price: $\alpha = 0.3$	26.95	13.96	12.99
$\beta = 0.5$	22.80	13.96	8.84
Line haul transport	13.01	6.15	6.86

$h^2 = 4.00$

Output price	64.59	38.07	26.52
Input price: $\alpha = 0.3$	107.95	25.15	82.80
$\beta = 0.5$	66.49	25.15	41.34
Line haul transport	32.29	5.77	26.52

APPENDIX TABLE IC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.80	1.76	0.04
Input price: $\alpha = 0.3$	1.47	1.40	0.07
$\beta = 0.5$	1.45	1.40	0.05
Line haul transport	0.90	0.86	0.04
<u>$h^2 = 1.25$</u>			
Output price	8.59	7.72	0.87
Input price: $\alpha = 0.3$	7.53	6.00	1.53
$\beta = 0.5$	7.10	6.00	1.10
Line haul transport	4.29	3.42	0.87
<u>$h^2 = 1.50$</u>			
Output price	16.55	13.72	2.83
Input price: $\alpha = 0.3$	15.91	10.41	5.50
$\beta = 0.5$	14.13	10.41	3.72
Line haul transport	8.27	5.44	2.83
<u>$h^2 = 2.00$</u>			
Output price	31.12	23.02	8.10
Input price: $\alpha = 0.3$	36.03	16.79	19.24
$\beta = 0.5$	28.32	16.79	11.53
Line haul transport	15.56	7.46	8.10
<u>$h^2 = 4.00$</u>			
Output price	81.13	48.63	32.50
Input price: $\alpha = 0.3$	269	32.40	237
$\beta = 0.5$	104	32.40	72
Line haul transport	40.56	8.06	32.50

APPENDIX TABLE ID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.18	2.13	0.05
Input price: $\alpha = 0.3$	1.79	1.69	0.10
$\beta = 0.5$	1.76	1.69	0.07
Line haul transport	1.09	1.04	0.05
<u>$h^2 = 1.25$</u>			
Output price	10.49	9.43	1.06
Input price: $\alpha = 0.3$	9.66	7.33	2.33
$\beta = 0.5$	8.82	7.33	1.49
Line haul transport	5.24	4.18	1.06
<u>$h^2 = 1.50$</u>			
Output price	20.47	17.00	3.47
Input price: $\alpha = 0.3$	22.04	12.90	9.14
$\beta = 0.5$	18.17	12.90	5.27
Line haul transport	10.23	6.67	3.47
<u>$h^2 = 2.00$</u>			
Output price	39.26	29.18	10.08
Input price: $\alpha = 0.3$	62.30	21.32	40.98
$\beta = 0.5$	39.72	21.32	18.40
Line haul transport	19.63	9.55	10.08
<u>$h^2 = 4.00$</u>			
Output price	107.61	65.53	42.08
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.5$	*	*	*
Line haul transport	53.80	11.72	42.08

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE 1E

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.41	2.35	0.06
Input price: $\alpha = 0.3$	2.00	1.87	0.13
$\beta = 0.5$	1.95	1.87	0.08
Line haul transport	1.21	1.15	0.06
<u>$h^2 = 1.25$</u>			
Output price	11.67	10.50	1.17
Input price: $\alpha = 0.3$	11.25	8.17	3.08
$\beta = 0.5$	9.97	8.17	1.80
Line haul transport	5.83	4.66	1.17
<u>$h^2 = 1.50$</u>			
Output price	22.91	19.04	3.87
Input price: $\alpha = 0.3$	27.72	14.46	13.26
$\beta = 0.5$	21.17	14.46	6.71
Line haul transport	11.46	7.59	3.87
<u>$h^2 = 2.00$</u>			
Output price	44.34	33.03	11.31
Input price: $\alpha = 0.3$	106.32	24.16	82.16
$\beta = 0.5$	51.43	24.16	27.27
Line haul transport	22.17	10.86	11.31
<u>$h^2 = 4.00$</u>			
Output price	124.16	76.09	48.07
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.5$	*	*	*
Line haul transport	62.08	14.01	48.07

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.8, \alpha = 0.3, \beta = 0.5$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.88	2.81	0.07
Input price: $\alpha = 0.3$	2.44	2.23	0.21
$\beta = 0.5$	2.35	2.23	0.12
Line haul transport	1.44	1.37	0.07
<u>$h^2 = 1.25$</u>			
Output price	14.05	12.64	1.41
Input price: $\alpha = 0.3$	16.06	9.83	6.23
$\beta = 0.5$	12.73	9.83	2.90
Line haul transport	7.03	5.62	1.41
<u>$h^2 = 1.50$</u>			
Output price	27.81	23.14	4.67
Input price: $\alpha = 0.3$	59.02	17.57	41.45
$\beta = 0.5$	30.98	17.57	13.41
Line haul transport	13.90	9.23	4.67
<u>$h^2 = 2.00$</u>			
Output price	54.51	40.72	13.79
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.5$	*	*	*
Line haul transport	27.26	13.47	13.79
<u>$h^2 = 4.00$</u>			
Output price	157.25	97.20	60.05
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.5$	*	*	*
Line haul transport	78.63	18.58	60.05

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 3 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x). (h^2) is ratio of output after subsidy to output before subsidy. (α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.73	0.71	0.02
Input price: $\alpha = 0.3$	0.66	0.64	0.02
$\beta = 0.6$	0.66	0.64	0.02
Line haul transport	0.36	0.34	0.02
<u>$h^2 = 1.25$</u>			
Output price	3.38	3.03	0.35
Input price: $\alpha = 0.3$	3.16	2.70	0.46
$\beta = 0.6$	3.07	2.70	0.37
Line haul transport	1.69	1.34	0.35
<u>$h^2 = 1.50$</u>			
Output price	6.39	5.28	1.11
Input price: $\alpha = 0.3$	6.15	4.64	1.51
$\beta = 0.6$	5.84	4.64	1.20
Line haul transport	3.19	2.08	1.11
<u>$h^2 = 2.00$</u>			
Output price	11.60	8.51	3.09
Input price: $\alpha = 0.3$	11.83	7.35	4.48
$\beta = 0.6$	10.77	7.35	3.42
Line haul transport	5.80	2.71	3.09
<u>$h^2 = 4.00$</u>			
Output price	27.82	16.21	11.61
Input price: $\alpha = 0.3$	34.37	13.43	20.94
$\beta = 0.6$	27.03	13.43	13.60
Line haul transport	13.91	2.30	11.61

APPENDIX TABLE IIB

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.96	0.94	0.02
Input price: $\alpha = 0.3$	0.87	0.84	0.03
$\beta = 0.6$	0.86	0.84	0.02
Line haul transport	0.48	0.46	0.02
<u>$h^2 = 1.25$</u>			
Output price	4.55	4.09	0.46
Input price: $\alpha = 0.3$	4.31	3.63	0.68
$\beta = 0.6$	4.15	3.63	0.52
Line haul transport	2.27	1.81	0.46
<u>$h^2 = 1.50$</u>			
Output price	8.75	7.25	1.50
Input price: $\alpha = 0.3$	8.72	6.37	2.35
$\beta = 0.6$	8.07	6.37	1.70
Line haul transport	4.37	2.87	1.50
<u>$h^2 = 2.00$</u>			
Output price	16.40	12.12	4.28
Input price: $\alpha = 0.3$	18.03	10.48	7.55
$\beta = 0.6$	15.50	10.48	5.02
Line haul transport	8.20	3.92	4.28
<u>$h^2 = 4.00$</u>			
Output price	42.71	25.60	17.11
Input price: $\alpha = 0.3$	72.07	21.33	50.74
$\beta = 0.6$	44.60	21.33	23.27
Line haul transport	21.35	4.24	17.11

APPENDIX TABLE IIC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 12 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.25	1.22	0.03
Input price: $\alpha = 0.3$	1.14	1.09	0.05
$\beta = 0.6$	1.13	1.09	0.04
Line haul transport	0.62	0.59	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.01	5.40	0.61
Input price: $\alpha = 0.3$	5.84	4.80	1.04
$\beta = 0.6$	5.51	4.80	0.71
Line haul transport	3.00	2.39	0.61
<u>$h^2 = 1.50$</u>			
Output price	11.70	9.71	1.99
Input price: $\alpha = 0.3$	12.33	8.54	3.79
$\beta = 0.6$	10.95	8.54	2.41
Line haul transport	5.85	3.86	1.99
<u>$h^2 = 2.00$</u>			
Output price	22.39	16.63	5.76
Input price: $\alpha = 0.3$	28.02	14.39	13.63
$\beta = 0.6$	21.82	14.39	7.43
Line haul transport	11.20	5.44	5.76
<u>$h^2 = 4.00$</u>			
Output price	61.32	37.33	23.99
Input price: $\alpha = 0.3$	228	31.20	197
$\beta = 0.6$	76.42	31.20	45.22
Line haul transport	30.66	6.67	23.99

APPENDIX TABLE IID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.72	1.68	0.04
Input price: $\alpha = 0.3$	1.58	1.50	0.08
$\beta = 0.6$	1.55	1.50	0.05
Line haul transport	0.86	0.82	0.04
<u>$h^2 = 1.25$</u>			
Output price	8.34	7.50	0.84
Input price: $\alpha = 0.3$	8.59	6.66	1.93
$\beta = 0.6$	7.76	6.66	1.10
Line haul transport	4.17	3.33	0.84
<u>$h^2 = 1.50$</u>			
Output price	16.42	13.65	2.77
Input price: $\alpha = 0.3$	19.80	12.01	7.79
$\beta = 0.6$	15.87	12.01	3.86
Line haul transport	8.21	5.44	2.77
<u>$h^2 = 2.00$</u>			
Output price	31.98	23.85	8.13
Input price: $\alpha = 0.3$	57.92	20.66	37.26
$\beta = 0.6$	33.94	20.66	13.28
Line haul transport	15.99	7.86	8.13
<u>$h^2 = 4.00$</u>			
Output price	91.10	56.11	34.99
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.6$	*	*	*
Line haul transport	45.55	10.56	34.99

*Signifies this rate of increase in output not achievable from subsidy on factor price because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9 \quad \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.01	1.96	0.05
Input price: $\alpha = 0.3$	1.87	1.76	0.11
$\beta = 0.6$	1.82	1.76	0.06
Line haul transport	1.00	0.95	0.05
<u>$h^2 = 1.25$</u>			
Output price	9.79	8.81	0.98
Input price: $\alpha = 0.3$	10.65	7.83	2.82
$\beta = 0.6$	9.23	7.83	1.40
Line haul transport	4.90	3.92	0.98
<u>$h^2 = 1.50$</u>			
Output price	19.38	16.12	3.26
Input price: $\alpha = 0.3$	26.81	14.18	12.63
$\beta = 0.6$	19.33	14.18	5.15
Line haul transport	9.69	6.43	3.26
<u>$h^2 = 2.00$</u>			
Output price	37.98	28.37	9.61
Input price: $\alpha = 0.3$	112.30	24.57	87.73
$\beta = 0.6$	44.97	24.57	20.40
Line haul transport	18.99	9.38	9.61
<u>$h^2 = 4.00$</u>			
Output price	109.71	67.85	41.86
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.6$	*	*	*
Line haul transport	54.85	12.99	41.86

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 0.9, \alpha = 0.3, \beta = 0.6$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
 (h^2) is ratio of output after subsidy to output before subsidy.
 (α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.59	2.53	0.06
Input price: $\alpha = 0.3$	2.49	2.27	0.22
$\beta = 0.6$	2.37	2.27	0.10
Line haul transport	1.30	1.24	0.06
<u>$h^2 = 1.25$</u>			
Output price	12.71	11.44	1.27
Input price: $\alpha = 0.3$	16.96	10.17	6.79
$\beta = 0.6$	12.57	10.17	2.40
Line haul transport	6.35	5.08	1.27
<u>$h^2 = 1.50$</u>			
Output price	25.28	21.05	4.23
Input price: $\alpha = 0.3$	68.63	18.52	50.11
$\beta = 0.6$	29.37	18.52	10.85
Line haul transport	12.64	8.41	4.23
<u>$h^2 = 2.00$</u>			
Output price	49.97	37.40	12.57
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.6$	*	*	*
Line haul transport	24.99	12.42	12.57
<u>$h^2 = 4.00$</u>			
Output price	146.93	91.32	55.61
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.6$	*	*	*
Line haul transport	73.47	17.86	55.61

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIIA

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 3 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.202	{ 0.198	0.004
Input price: $\alpha = 0.3$	0.203		0.005
$\beta = 0.7$	0.202		0.004
Line haul transport	0.101	0.097	0.004
<u>$h^2 = 1.25$</u>			
Output price	1.00	{ 0.90	0.10
Input price: $\alpha = 0.3$	1.01		0.11
$\beta = 0.7$	1.00		0.10
Line haul transport	0.50	0.40	0.10
<u>$h^2 = 1.50$</u>			
Output price	2.00	{ 1.67	0.33
Input price: $\alpha = 0.3$	2.05		0.38
$\beta = 0.7$	2.01		0.34
Line haul transport	1.00	0.67	0.33
<u>$h^2 = 2.00$</u>			
Output price	4.00	{ 3.00	1.00
Input price: $\alpha = 0.3$	4.21		1.21
$\beta = 0.7$	4.03		1.03
Line haul transport	2.00	1.00	1.00
<u>$h^2 = 4.00$</u>			
Output price	12.00	{ 7.50	4.50
Input price: $\alpha = 0.3$	14.15		6.65
$\beta = 0.7$	12.36		4.86
Line haul transport	6.00	1.50	4.50

APPENDIX TABLE IIIB

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 7% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h²) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>h² = 1.05</u>			
Output price	0.472	{	0.011
Input price: α = 0.3	0.475		0.014
β = 0.7	0.472		0.011
Line haul transport	0.236	0.225	0.011
<u>h² = 1.25</u>			
Output price	2.33	{	0.23
Input price: α = 0.3	2.41		0.31
β = 0.7	2.35		0.25
Line haul transport	1.16	0.93	0.23
<u>h² = 1.50</u>			
Output price	4.67	{	0.78
Input price: α = 0.3	4.98		1.09
β = 0.7	4.73		0.84
Line haul transport	2.34	1.56	0.78
<u>h² = 2.00</u>			
Output price	9.33	{	2.33
Input price: α = 0.3	10.68		3.68
β = 0.7	9.56		2.56
Line haul transport	4.66	2.33	2.33
<u>h² = 4.00</u>			
Output price	28.00	{	10.50
Input price: α = 0.3	46.40		28.90
β = 0.7	30.57		13.07
Line haul transport	14.00	3.50	10.50

APPENDIX TABLE IIIC

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.81	{ 0.79	0.02
Input price: $\alpha = 0.3$	0.82		0.03
$\beta = 0.7$	0.81		0.02
Line haul transport	0.40	0.38	0.02
<u>$h^2 = 1.25$</u>			
Output price	4.00	{ 3.60	0.40
Input price: $\alpha = 0.3$	4.25		0.65
$\beta = 0.7$	4.04		0.44
Line haul transport	2.00	1.60	0.40
<u>$h^2 = 1.50$</u>			
Output price	8.00	{ 6.67	1.33
Input price: $\alpha = 0.3$	9.10		2.43
$\beta = 0.7$	8.20		1.53
Line haul transport	4.00	2.67	1.33
<u>$h^2 = 2.00$</u>			
Output price	15.99	{ 12.00	3.99
Input price: $\alpha = 0.3$	21.18		9.18
$\beta = 0.7$	16.81		4.81
Line haul transport	7.99	4.00	3.99
<u>$h^2 = 4.00$</u>			
Output price	48.00	{ 30.00	18.00
Input price: $\alpha = 0.3$	193.95		163.95
$\beta = 0.7$	60.53		30.53
Line haul transport	24.00	6.00	18.00

APPENDIX TABLE IIID

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.35	{ 1.32	0.03
Input price: $\alpha = 0.3$	1.38		0.06
$\beta = 0.7$	1.35		0.03
Line haul transport	0.67	0.64	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.66	{ 6.00	0.66
Input price: $\alpha = 0.3$	7.57		1.57
$\beta = 0.7$	6.82		0.82
Line haul transport	3.33	2.67	0.66
<u>$h^2 = 1.50$</u>			
Output price	13.34	{ 11.12	2.22
Input price: $\alpha = 0.3$	17.69		6.57
$\beta = 0.7$	14.03		2.91
Line haul transport	6.67	4.45	2.22
<u>$h^2 = 2.00$</u>			
Output price	26.65	{ 19.99	6.66
Input price: $\alpha = 0.3$	53.79		33.80
$\beta = 0.7$	30.06		10.07
Line haul transport	13.32	6.66	6.66
<u>$h^2 = 4.00$</u>			
Output price	80.00	50.00	30.00
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.7$	*	*	*
Line haul transport	40.00	10.00	30.00

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIIE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.69	{ 1.65	0.04
Input price: $\alpha = 0.3$	1.75		0.10
$\beta = 0.7$	1.70		0.05
Line haul transport	0.84	0.80	0.04
<u>$h^2 = 1.25$</u>			
Output price	8.33	{ 7.50	0.83
Input price: $\alpha = 0.3$	10.07		2.57
$\beta = 0.7$	8.62		1.12
Line haul transport	4.16	3.33	0.83
<u>$h^2 = 1.50$</u>			
Output price	16.68	{ 13.90	2.78
Input price: $\alpha = 0.3$	25.91		12.01
$\beta = 0.7$	18.02		4.12
Line haul transport	8.34	5.56	2.78
<u>$h^2 = 2.00$</u>			
Output price	33.31	{ 24.99	8.32
Input price: $\alpha = 0.3$	118.59		93.60
$\beta = 0.7$	41.17		16.18
Line haul transport	16.65	8.33	8.32
<u>$h^2 = 4.00$</u>			
Output price	100.00	62.50	37.50
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.7$	*	*	*
Line haul transport	50.00	12.50	37.50

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE IIIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.0, \alpha = 0.3, \beta = 0.7$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.36	{ 2.31	0.05
Input price: $\alpha = 0.3$	2.53		0.22
$\beta = 0.7$	2.39		0.08
Line haul transport	1.18	1.13	0.05
<u>$h^2 = 1.25$</u>			
Output price	11.66	{ 10.50	1.16
Input price: $\alpha = 0.3$	17.89		7.39
$\beta = 0.7$	12.57		2.07
Line haul transport	5.83	4.67	1.16
<u>$h^2 = 1.50$</u>			
Output price	23.36	{ 19.47	3.89
Input price: $\alpha = 0.3$	79.67		60.20
$\beta = 0.7$	28.68		9.21
Line haul transport	11.68	7.79	3.89
<u>$h^2 = 2.00$</u>			
Output price	46.63	34.98	11.65
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.7$	*	*	*
Line haul transport	23.32	11.67	11.65
<u>$h^2 = 4.00$</u>			
Output price	139.99	87.50	52.49
Input price: $\alpha = 0.3$	*	*	*
$\beta = 0.7$	*	*	*
Line haul transport	70.00	17.51	52.49

*Signifies this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 12% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.450	0.441	0.009
Input price: $\alpha = 0.3$	0.499	{ 0.486	0.013
$\beta = 0.8$	0.496		0.010
$\alpha = 0.4$	0.498		0.012
$\beta = 0.7$	0.496		0.010
Line haul transport	0.225	0.216	0.009
<u>$h^2 = 1.25$</u>			
Output price	2.39	2.16	0.23
Input price: $\alpha = 0.3$	2.74	{ 2.40	0.34
$\beta = 0.8$	2.65		0.25
$\alpha = 0.4$	2.70		0.30
$\beta = 0.7$	2.65		0.25
Line haul transport	1.19	0.96	0.23
<u>$h^2 = 1.50$</u>			
Output price	5.11	4.29	0.82
Input price: $\alpha = 0.3$	6.18	{ 4.81	1.37
$\beta = 0.8$	5.70		0.89
$\alpha = 0.4$	5.98		1.17
$\beta = 0.7$	5.74		0.93
Line haul transport	2.56	1.74	0.82
<u>$h^2 = 2.00$</u>			
Output price	11.10	8.48	2.62
Input price: $\alpha = 0.3$	15.32	{ 9.59	5.73
$\beta = 0.8$	12.60		3.01
$\alpha = 0.4$	14.15		4.56
$\beta = 0.7$	12.81		3.22
Line haul transport	5.55	2.93	2.62
<u>$h^2 = 4.00$</u>			
Output price	38.53	24.95	13.58
Input price: $\alpha = 0.3$	165	{ 28.80	136
$\beta = 0.8$	50.28		21.48
$\alpha = 0.4$	99.65		70.85
$\beta = 0.7$	55.14		26.34
Line haul transport	19.26	5.68	13.58

APPENDIX TABLE IVD

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.05	1.03	0.02
Input price: $\alpha = 0.3$	1.18	{ 1.13	0.05
$\beta = 0.8$	1.16		0.03
$\alpha = 0.4$	1.17		0.04
$\beta = 0.7$	1.16		0.03
Line haul transport	0.52	0.50	0.02
<u>$h^2 = 1.25$</u>			
Output price	5.32	4.80	0.52
Input price: $\alpha = 0.3$	6.58	{ 5.33	1.25
$\beta = 0.8$	5.95		0.62
$\alpha = 0.4$	6.32		0.99
$\beta = 0.7$	6.00		0.67
Line haul transport	2.66	2.14	0.52
<u>$h^2 = 1.50$</u>			
Output price	10.93	9.14	1.79
Input price: $\alpha = 0.3$	15.70	{ 10.23	5.47
$\beta = 0.8$	12.47		2.24
$\alpha = 0.4$	14.29		4.06
$\beta = 0.7$	12.71		2.48
Line haul transport	5.47	3.68	1.79
<u>$h^2 = 2.00$</u>			
Output price	22.58	17.07	5.51
Input price: $\alpha = 0.3$	49.91	{ 19.32	30.59
$\beta = 0.8$	27.21		7.89
$\alpha = 0.4$	38.77		19.45
$\beta = 0.7$	28.56		9.24
Line haul transport	11.29	5.78	5.51
<u>$h^2 = 4.00$</u>			
Output price	72.10	45.79	26.31
Input price: $\alpha = 0.3$	{ *	{ *	{ *
$\beta = 0.8$			
$\alpha = 0.4$			
$\beta = 0.7$			
Line haul transport	36.05	9.74	26.31

*See footnote to Table IIIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.42	1.39	0.03
Input price: $\alpha = 0.3$	1.62	{ 1.53	0.09
$\beta = 0.8$	1.57		0.04
$\alpha = 0.4$	1.60		0.07
$\beta = 0.7$	1.58		0.05
Line haul transport	0.71	0.68	0.03
<u>$h^2 = 1.25$</u>			
Output price	7.16	6.45	0.71
Input price: $\alpha = 0.3$	9.50	{ 7.17	2.33
$\beta = 0.8$	8.08		0.91
$\alpha = 0.4$	8.89		1.72
$\beta = 0.7$	8.19		1.02
Line haul transport	3.58	2.87	0.71
<u>$h^2 = 1.50$</u>			
Output price	14.57	12.17	2.40
Input price: $\alpha = 0.3$	25.04	{ 13.63	11.41
$\beta = 0.8$	17.01		3.38
$\alpha = 0.4$	21.36		7.73
$\beta = 0.7$	17.56		3.93
Line haul transport	7.28	4.88	2.40
<u>$h^2 = 2.00$</u>			
Output price	29.75	22.43	7.32
Input price: $\alpha = 0.3$	125.21	{ 25.40	99.81
$\beta = 0.8$	38.76		13.36
$\alpha = 0.4$	76.29		50.89
$\beta = 0.7$	42.47		17.07
Line haul transport	14.87	7.55	7.32
<u>$h^2 = 4.00$</u>			
Output price	93.09	58.82	34.27
Input price: $\alpha = 0.3$	{ *	{ *	{ *
$\beta = 0.8$			
$\alpha = 0.4$			
$\beta = 0.7$			
Line haul transport	46.54	12.27	34.27

*See footnote to Table IIIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.1, \alpha = 0.3, \beta = 0.8$$

$$\text{and } \alpha = 0.4, \beta = 0.7$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.17	2.12	0.05
Input price: $\alpha = 0.3$	2.57	{ 2.34	0.23
$\beta = 0.8$	2.41		0.07
$\alpha = 0.4$	2.51		0.17
$\beta = 0.7$	2.43		0.09
Line haul transport	1.09	1.04	0.05
<u>$h^2 = 1.25$</u>			
Output price	10.82	9.75	1.07
Input price: $\alpha = 0.3$	18.85	{ 10.83	8.02
$\beta = 0.8$	12.66		1.83
$\alpha = 0.4$	15.99		5.16
$\beta = 0.7$	13.08		2.25
Line haul transport	5.41	4.34	1.07
<u>$h^2 = 1.50$</u>			
Output price	21.85	18.23	3.62
Input price: $\alpha = 0.3$	92.36	{ 20.41	71.95
$\beta = 0.8$	28.48		8.07
$\alpha = 0.4$	56.18		35.77
$\beta = 0.7$	31.22		10.81
Line haul transport	10.92	7.30	3.62
<u>$h^2 = 2.00$</u>			
Output price	44.09	33.16	10.93
Input price: $\alpha = 0.3$	{ *	{ *	{ *
$\beta = 0.8$			
$\alpha = 0.4$			
$\beta = 0.7$			
Line haul transport	22.04	11.11	10.93
<u>$h^2 = 4.00$</u>			
Output price	135.06	84.87	50.19
Input price: $\alpha = 0.3$	{ *	{ *	{ *
$\beta = 0.8$			
$\alpha = 0.4$			
$\beta = 0.7$			
Line haul transport	67.53	17.34	50.19

*See footnote to Table IIIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.2, \alpha = 0.4, \beta = 0.8$$

Transport costs before subsidy (y) = 20% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	0.80	0.78	0.02
Input price: $\alpha = 0.4$	0.97	0.94	0.03
$\beta = 0.8$	0.96	0.94	0.02
Line haul transport	0.40	0.38	0.02
<u>$h^2 = 1.25$</u>			
Output price	4.23	3.82	0.41
Input price: $\alpha = 0.4$	5.44	4.67	0.77
$\beta = 0.8$	5.16	4.67	0.49
Line haul transport	2.11	1.70	0.41
<u>$h^2 = 1.50$</u>			
Output price	8.99	7.55	1.44
Input price: $\alpha = 0.4$	12.70	9.34	3.36
$\beta = 0.8$	11.23	9.34	1.89
Line haul transport	4.49	3.05	1.44
<u>$h^2 = 2.00$</u>			
Output price	19.38	14.78	4.60
Input price: $\alpha = 0.4$	36.33	18.66	17.67
$\beta = 0.8$	25.87	18.66	7.21
Line haul transport	9.69	5.09	4.60
<u>$h^2 = 4.00$</u>			
Output price	66.24	42.75	23.49
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.8$	*	*	*
Line haul transport	33.12	9.63	23.49

*Signified this rate of increase in output not achievable from subsidy on factor price, because of requirement that factor price less subsidy must be positive.

APPENDIX TABLE VE

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.2, \alpha = 0.4, \beta = 0.8$$

Transport costs before subsidy (y) = 25% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.21	1.18	0.03
Input price: $\alpha = 0.4$	1.48	1.42	0.06
$\beta = 0.8$	1.45	1.42	0.03
Line haul transport	0.60	0.57	0.03
<u>$h^2 = 1.25$</u>			
Output price	6.20	5.59	0.61
Input price: $\alpha = 0.4$	8.40	6.83	1.57
$\beta = 0.8$	7.66	6.83	0.83
Line haul transport	3.10	2.49	0.61
<u>$h^2 = 1.50$</u>			
Output price	12.87	10.78	2.09
Input price: $\alpha = 0.4$	20.71	13.35	7.36
$\beta = 0.8$	16.58	13.35	3.23
Line haul transport	6.43	4.34	2.09
<u>$h^2 = 2.00$</u>			
Output price	26.95	20.43	6.52
Input price: $\alpha = 0.4$	79.67	25.82	53.85
$\beta = 0.8$	39.90	25.82	14.08
Line haul transport	13.47	6.95	6.52
<u>$h^2 = 4.00$</u>			
Output price	87.96	56.16	31.80
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.8$	*	*	*
Line haul transport	43.98	12.18	31.80

*See footnote to Table VD

APPENDIX TABLE VF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.2 \quad \alpha = 0.4, \beta = 0.8$$

Transport costs before subsidy (y) = 35 % of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	2.01	1.97	0.04
Input price: $\alpha = 0.4$	2.55	2.38	0.17
$\beta = 0.8$	2.45	2.38	0.07
Line haul transport	1.01	0.97	0.04
<u>$h^2 = 1.25$</u>			
Output price	10.14	9.14	1.00
Input price: $\alpha = 0.4$	16.74	11.16	5.58
$\beta = 0.8$	13.14	11.16	1.98
Line haul transport	5.07	4.07	1.00
<u>$h^2 = 1.50$</u>			
Output price	20.63	17.23	3.40
Input price: $\alpha = 0.4$	63.15	21.36	41.79
$\beta = 0.8$	30.79	21.36	9.43
Line haul transport	10.32	6.92	3.40
<u>$h^2 = 2.00$</u>			
Output price	42.09	31.73	10.36
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.8$	*	*	*
Line haul transport	21.04	10.68	10.36
<u>$h^2 = 4.00$</u>			
Output price	131.40	82.97	48.43
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.8$	*	*	*
Line haul transport	65.70	17.27	48.43

*See footnote to Table VD

APPENDIX TABLE VIF

SUBSIDY COST, INCREASED PROFIT AND NET SOCIAL
COST PER UNIT OF OUTPUT

$$\alpha + \beta = 1.3, \alpha = 0.4, \beta = 0.9$$

Transport costs before subsidy (y) = 35% of original selling price

All subsidy costs and increased profits are expressed as percentages of the original selling price before subsidy (p_x).
(h^2) is ratio of output after subsidy to output before subsidy.
(α) is capital coefficient, (β) is labour coefficient.

<u>(h^2) value and type of subsidy</u>	<u>Subsidy cost</u>	<u>Increased profit</u>	<u>Net social cost</u>
<u>$h^2 = 1.05$</u>			
Output price	1.89	1.85	0.04
Input price: $\alpha = 0.4$	2.59	2.41	0.18
$\beta = 0.9$	2.48	2.41	0.07
Line haul transport	0.94	0.90	0.04
<u>$h^2 = 1.25$</u>			
Output price	9.57	8.63	0.94
Input price: $\alpha = 0.4$	17.51	11.50	6.01
$\beta = 0.9$	13.27	11.50	1.77
Line haul transport	4.78	3.84	0.94
<u>$h^2 = 1.50$</u>			
Output price	19.63	16.41	3.22
Input price: $\alpha = 0.4$	70.88	22.30	48.58
$\beta = 0.9$	30.73	22.30	8.43
Line haul transport	9.82	6.60	3.22
<u>$h^2 = 2.00$</u>			
Output price	40.48	30.58	9.90
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.9$	*	*	*
Line haul transport	20.24	10.34	9.90
<u>$h^2 = 4.00$</u>			
Output price	128.58	81.55	47.03
Input price: $\alpha = 0.4$	*	*	*
$\beta = 0.9$	*	*	*
Line haul transport	64.29	17.26	47.03

*See footnote to Table VD